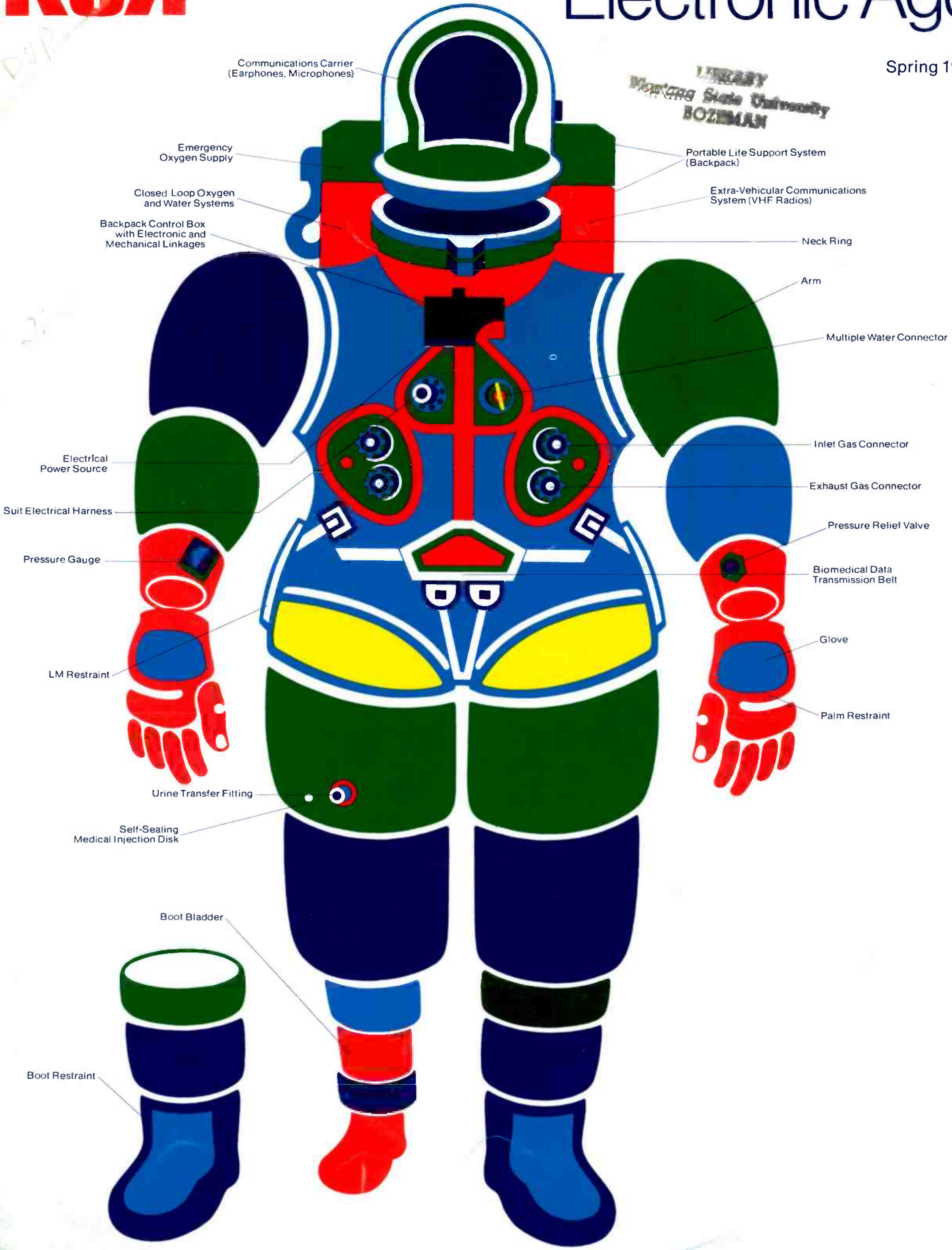
RCA

Electronic Age

Spring 1969



Cover: The Apollo space suit will be man's electronic link to his earthly environment while in space or on the moon. Within his suit and its life-support backpack are systems to provide oxygen for his breathing and pressurization and water for body cooling. There are electronic equipment to relay his medical data to doctors back on earth and VHF radios to keep him in constant communication with fellow astronauts as well as with mission control. For a report on what is ahead for "Man on the Moon," turn to page 8.

Electronic Age

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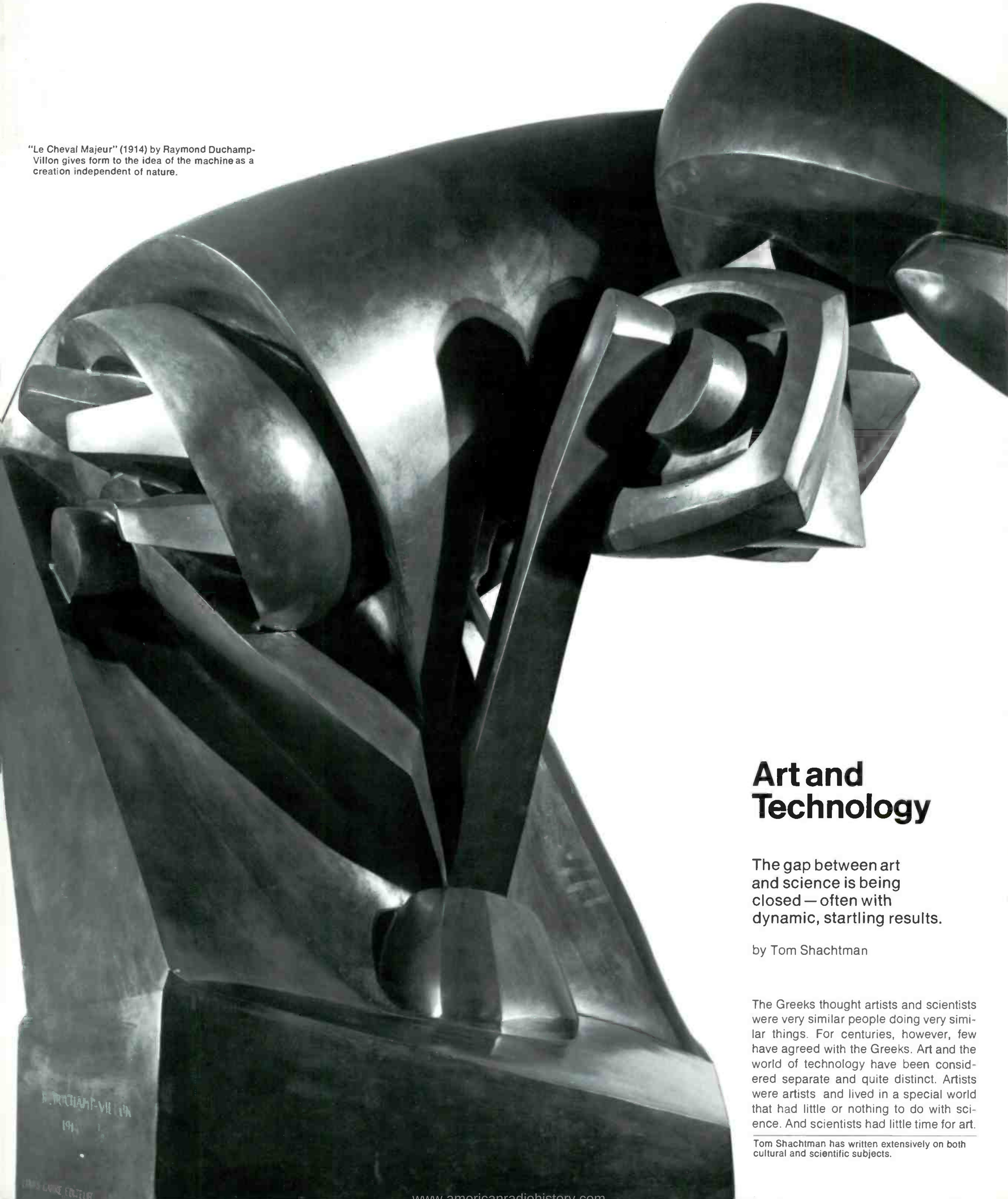


"Le Cheval Majeur" (1914) by Raymond Duchamp-Villon gives form to the idea of the machine as a creation independent of nature.

Art and Technology

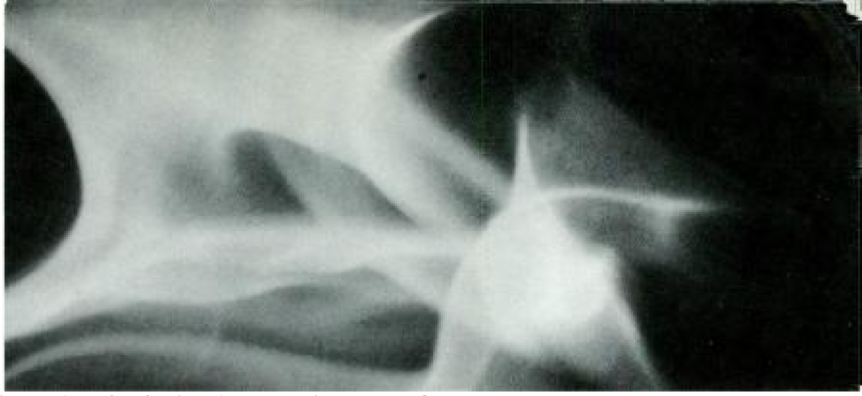
The gap between art and science is being closed — often with dynamic, startling results.

by Tom Shachtman

The Greeks thought artists and scientists were very similar people doing very similar things. For centuries, however, few have agreed with the Greeks. Art and the world of technology have been considered separate and quite distinct. Artists were artists and lived in a special world that had little or nothing to do with science. And scientists had little time for art.

Tom Shachtman has written extensively on both cultural and scientific subjects.

"La Royale" (1931) by Ettore Bugatti shows the car as the supreme effort of mechanics and the symbol of individualism.



"Lumia Tanus" (1968), by scientist Fred Herzfeld of RCA and artist Earl M. Reiback, is a mechanized light box of abstract designs and flowing colors.

Today, however, in the midst of an age formed by technology, artists and scientists are drawing closer together to create new art objects. The child of their union — technologically oriented art — is often startling, both technically and artistically. For artists, this union may be what John Canaday, art critic for the New York *Times,* calls "a problem in aesthetic and spiritual miscegenation." For scientists and engineers, it may be only an interesting diversion. But even so, there is little doubt that this unlikely "marriage" is of importance to modern art and of great interest to art lovers.

Three large exhibitions at museums in two countries have been devoted to this union: "Cybernetic Serendipity" at the Institute of Contemporary Arts in London, "The Machine as Seen at the End of the Mechanical Age" at the Museum of Modern Art in New York City and "Some More Beginnings" at the Brooklyn Museum. All were hailed as emblematic of an exciting turning point in art. They were enthusiastically received by the art public, and they attracted many thousands of scientists and engineers because of their great emphasis on technology.

The coming together of art and science is new, but the union has its roots in three trends that slowly have been making themselves felt over the past several centuries. The first is a thrust toward the inclusion of movement in the artist's work. A painting or sculpture in the classical form is a frozen moment. There is no indication of movement — it must be inferred. Since movement is a telling characteristic of life, artists have been striving to capture it by showing the subject in motion or by imbuing the painting or sculpture with locomotion by the ebb and flow of the lines, colors and materials that make up the piece of art. With the inclusion of technology, actual movement itself can be introduced into art works.

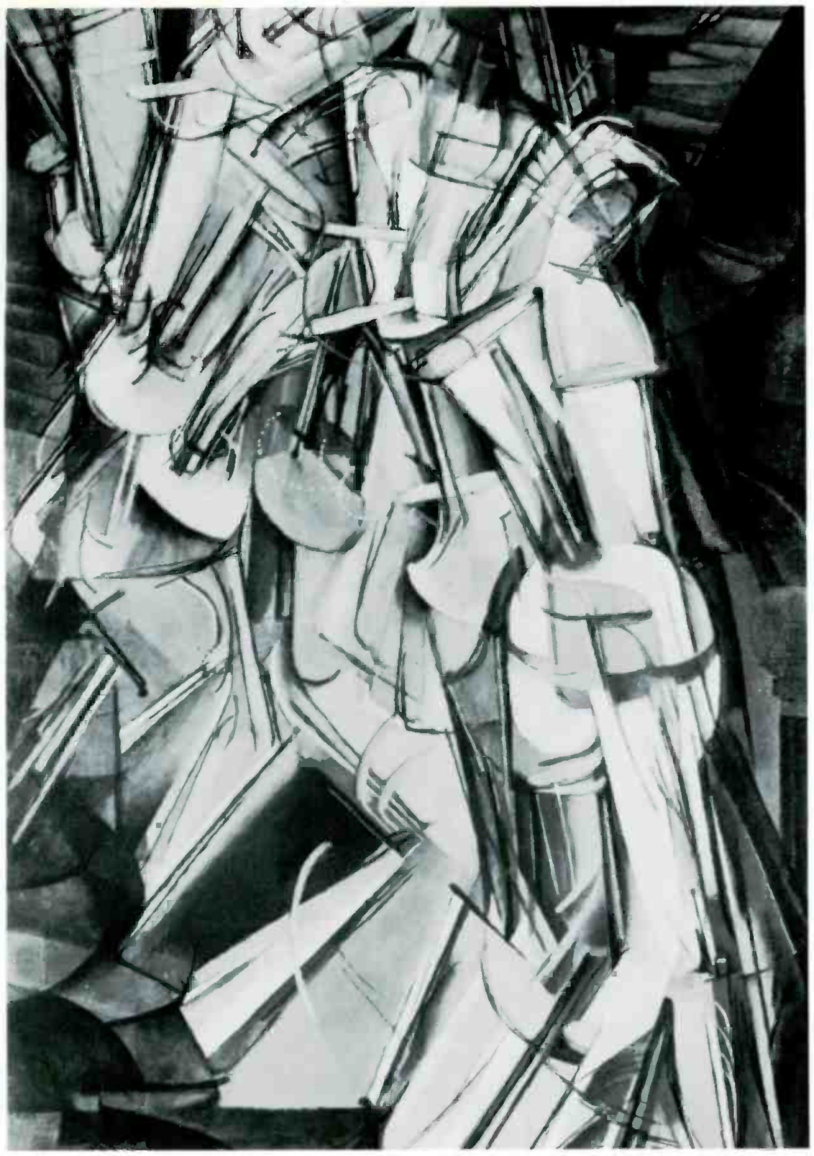
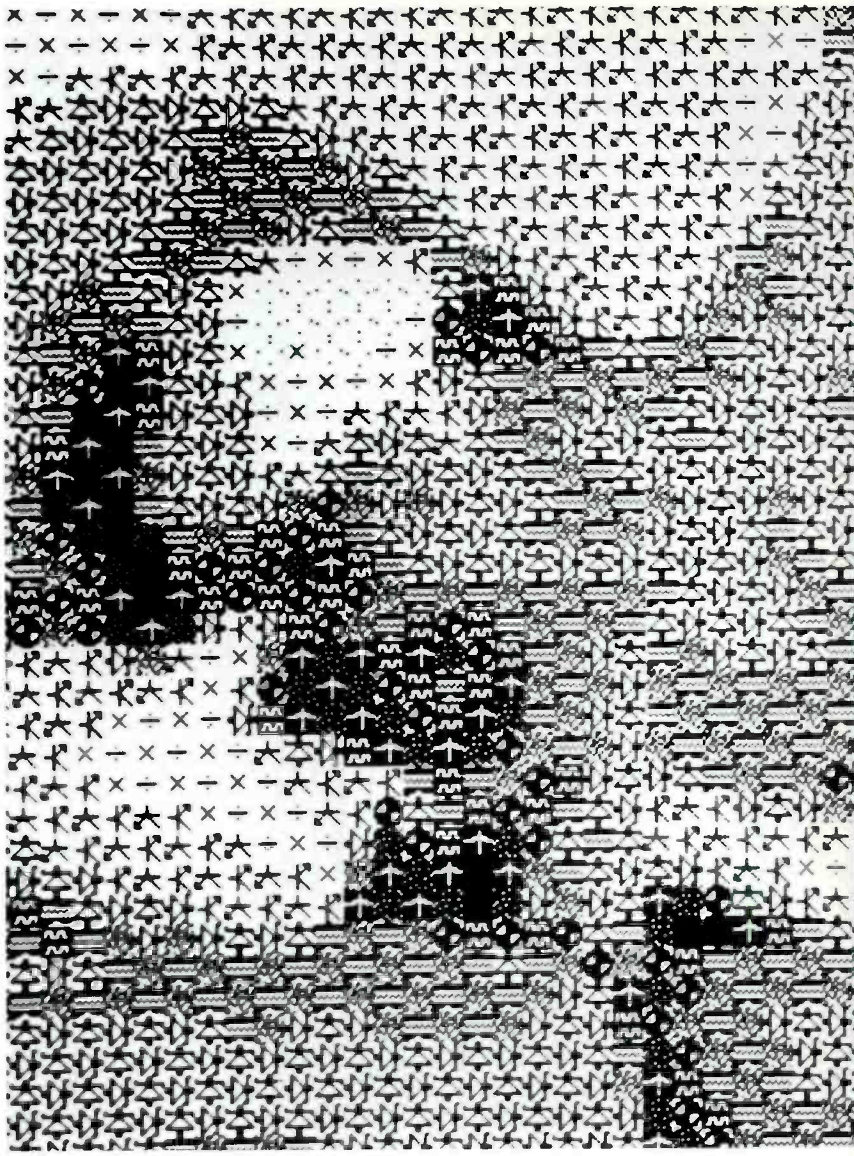
A second thrust that has led to the present union is the gradual melding of one art form into another, such as paintings into sculpture, collage and constructions. As the boundaries that separated one art form from another gradually disappeared or were bypassed, the way was paved for the inclusion of various technological products — and then of technology itself — into the work.

The third trend — considerably more ephemeral — stems from the artist's eternal concern with involving the spectator in his work. It is the awareness that every art work is a communication from artist to spectator. Technology has given the artist more powerful, more differentiated means of expression.

The Museum of Modern Art exhibit examined the historical background for the increasing number of art-technology unions. Although there is a Greek word, *techne,* that means both art and technics, the importance of machines to art really started with Leonardo da Vinci, famed for both his scientific and artistic achievements. K. G. Pontus Hulten, a European museum director and prominent art historian, claims that da Vinci was primarily a scientist, and only secondarily an artist. This is because an overwhelming interest of his life was in the creation of machines, primarily a flying machine. IBM has reconstructed models of da Vinci's machines as described by his voluminous sketches, and some of these appeared in the MOMA exhibition.

For hundreds of years following da Vinci, however, artists had little to do with machines. Their interest was revived briefly with automata, clever mechanical toys, that were all the rage in eighteenth-century France but were never really accepted as art objects. The coming of the Industrial Revolution, and the resulting interest in the practical aspects of machines, further de-emphasized any evaluation of them as works of art. Artists simply forgot about machines. At best, they considered them as objects set into the general landscape of the times, things of purely sociological interest. Throughout the nineteenth century with its prevailing wind of naturalism, technology and art remained generally apart.

In the last years of the nineteenth century, artists began to rediscover machines as art. This was fostered by the increasing public distaste for ugly machines, such as some of the early, purely functional horseless carriages, and by the efforts of the Impressionists to free art from the confining boundaries of naturalism. The Parisian newspaper *Figaro* sponsored a competition in an attempt to

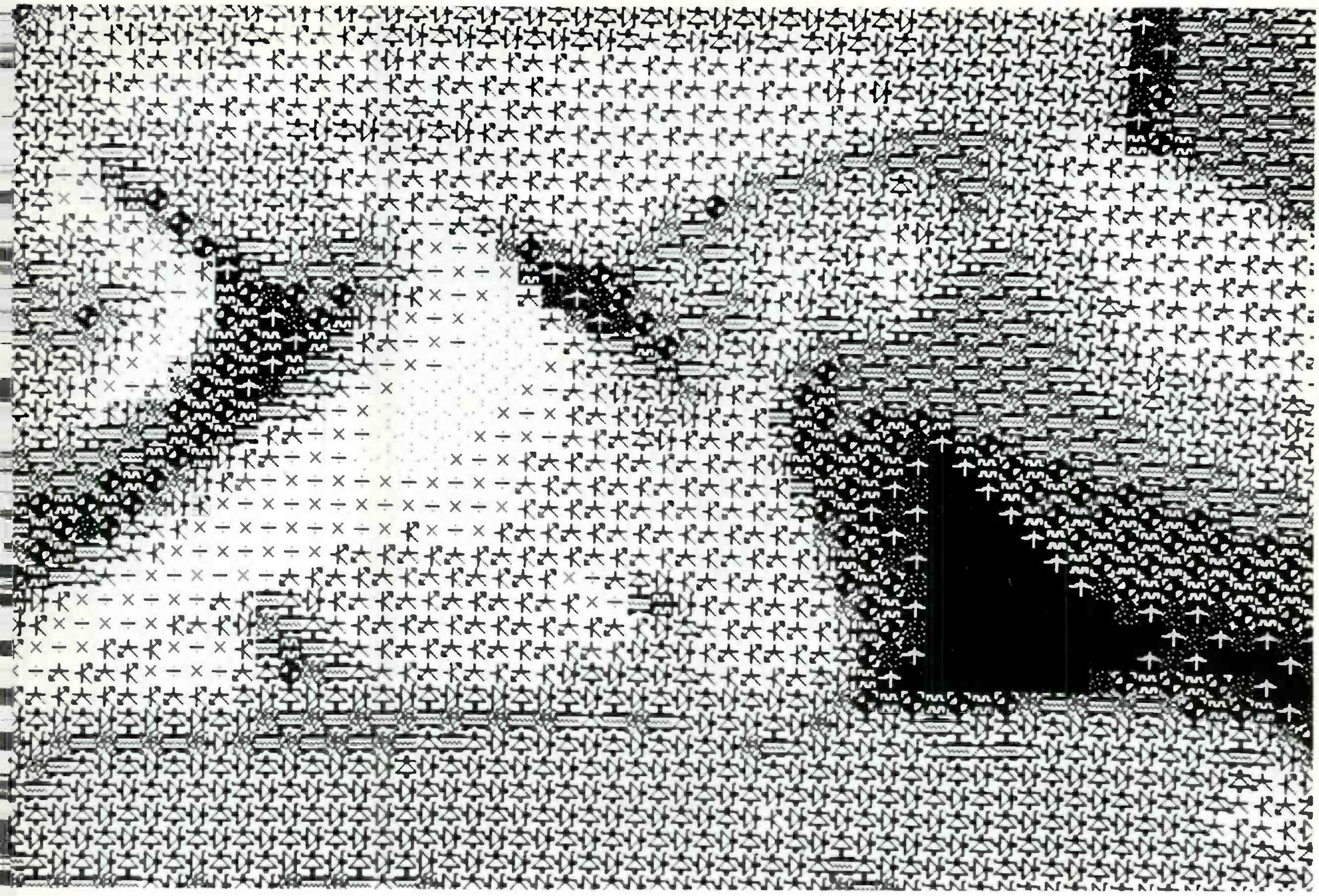
Top: "Nude Descending a Staircase, No. 3" (1916) by Marcel Duchamp is an early twentieth-century attempt to show motion in art.
Center: "Studies in Perception I, II and III" (1967), by scientist Kenneth C. Knowlton and artist Leon D. Harmon, represents a growing interest in computer art.
Right: "Speak That I May See" (1968), by artist Roberta Phillips and scientist Copthorne MacDonald, is a life-size plastic nude with a cathode ray tube for a face.

find more beautiful forms for automobiles but failed to produce anything really striking. *Figaro* concluded, "Unhappily, we have not been able to celebrate the hoped-for marriage between art and science and are barely able to feel that we have brought about their engagement."

With the new century, some artists again viewed machines as art objects. Lyonel Feininger, famous American Cubist painter, made sculptures of trains, both real and imaginary. The Futurists, a group of Italian and French artists, committed themselves to the capture of the mechanization, speed and dynamism they felt coursing through the machines that were proliferating throughout the modern world. Marinetti, a leading Futurist and author of the movement's manifesto, declared that "a roaring motor car . . . is more beautiful than the 'Victory of Samothrace.' "

In an era that believed it was seeing the last gasps of classical sculpture from the hands of Auguste Rodin, Marinetti's statement was prophetic. The Futurists influenced sculptors like Duchamp-Villon, whose important work, "Le Cheval Majeur," was one of the most striking pieces in the MOMA exhibition. Certain parts of the work resemble shafts and pistons but are not actual mechanical devices. Rather, the impression of movement and function comes from what is described as "the same kind of economy and straightforwardness that a designer of machines uses to achieve the most efficient performance of his apparatus."

Marcel Duchamp, Duchamp-Villon's brother, was perhaps the most powerful and all-pervasive art force besides Picasso in this century, and he was very important in closing the science-art gap. Duchamp recognized technology as an art subject. He studied mathematical theories and found beauty in technological objects, like bicycles and boxes. His "Nude Descending a Staircase," the famous abstract of what seem to be a dozen representations of one figure moving down a flight of stairs, created a sensation in 1913 and revolutionized the tenor of early twentieth-century art. Duchamp considered it an attempt to include movement in his art. "I try to show what it does. I do not make a still-life picture of it," he wrote. In his "The Bride Stripped Bare by Her Bachelors," a painting and construction of oil, lead wire, foil, dust, and varnish on glass, he erased the boundaries of painting and sculpture. In his studies of precision optics and motorized constructions of the 1920s, Duchamp attempted to bring the spectator into the work of art by the use of a product of technology — moving optical illu-



sions. In Duchamp's mind, the world could be divided into two categories — art and nature. Everything that was man-made, be it painting, machine, sculpture or product, was art. This conception extended the boundaries of art into the realm of science and engineering.

In the period between World Wars I and II, many Europeans and Americans used technology and the inspiration of science extensively in their works. These included Tatlin, a Russian artist whose "Monument for the Third Internationale" influenced a generation of Constructivists; El Lissitzsky, Max Ernst and Laszlo Moholy-Nagy, whose works depict machines as pure art objects; and Alexander Calder, an artist trained as an engineer and the inventor of the mobile, which uses the basic principles of dynamics. Also important was Alberto Giacometti, whose "The Captured Hand" is a startling example of the attempt to invite the spectator into a work of art. In this case, the viewer is asked to move a lever that captures a wooden hand inside the mechanism of the sculpture.

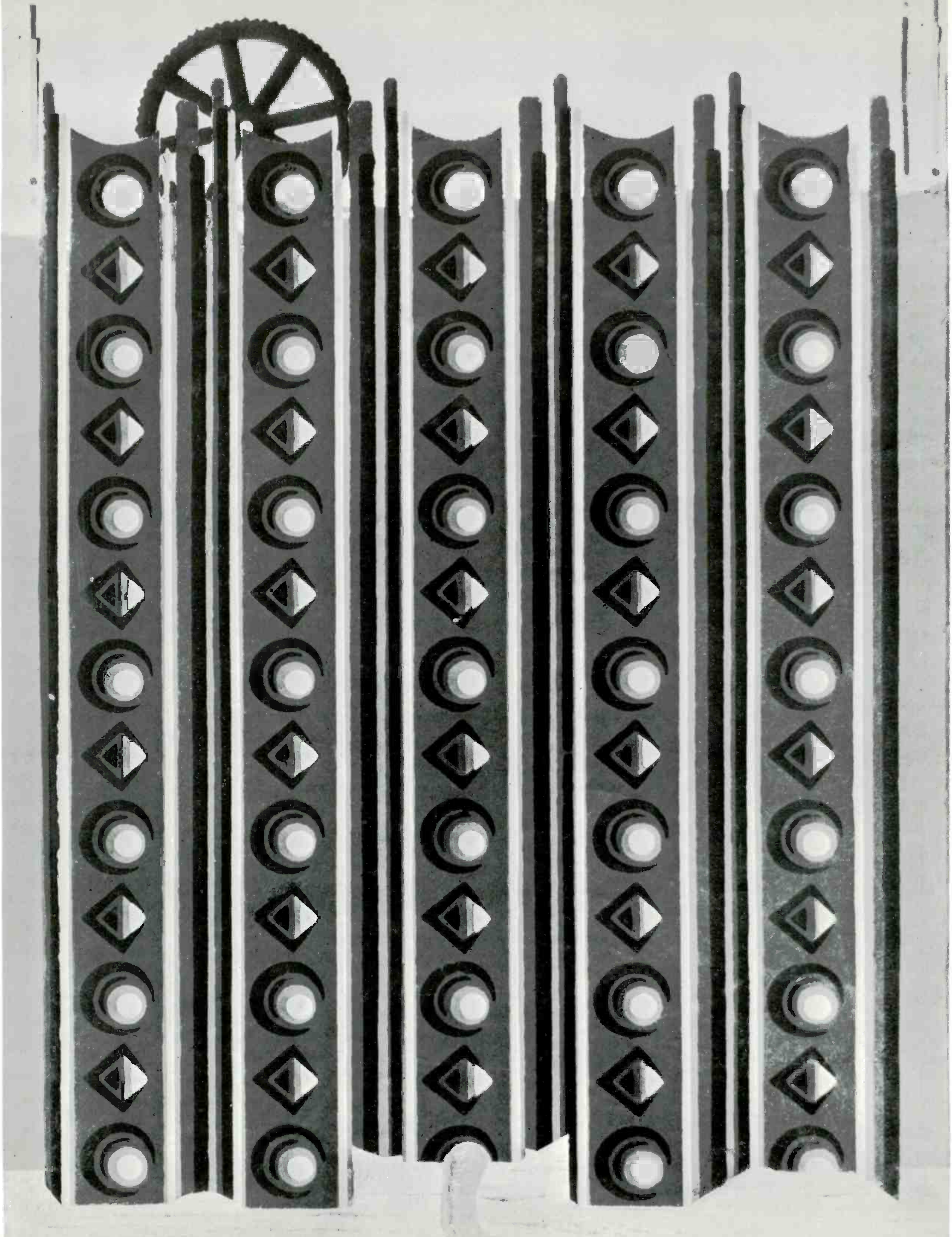
Many modern works, such as Kienholz' "The Friendly Gray Computer — Star Gauge Model 54," directly incorporate technological objects and processes. Tinguely's "Rotozaza, No. 1" goes even further by asking the spectator to throw balls into it. It is, in effect, a caricature of the producing machines — reversing the usual processes. Instead of carrying away what the machine produces, man has to produce for the machine because "the machine demands it."

Technically oriented art is dynamic, keeping pace with the changing world of science and engineering with many works incorporating such sophisticated advances as lasers, holography and computers. And heavy emphasis is placed on relating these advances in terms of human senses or experiences. This was illustrated at the Brooklyn Museum show, "Some More Beginnings," where artists collaborated with technologists. Typical works were:

"Speak That I May See," a seated, life-size, voice-controlled plexiglass nude with a cathode ray tube for a face. When it is spoken to, images appear and change on the tube according to the volume and tone of the speaker.

"Pulsation 8," a display of small, variable-size black-and-white disks rotating on individual shafts to produce patterns that pulsate in intriguing ways.

"Lumia Tanus," a light box of mysterious and beautiful abstract designs and flowing colors that can be viewed for hours without a repetitive pattern appearing. This work was designed in part by



"Many works incorporate such sophisticated advances as lasers, holography and computers."

Fred Herzfeld of the RCA Laboratories.

"Light Trivium," a construction of Teflon, mirrors, a helium-neon laser, motors, wood and cloth, in which the spectator moves the Teflon pads to direct and bounce the laser light in original patterns. The work was designed by David Chapin, an artist, and Jacques Pankove of RCA Laboratories.

"Heart Beats Dust," in which a synthetic membrane vibrates a pile of dust into the controlled atmosphere of a box filled with eerie red light. The sounds that cause the membrane to vibrate are the heartbeats of the viewer, fed into the machine by means of an attached stethoscope.

"Fakir in ¾ Time," in which a variable-speed motor takes in and spews out friction tape in a loop whose shape and twists are controlled by varying the speed of several motors.

"Cybernetic Sculpture," a grouping of vibrating stainless-steel rods illuminated by strobe lights, which flash and gyrate in response to sounds generated by spectators.

Although computers per se were in evidence in the Brooklyn exhibit, they were not the stars of the show as they were in the "Cybernetic Serendipity" exhibition in London. That show featured examples of the computer's interaction and work in various artistic disciplines. Included were computer-generated films, designs, poetry and other writings as well as the varieties and vagaries of computer-generated and computer-played music, which is coming into its own as an important cultural contribution. One of the most interesting works was a computer-programmed choreography, in which "movement directions come spilling out of a computer very much like so many beads without any string to hold them in line." The dancers must learn to interrelate the movement directions given them by the computer.

There was even a computer-controlled actress called Rosa (Radio operated simulated actress) Bosom. Rosa, who appeared in a French production of *The Three Musketeers* in the role of the Queen of France, was chased by another robot, Mate, who followed her around and interacted by means of ultrasonics, infrared, and sonic signals.

Artist Nicholas Schöffer provided what might be the ultimate glimpse of the future in his plans for a monumental structure, hundreds of feet high, to be erected in the heart of Paris. It would be made of steel sheets and several hundred mirrors and contain 100 revolving axes driven by electric motors of varying speeds, which would be controlled by a computer. "The sound, temperature, traffic flow and humidity will affect the movement and luminosity of the tower. It can serve as a barometer, announcing bad weather, for example, through emission of red beams and fine weather by the slowing up of its movements and the predominance of blue. It will also be able to serve up the stock market trends: increasing brightness for a rising market, a more or less accentuated slowing-up for a falling market. For road traffic, it can be made to serve as the coordinator and broadcaster of information by visual signals, indicating the directions to take or avoid."

Schöffer's tower is, at the moment, a creation of fantasy, but one can never tell because the union of art and technology is happening quickly, as evidenced by many projects throughout the world. What was once thought of as a fanciful design by the famous French artist Jean Dubuffet, "Tour aux Figures," is to be created as a 26-foot-high cement figure by an American cement concern working in conjunction with the artist under a new art-technology program inaugurated by the Los Angeles County Museum of Art.

In addition, the Institute of Electrical and Electronics Engineers has formed a committee on art and technology to foster the collaboration from the technologist's side. And at MIT under Gyorgy Kepes, there was recently organized a Center for Advanced Visual Studies, whose main function is to increase the possibilities for cooperation and interaction between artists and scientists. Six artists were in residence at the MIT Center this year and all have done interesting and significant work. One of the most important of these new artists is Vassilakis Takis, a Greek who works extensively with magnetism. Takis says the MIT program tries "to achieve spiritual collaboration between artist and scientist. Otherwise, the technology is just a gadget. For me, the scientist is a poet, a creator."

An apocryphal story is told of the day on which Takis met the famed sculptor Alberto Giacometti and showed him some of his works. Giacometti was fascinated but perplexed. "I am the last of the sculptors," he said. "You are the first of the new breed."

The new breed is the offspring of what was thought of not too long ago as the unlikeliest of marriages, the union of art and technology. ■

Left: "The Little Tear Gland That Says Tic Tac" (1920) by Max Ernst is a machine-age representation of the sun and forest.
Center: "The Mechanic" (1920) by Fernand Léger exalts, in the words of the artist, "the world of artisan creators."
Above: This paper sculpture, created by Ray Ameijide, is the artist's conception of an emerging technology—voice communication between man and machine.

Man on the Moon

The barren lunar landscape may someday be the site of profitable manufacturing and mining operations as well as the window on the universe.

by Norman H. Solon

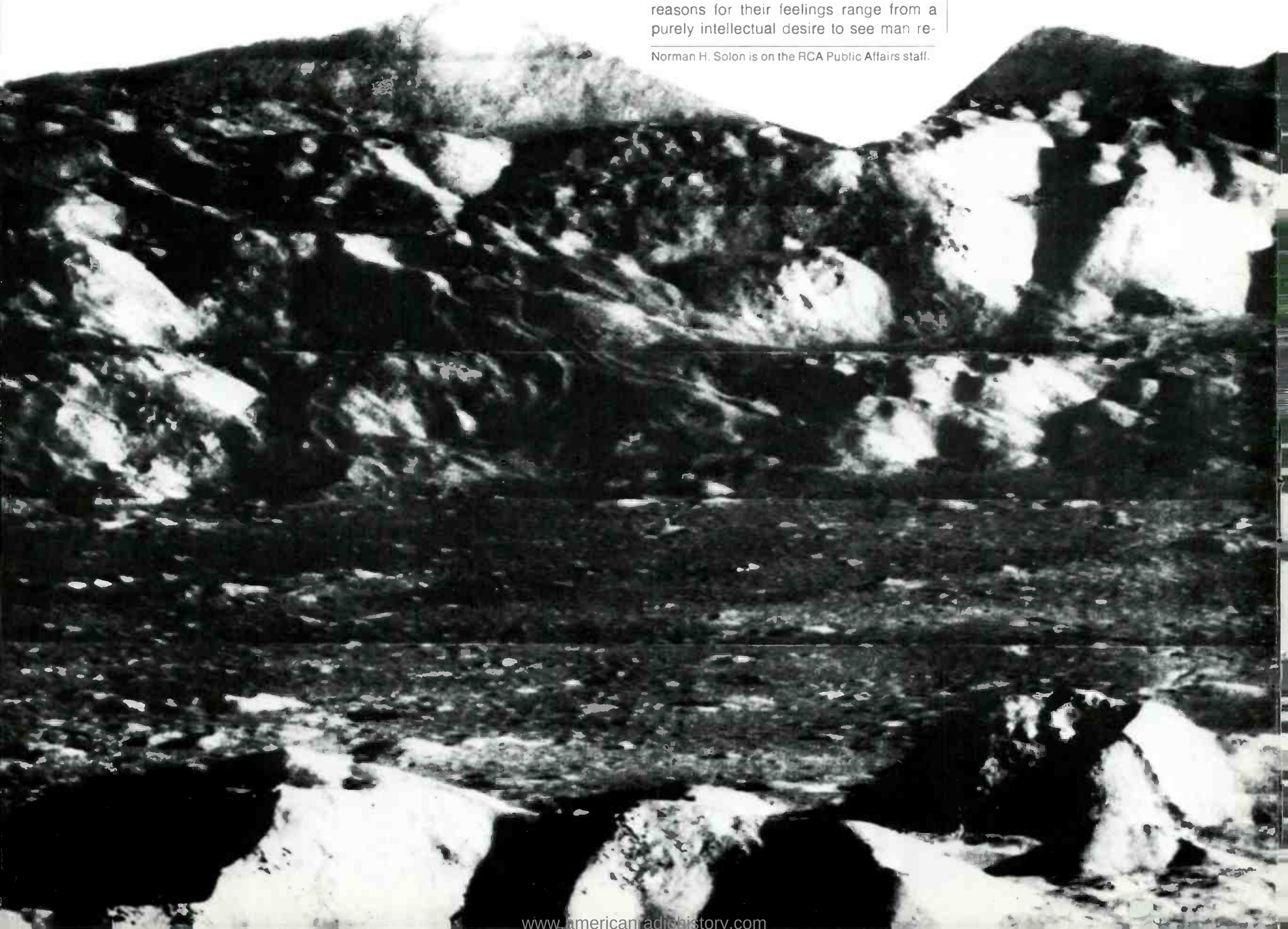
Lieutenant Colonel Mike Collins, an articulate veteran of the Gemini 10 mission and the man chosen to pilot the Apollo 11 spacecraft on its historic journey to place men on the moon, slowly rose from his desk at the NASA Manned Flight Space Center and replied:

"Scrap the manned exploration mission in favor of placing instrument packages on the moon? That would be the same as Columbus sailing to within 60 miles of the Florida coast and deciding to turn around and go home."

Colonel Collins' response to recent proposals to shift the emphasis of the U.S. space program from men to machines is echoed by most of the men directly involved in the Apollo manned flight program, both the astronauts and the scientists who back them up. The reasons for their feelings range from a purely intellectual desire to see man released from his earthly boundaries to a thirst to tap what is probably the most valuable natural resource of the moon — raw knowledge. Nobel laureate Harold C. Urey admits that automated instruments can gather information; however, "only man, standing on the moon, can grasp the significance of its many and complex phenomena."

However, manned exploration of the moon is far more than a multi-billion-dollar space safari. The history and many secrets of the solar system may be etched on the surface of the moon, largely unaffected by the ravages of wind, atmosphere, oceans and man himself. And information garnered from the moon also can have practical value back on earth.

Norman H. Solon is on the RCA Public Affairs staff.



For one thing, geologist-astronaut Harrison H. Schmitt believes that the study of mineral deposits on the lunar surface, which are not veiled by a sedimentary crust, may help in the exploitation and conservation of natural resources on earth. For example, it may reveal the type of geological conditions and processes that make copper plentiful in areas like the southwestern United States and relatively nonexistent in other areas.

In the coming decades, both optical and radio telescopes will probably be erected on the lunar surface. This will make the moon a window on the universe, giving astronomers a clear, deep view of the heavens without the warping effect of an ocean of air and the interference of man-generated radio waves. And twice as much light from every point in existence reaches the moon than reaches the earth. If the 200-inch Mt. Palomar telescope were located on the moon instead of in the California observatory, many scientists believe that planets could be seen circling nearby stars. (The gravitational effects of a planet with a mass 60 per cent greater than that of Jupiter have been determined from deviations in the path of Bernard's Star, some six light-years away. But the light reflected from that planet is too dim to be seen from earth.) A lunar telescope may even be able to extend man's vision to the edges of the universe where traces of the primeval explosion that marked the start of creation are still visible.

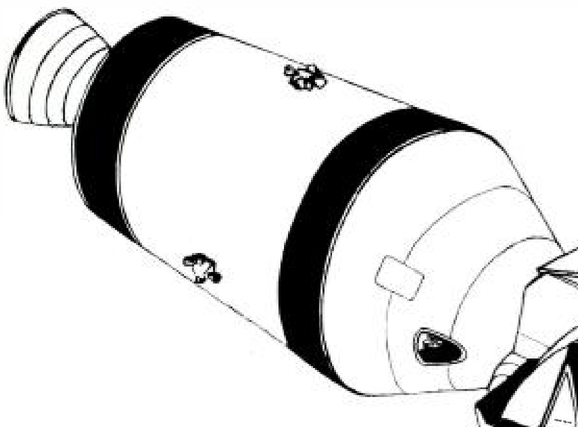
Telescopes will be located on the dark side of the moon so that the entire lunar mass will act as a filter against radio waves from earth. And since the moon travels around the earth once a month, the entire universe can be scanned in that period. (This can be compared to a man sitting on the rim of a merry-go-round facing outward. He would view the entire surrounding area with every revolution.)

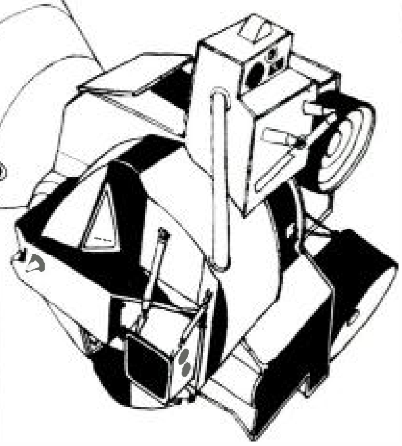
It would be simpler and more economical to place a telescope mounted on a satellite in orbit around the earth or moon, and NASA is planning such a project for the early 1970s. But although it would be a major improvement over earth-bound instruments, an orbiting telescope has limitations. It would be affected by the slightest planetary perturbations, and it also would be difficult for the telescope to keep a target in continuous, precise focus because of the speed of the satellite on which the telescope is anchored. The satellite itself would be an unstable platform compared to the lunar surface.

Someday, specialized industries may be established on the moon. The almost perfect vacuum, absence of humidity, low gravity and relatively high range of temperature extremes make the lunar outdoors ideal for producing such items as miniature electronic components, almost perfectly round ball bearings, tubes and films for export to earth. Semiconductors, for example, could be cleaned merely by exposing them for a time to the 265° F.

Panoramic view of rugged pockmarked landscape of moon crater Copernicus.

The Apollo Lunar Module (LM) and its proposed derivatives may have important roles in future space missions. From left to right are artist's renditions of the LM; the manned LM Laboratory, capable of operating in earth or lunar orbit; an astronaut deploying an Apollo lunar scientific experiment package; Lunar Roving Vehicle, which can be controlled by an astronaut or remotely from earth via a communications link; and a Rescue LM picking up an astronaut stranded in space.





temperature of the lunar midday. In addition, many scientists believe most of the critical items — ranging from rocket fuel to synthesized food — needed by the space colonists could be manufactured on the moon.

Electronic beam welding, to join together metals with ultrahigh melting temperatures, would be easy and inexpensive since there would be no need to eliminate contaminating gases. In addition, many metals could be self-welded in the icy two-week-long night. If extreme heat were needed, a solar furnace could be erected. Such a furnace would be far more effective than its counterpart on earth since it could focus the sun's rays directly without the filtering effect of an atmosphere.

If the lunar rocks prove rich in valuable materials, mining the moon may be profitable. Platinum, for example, has been found both in meteorites and volcanic rock on earth, and it also exists elsewhere in space. One NASA official has stated that there is $50 trillion worth of platinum in the three-mile-diameter asteroid Ivan — enough to retire the national debt and eliminate poverty on earth, as well as to support the most ambitious of space programs.

Even if the moon does not contain significant amounts of familiar precious metals, it may be a storehouse of other valuable minerals — quite different from anything on earth — that may be used in manufacturing. Since the moon has no atmosphere, its surface materials have not been oxidized as in the case of earth rocks. In addition, lunar materials have been bombarded for billions of years by intense radiation from the sun, unshielded by a filter of air. Thus, they may have developed properties completely foreign to the geological landscape of earth.

The feasibility of commercial lunar manufacturing and mining is dependent on the availability of economical transportation. However, the expense and difficulty of delivering a heavy payload from the earth to the moon are not indicative of the considerably lower cost of the return trip. A spacecraft launched from the moon needs to obtain a velocity only one-sixth of that needed on earth. And a straight-up launch, designed to get through the atmosphere as quickly as possible, would not be required. Instead, it would be possible to launch a spacecraft almost horizontally on a sled attached to a rail system using the catapult principle. According to Walter Sullivan, science editor of the New York *Times,* "it has been calculated that a payload of raw materials, able to withstand an acceleration 50 times the force of the earth's gravity, could be launched from the moon on a four-mile track."

A cargo spacecraft would not require any fuel for a lunar launch — it would be powered instead by a nuclear reactor or giant solar energy converter constructed on the moon. And the atmosphere of the earth would provide a natural brake at its destination. The only fuel needed would be a small amount for en route navigation and maneuvering.

The lunar launcher also could be used to project reusable tanks of hydrogen or other moon-processed propellant into orbit around the earth for rendezvous refueling. This would be like placing "gas stations" in the sky, so that a spacecraft launched from earth would need to carry only enough fuel to get it into orbit.

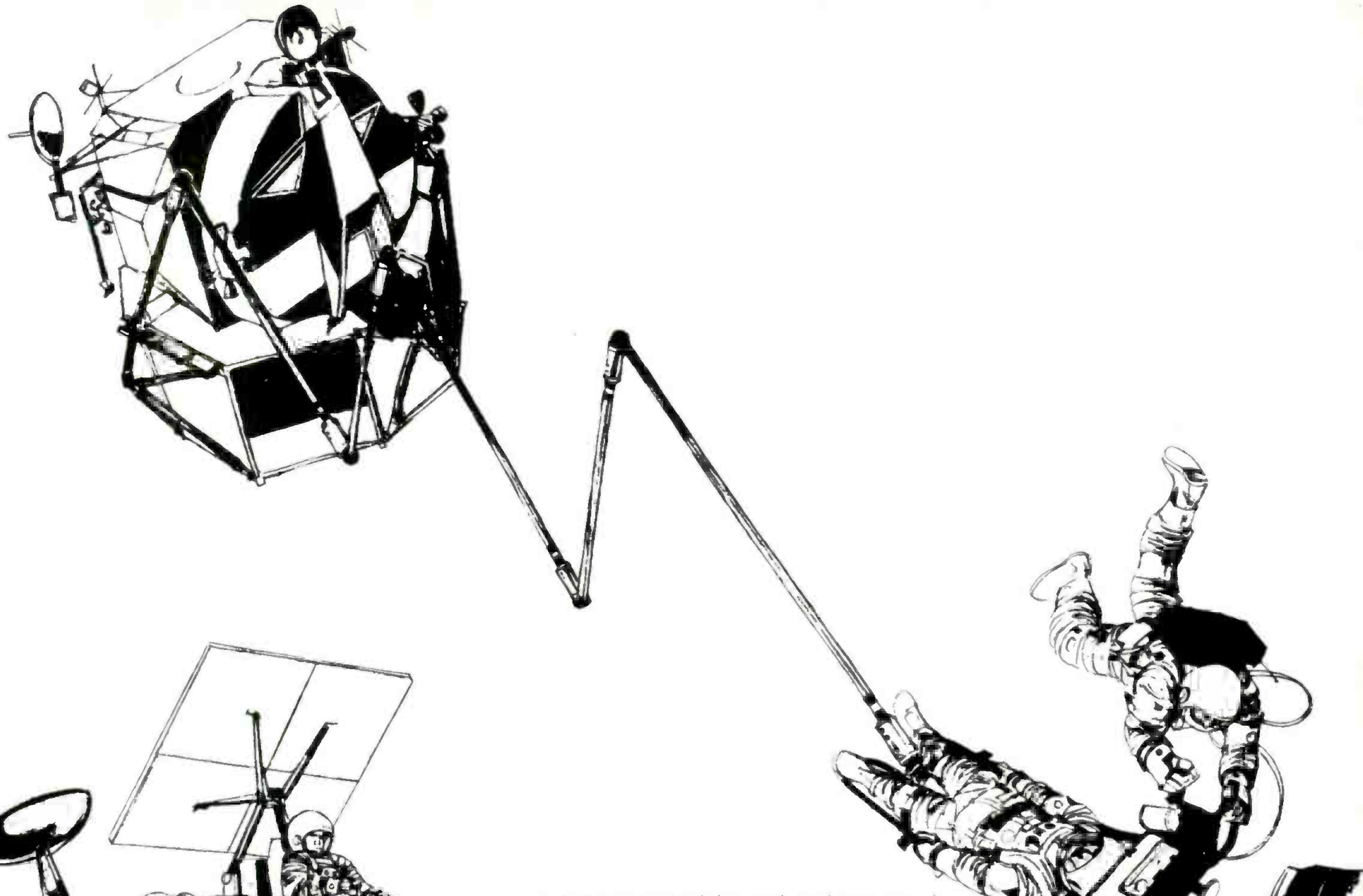
Looking even further ahead, the moon may have medical uses, although many scientists are skeptical. Lunar gravity may reduce the strain on human organs so that diseased hearts and lungs may function normally. And the crippled may walk again in an environment in which a 200-pound person weighs less than 34 pounds. However, the moon sanitarium will have to wait until major advances in propulsion — perhaps unlimited nuclear energy — make space travel no more taxing than a Sunday drive in the country.

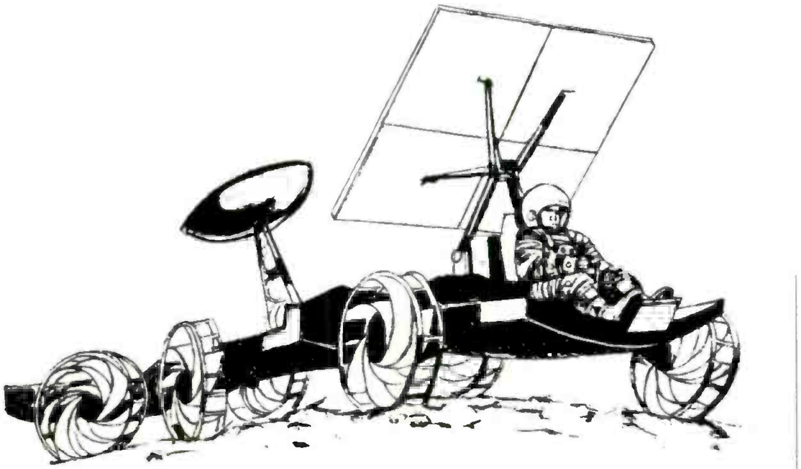
Although some of these moon colony projects involve the need for new or at least improved technology, there is no longer any doubt of man's ability to survive on the moon. Ground tests, unmanned space flights and the earlier Mercury and Gemini manned programs have shown that the environment of the moon is far less hostile — both physiologically and psychologically — than was first feared. For example, many scientists believed that the steady rain of micrometeoroids that pelts the lunar surface would prove fatal to astronauts and damaging to their equipment. However, instruments aboard two of the unmanned lunar-orbiter spacecrafts that mapped the surface of the moon indicated that only a total of 30 microparticles hit these ships —none with nearly enough force to puncture the outer layer of a space suit.

As a result, most NASA officials now believe that man can live on the surface of the moon in an artificial earth environment created inside of a collapsible plastic bubble, instead of having to depend on natural or dug-out caves for shelter. One scientist put it this way, "There is a chance that a meteorite might strike a given point with enough force to create damage. But the odds of this happening resemble those of a spectator in the back of the bleachers being hit by a batted ball on a given pitch."

At the start of this decade, many psychologists were fearful that the feeling of alienation caused by space travel would disorient a person to a point where he couldn't function efficiently. However, in addition to lengthy space flights, men have undergone tests in isolation chambers for long periods of time with no signs of this happening.

The first manned landing on the moon will take place on one of five sites located in maria, long, level plains that are





among the most prominent features on the near side of the moon. According to one NASA official, these potential sites have been selected to provide as smooth and unobstructed a landing field as possible for the Lunar Module (LM), the bug-shaped commuter vehicle that will carry two astronauts from the orbiting mother ship (CSM) to the surface of the moon. The final site will be relatively flat, with few obtrusive landscape features, and yet will provide certain desired lighting angles. During the early moon missions, scientific and geological considerations will play only a small role in site selection.

Initial lunar exploration will be modest — with the astronauts venturing no farther than 50 to 100 feet from the LM. Their mission will be to collect some 40 pounds of assorted rock samples and set up a group of lunar surface experiments that will continue to radio data back to earth. Instruments will report temperature changes, measure seismic activity (moonquakes) and search for minute traces of gas on the moon. On one mission, a laser reflector, which operates on the same principle as radar except that light is used instead of sound pulses, will bounce signals back to earth, and the echo will give the most precise measurement ever obtained of the distance between the two globes, and also of the aberrations in the rotation of the earth.

The lunar rocks will be of primary interest, however, and NASA has selected 130 top scientists to study the samples. Their tests will include chemical analysis and isotopic dating in an attempt to discover the nature and origin of lunar matter. One of the first questions that will be tackled is the origin of the maria. Commonly called seas, these plains were named by the seventeenth-century astronomer Riccioli who thought they were water-filled areas. Now, they are believed to be depressions filled with lava or volcanic ash. Samples of these ashes may give important indications as to whether the moon is a hot body (heated internally) or a cold body heated only by the radiation of the sun.

A study of these rocks may help to answer questions as to the origin of the moon itself. Presently there are three theories. One is that the moon was literally torn from the upper layers of the earth's crust, most likely from the area that is now the Pacific Ocean. Since the outer crust of the earth is lighter than the planet's over-all density, this would account for the lightweight composition of the moon. But most scientists do not believe that the earth's tides could have reached sufficient height for such a breakaway. The second theory holds that the moon was actually an asteroid or comet that approached the earth and was captured in its orbit. However, the odds against a body approaching the earth at precisely the correct angle and speed to obtain orbit are astronomical. The third and most commonly accepted theory is that the earth and moon are twin planets, formed at almost the same time but always separate.

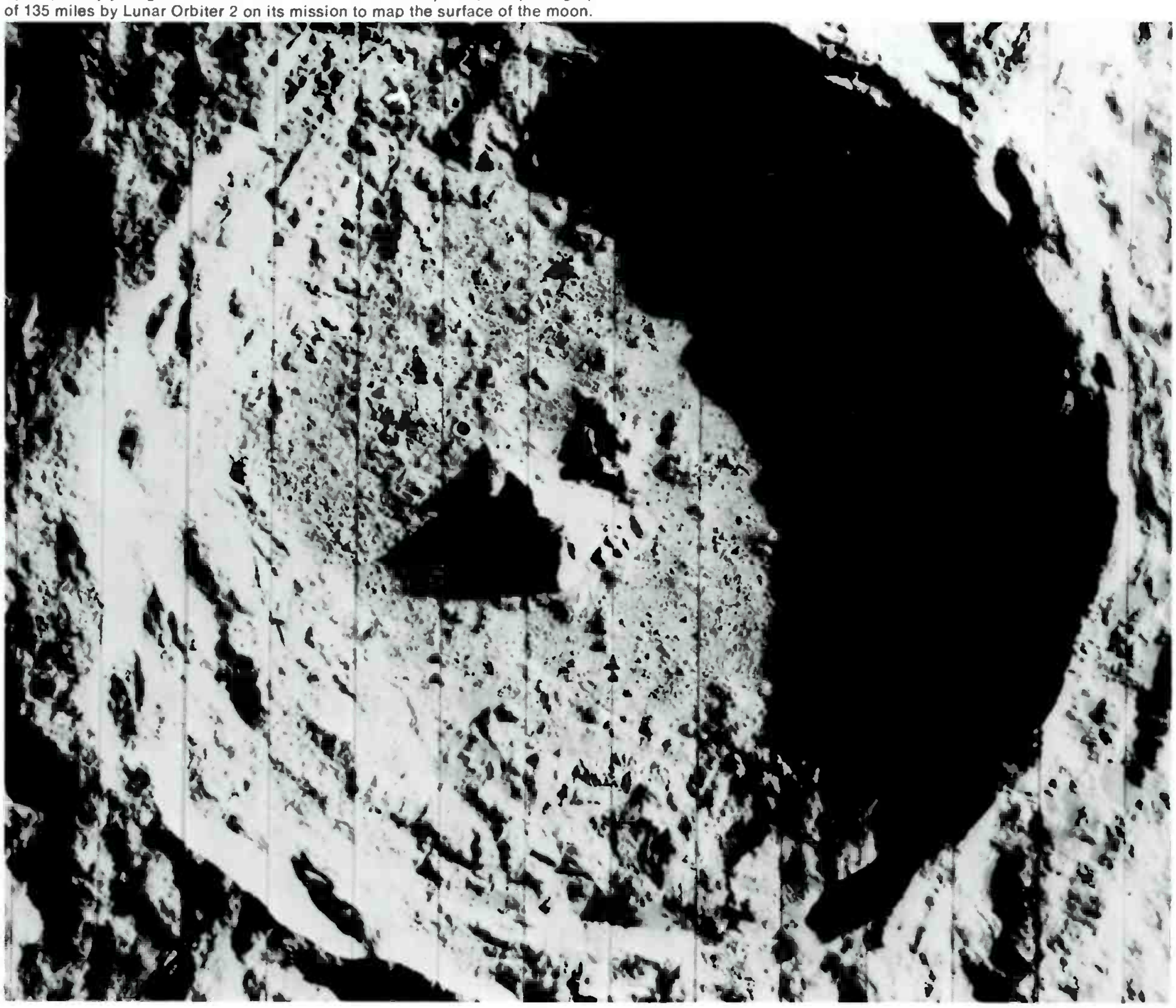
If the asteroid theory is proven, man will have a chance to study matter from a distant area of the solar system. If, as seems more likely, either of the other two explanations is true, man may find an understanding of how the earth was formed and why there are seas and continents. He may also discover the nature of natural forces that create mountains and wipe out cities. Lee Scherer, director of Apollo lunar exploration, points out that "the moon may well describe the first billion years on earth."

Most scientists are convinced that the moon is now devoid of life. However, elaborate precautions will be taken against the consequences of what one astronaut calls, "the billion-to-one shot of dangerous alien viruses or other micro-organisms infecting human beings." The entire moon landing crew will be enclosed in a van from the time of recovery after splashdown. A doctor will join the astronauts aboard the recovery ship, and the van will be flown to the Houston space center for two weeks of intensive tests.

A definitive answer as to whether the moon has ever housed life will probably have to wait until later missions when astronauts can explore the subsurface, volcanic areas or the permanently shaded areas near the lunar poles. There, life or microfossils might conceivably have been protected through the centuries from the heat and radiation of the sun — perhaps frozen in ice.

Regardless of its past history, the moon can support life with the aid of human technology. An almost closed ecological cycle on the moon may be possible, with a gradual lessening of dependence on cargoes from earth. Many scientists forecast a lunar society in which everything from the air that is breathed to the food that is eaten is based on algae — the green scum that lies on the surface of stagnant pools. Algae are made up of between 50 to 70 per cent protein with the rest carbohydrates and fats that can be converted into edible, even appetizing food products. The percentages even can be changed by adding a solution to the water in which the algae are cultivated. And because the plant grows by photosynthesis — absorbing the carbon dioxide and radiation in the air and giving off oxygen as a by-product of metabolism — it also constantly refreshes the

Tycho, a very young crater in the moon's southern hemisphere, was photographed from an altitude of 135 miles by Lunar Orbiter 2 on its mission to map the surface of the moon.



air. "We need five pounds of algae per day per man to keep him fed and breathing," one authority stated.

Other scientists believe that moon colonists can extract from the lunar rocks those elements that combine to form organic molecules, which then could be synthesized into proteins, carbohydrates and fats for human consumption. On the other hand, NASA's Schmitt is not convinced that man will need to turn to these exotic methods for obtaining food. In his view, it may be possible for moon dwellers of the future to grow foodstuffs directly in the lunar soil.

The lunar rocks also may be the source of water for future astronauts. A number of scientists believe that the moon may not be so dry as commonly believed, with water existing as minable ice under the surface. If water is not present in free form, the lunar rocks can be crushed and baked to extract the water of crystallization from them. Volcanic rocks on earth, for example, hold an average of about 1 per cent water while some magnesium silicates contain as much as 13 per cent water by weight. Even if the lunar rocks prove different from their earth counterparts and do not hold water, the vital liquid can be manufactured. A NASA-funded project has resulted in a chemical process that produces both water and oxygen from silicates and certain other rocks. The rocks are broken down into carbon monoxide and hydrogen, pumped to a chemical reactor and converted into methane and water.

During early moon missions, the Lunar Module will provide shelter as well as ferry astronauts to the surface of the moon. It is presently designed to sustain the needs of two astronauts for about 48 hours away from the CSM, carry a 300-pound scientific payload to the moon and transport 75 pounds of lunar rocks back to the CSM. However, it can be modified to serve as a semipermanent shelter, minus its ascent propulsion system. In that form, it might remain quiescent for up to two months and support two men for 14 days.

Astronauts may be able to travel from these LM shelters in land-roving, battery-powered vehicles. One such vehicle, presently on the drawing board at Grumman Aircraft, could carry 500 pounds, including astronauts, and travel 25 nautical miles on a battery charge. However, communication considerations would probably limit its range to a radius of eight miles.

With the growth of a moon colony, larger shelters would be constructed. Eventually, a giant air-inflated, air-supported plastic dome may cover an entire lunar settlement, maintaining an earth-like atmosphere of around seven pounds per square inch. This would free residents from the limitations of their own dwellings without the time-consuming job of donning a space suit.

Dr. I. M. Levitt, Director of the Fels Planetarium of The Franklin Institute in Philadelphia, has designed a mock-up of a "moon room" with plastic furnishings made from such basic elements as hydrogen, carbon, nitrogen and oxygen — all possibly obtainable on the moon. Because of the lighter lunar gravity, the furnishings would need very little weight support; the chair could be frail and the mattress on the bed very thin. The 84 per cent reduction in gravity also means that an astronaut will have to exercise continuously to avoid losing muscle tone. This exercise might consist of lifting heavy weights or attempting muscle-powered flight with plastic wings, in the manner of the mythical father-and-son team of Daedalus and Icarus. According to scientist-writer Arthur C. Clarke, this would be a possible but difficult lunar sport.

There would be few books in the "moon room" because of weight considerations, but the astronaut will be able to obtain his reading matter via microfilm monitor. There will be a limited supply of fresh water for drinking and washing, with all waste processed for recirculation or for use in agriculture. Color will be very important in the room since the astronaut will be confined to a relatively small area. Shades of blues and greens will probably dominate for psychological reasons. However, the lunar gym will be a strong orange since it is a stimulating color.

Until the time that man can create this artificial earth-like atmosphere, his space suit will remain the key to his existence on the alien world. The term "space suit" is actually a misnomer. It is three layers of suits linked with a common oxygen supply and medical wires. On Apollo moon missions, the suits are designed to permit an astronaut to exist in a vacuum for up to three hours under the extreme heat and cold that he will be subjected to on the lunar surface. He can work fairly comfortably during the lunar noon since, as one astronaut put it, "There will be yards of tubes filled with chilled water running through my long johns." The suit also contains an automatic urine disposal unit, but there is no provision for a back scratcher in case the astronaut develops an itch.

The carfare for the first trip to the moon will be more than $20 billion. But this money already has bought more than the half-million-mile round trip: it has provided the technology that has brought new worlds within the grasp of man. ■

The Burgeoning youth Market

Everything from portable radios to luxury automobiles is coming under the all-encompassing influence of youth.

by David Lachenbruch

"In our generation, you had to keep up with the Joneses. Today, it's important to keep up with the Joneses' kids. Remember, they've never lived through a depression. To them Babe Ruth is a candy bar, and World War II is ancient history. They want what they want now. And they get it."

So said David L. Yunich, President of R. H. Macy and Company, in commenting upon the economic power of youth, probably the single most important new influence in the American consumer market of the last 25 years.

Teen-agers alone, according to one estimate, wield about $50 billion annually in purchasing power and direct buying influence. The indirect influence of youth is an immeasurable figure and is becoming a dominant factor in marketing and product design in many fields, including consumer electronics.

The direct youth market is poorly defined, but, no matter how it is measured, it's a large and growing group. More than 50 per cent of the United States population today are under 27. And they are growing in number much faster than the population as a whole.

From 1960 to 1967, the total population of the United States increased by only 10.6 per cent. During the same period, the 10 to 14 age group grew by 18.6 per cent, and the 15- to 19-year-old population expanded by more than 35 per cent. Until recently, this latter group had been the fastest-growing segment of the population, but now it's the young-adult category that is increasing most rapidly. The number of Americans between the ages of 20 and 24 has soared by more than 40 per cent in the seven-year period — four times the national population growth.

By 1980, according to projections by the Metropolitan Life Insurance Company, the 18 — 19-year-old age group will increase by 22 per cent, and the 20 — 21 bracket by 29 per cent, to about 8.5 million each. But the 22- to 24-year-old segment will rise another 45 per cent to total more than 12.5 million. This latter group is the one that supplies the initial demand for major consumer durable products.

Teen-age America constitutes an important segment of the consumer electronics buying market. These 13- to 19-year-olds seem to come with transistor radio and phonograph as standard equipment. Although they have a seemingly minuscule average annual income — estimated at somewhat more than $600, largely from allowances and part-time jobs — teen-agers have a spending power of some $15-$21 billion a year. But it's a unique type of spending power. Since the vast majority of these youngsters are not breadwinners, nearly all of their expenditures are for personal pleasure. The items they buy — particularly in the entertainment field — may be considered luxuries by adults, but nonetheless are necessities to the teen tribe.

One survey found that entertainment in all its aspects, from movies to records to transistor radios, was the number one category of purchases made by 16- to 19-year-old boys, and second only to clothes and cosmetics for girls of the same age group. Another study showed that 91 per cent of all teen-agers own radios, 48 per cent have phonographs, and 25 per cent television sets.

But direct purchases are only a part of the story. On top of their own buying power, teens exert a powerful influence in determining what the family buys. In fact, some market researchers call them a major contributing factor behind $30 billion in purchases by older members of their households. Other market studies say teen-agers influence the spending of at least four times the amount they spend themselves. Even using the more conservative estimates, they make and influence roughly 15 per cent of the total U.S. expenditures for goods and services.

Although many college students are teen-agers, they fall into their own special category since they are tomorrow's opinion leaders — and biggest spenders. Today, almost 7-million students are enrolled in the nation's colleges, including some 40 per cent of all 18- to 21-year-olds. The college student has more money to spend than the average youth of his age group, with one out of every three having $950 or more a year in pocket money, according to one researcher.

Young marrieds also are an increasingly important part of the youth market. From 1960 to 1966, the number of families headed by persons under 25 has grown by 44 per cent. More than one-half of the 22- to 24-year-old male population are married — as are 23 per cent of the 18 — 19-year-old women and 74 per cent of the 22- to 24-year-old women. Four of every 10 brides are teen-agers, and more wives have their first baby in their nineteenth year than at any other age.

At the other end of this youth market is the pre-teen group, which influences the purchase of a variety of products ranging from breakfast food to toys. Today, a well-equipped grade-school youngster probably has a phonograph and at least one radio, and quite possibly a portable tape recorder. And since some 6-million kids under 12 go to summer camp, there's no reliable estimate of how many

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David Lachenbruch is Editorial Director of *Television Digest*.

rectangle of yesteryear, it has burst into color and novel shapes. Today's portable radios look like cameras, compacts, hatboxes and travel clocks. Some are built for very special purposes, such as the water-tight set that floats, for use as a boating or swimming companion. For example, RCA makes the "pockette" radio for the youth market, featuring brightly colored, interchangeable carrying straps to match an outfit or a mood.

Radios-on-the-move must be made for hard knocks as well as good looks. For the beach, they must be sandproof and moisture-resistant. For the ski weekend, they must withstand the cold and must play even if dropped in the snow. Partly as a result of these many special-purpose designs, demand has skyrocketed. The number of radios sold in the United States in the last two years exceeds the total number of households in America by a sizable margin.

Once a relatively stationary piece of equipment, the phonograph also has been moving outdoors. Nearly 5-million portable phonographs were purchased in the United States last year — mostly by young people. And an increasingly greater percentage of phonographs sold each year are battery-operated and/or equipped with built-in radios.

Black-and-white TV, once strictly an immobile instrument in a wood-colored cabinet, is now feeling the liberating influence of youth. Here, too, portability is becoming a significant factor, although only a relatively small percentage currently are of the battery-operated, play-anywhere type. Sets with mini-screen sizes are growing in popularity for personal use by youngsters. More than 34 per cent of all monochrome portables sold last year had screens 12 inches or less in viewable diagonal measurement. The mass movement of television into youngsters' rooms is documented by the latest nationwide American Research Bureau survey made last November, which indicated that nearly 21-million households, or 36 per cent of all television homes, had two or more sets.

Sales of another youth-oriented product category — portable tape players and recorders — are now reaching boom proportions. Total tape instrument sales last year hit an all-time high of some 8-million units, largely as the result of the popularity of lightweight battery-powered, cartridge-loaded systems. Playback-only Stereo 8 players are available in home, auto and portable formats and satisfy that almost endless need for a stream of music in the background or foreground. Portable cassette recorders are becoming near necessities for many school courses — and they're used for recording amateur groups, too.

Designing for the youth market has more than its share of perils. This is a fast-moving crowd, which is quick to adopt fads and even quicker to drop them. Since about 20 months of lead time are usually required from conception to marketing of a consumer electronic product, the risks are high, particularly if an effort is made to capitalize on instant crazes. The best answer so far is the avoidance of design that is so far out it may never come back in.

For all their unpredictability, today's young people are individuals and, being better informed and better educated than any similar generation in history, they appreciate design with good taste. Although they like lighthearted and even whimsical product design, it must serve a credible purpose. Anyone want to buy a warehouse full of hula hoops with built-in radios?

Youth influence now extends far beyond the under-30 group. It permeates throughout today's mode of living and reaches well into the older minority (now only 47 per cent of the population) that still controls the major part of the nation's purse strings. As a result, youth power has dictated a marked new emphasis in product marketing and advertising aimed not at today's under-30s but at their elders and geared not to the youth market but to the youthful market.

It's a fact of family life that young people imitate their elders. But on a collective basis, the 30-and-over minority today is following the youngsters, albeit at a safe distance. The mother, who three years ago forbade her daughter to go out on the streets with a skirt three inches above the knees, is now wearing one herself and bracing herself for a personal policy decision on bell-bottom trousers. The father, who once forced his son to get a haircut, is now wearing his own hair just a little on the longish side, and his sideburns inexorably are creeping downward in the direction of his turtleneck collar. Although statistics prove that people live longer with each succeeding generation, there seem to be fewer gray-haired ladies around than there were just a few years ago. And hair-weaving and -dyeing for men are becoming important industries.

In terms of sheer numbers, the balance of power is swinging toward youth — while the balance of buying power continues to rest with the 30-and-over senior citizens. But youth has become the touchstone for all ages. Much of the nation's advertising is aimed at "those who think young"— not necessarily those who are young.

When they first came on the scene, the Beatles were considered just a lot of "kid noises." Now, upon careful analysis, their music is found to represent the beginning of a new art form. Adults no longer wince when rock-and-roll music accompanies a TV commercial for such an over-30 product as a medium-priced automobile.

Although young folks do own cars, fully 86 per cent of all auto purchases by the relatively affluent college student group were for used vehicles. Yet, the sporty cars such as Mustang, Barracuda, Camaro and Cougar have made big inroads into the respectable middle-age domain of the gray sedan.

Regardless of age, youth power affects the entire population in terms of attitudes, tastes and purchases. Even home furnishings design, the last stronghold of the traditionalist, is becoming less austere. Bright colors first made inroads into the kitchen, then came into the living room in the form of the increasingly popular painted wood finishes.

The think-young feeling of today is affecting consumer electronics design for the youth-influenced as well as for youth. Although table-model television sets have largely been confined to dignified wood-finished boxes, with an occasional excursion into shocking beige or bravado black, the trend may now be turning to fuchsia, avocado and even bright red.

Traditional design continues to dominate in stereo consoles, but there is a growing consumer choice of components laid out in the open, in simple cubes, with no attempt made to hide the instrumented look of dials and knobs. In the future, these components — or entire consoles, for that matter — may be enclosed in brightly colored laminated plastic housings.

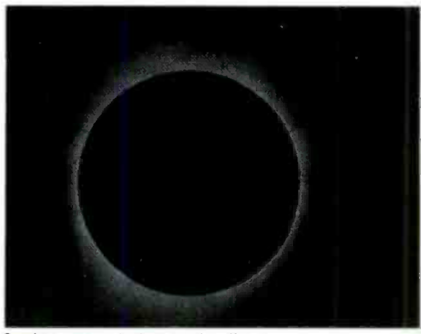
Increased use of color is the first evidence of new youth orientation in higher priced products. But it now seems that the direction is toward more unusual design and a further break with tradition.

The youngest major industry, electronics, is growing even younger — along with the rest of the world. ■

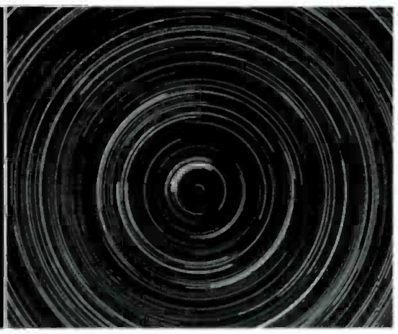
The New Age of Astronomy

Modern-day electronics has given man advanced tools to probe the mysteries of the heavens.

by Edward McIntyre

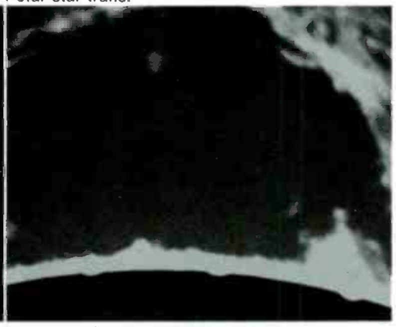

Sun's corona during total eclipse.


Head of Brook's Comet.


Polar star trails.


Great Galaxy in Andromeda.

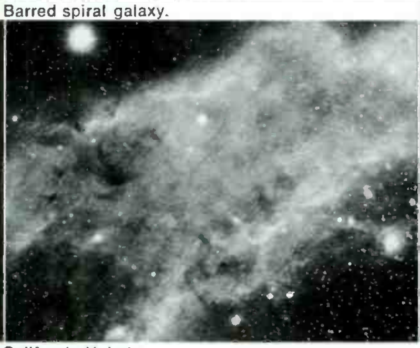

Barred spiral galaxy.

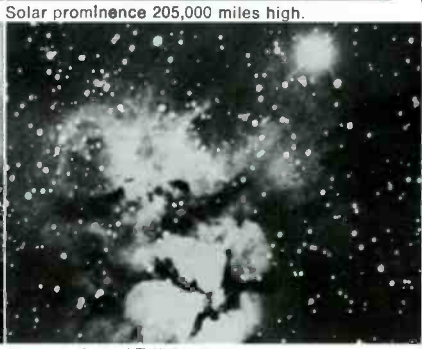

Solar prominence 205,000 miles high.

Significant and often profound discoveries made with electronic instruments have brought a new age of astronomy — one in which scientists are finding the universe to be stranger, yet far richer in pattern, than they previously suspected.

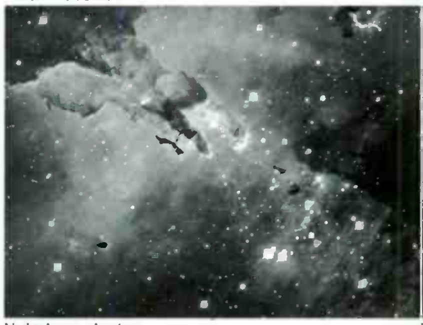
In 1962, for example, American astronomers launched a rocket, with X-ray sensing equipment aboard, to study the relatively weak rays known to emanate from the sun and, in particular, to find out whether or not they rebound off the


Trifid Nebula.

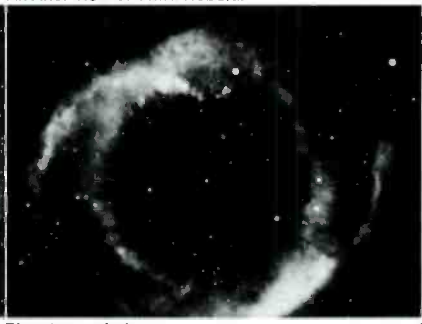

California Nebula.

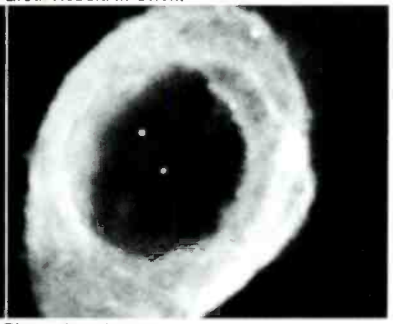

Another view of Trifid Nebula.

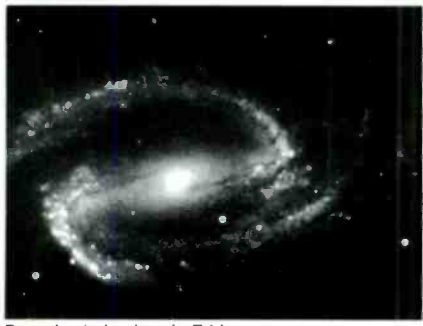

Great Nebula in Orion.

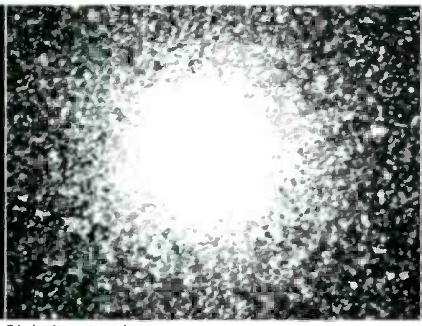

Nebulous cluster.

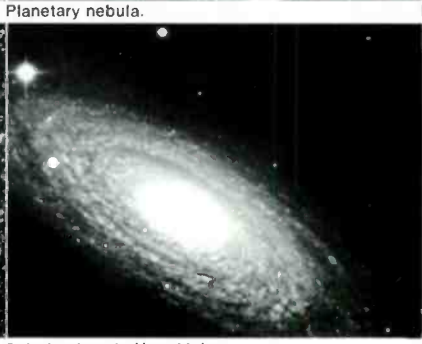

Pleiades star cluster.


Planetary nebula.


Ring nebula in Lyra.


Barred spiral galaxy in Eridanus.


Globular star cluster.

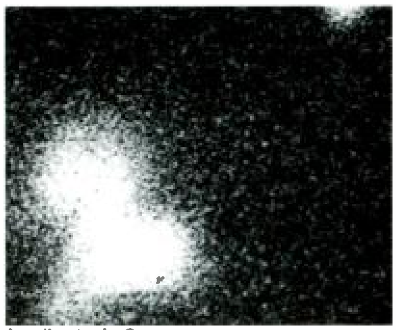

Spiral galaxy in Ursa Major.


Dumbbell nebula.

"Radio astronomers even now may be witnessing the birth of planets in a newly evolving solar system somewhere in space."

moon. (X-rays from space can't be studied at the earth's surface since the atmosphere blocks them out.) To the total surprise of the experimenters, instrument readings radioed back to earth reported a stream of X-rays coming from a distant point in space, a million times stronger than anything that could have been anticipated. It was a little like going out in the back yard to check on a leaking lawn sprinkler and finding a stream of water arching in from blocks away.

Later studies revealed the source of



A radio star in Cygnus.

these rays to be a star in the constellation Scorpio. This was the first discovery of an X-ray star — one that puts out a major part of its energy in the form of X-rays rather than light. Since that time, about 30 such stars have been found. Yet, before this unexpected discovery, no one knew or even suspected that these phenomena existed.

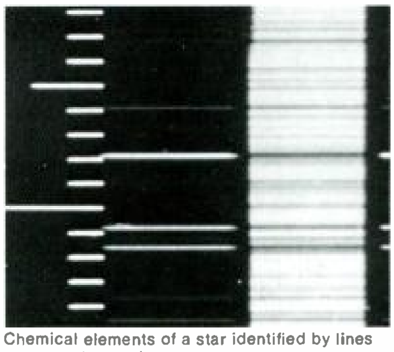
In another case, a year later, measurements at the Mount Palomar Observatory indicated that a celestial body, several billions of light-years distant, was emitting rather strong radio waves. In order to

Crab Nebula in Taurus.

reach the earth with such powerful signals, the object would have to be a titanically powerful "broadcaster," millions or even billions of times as strong as anything that the astronomers could then account for.

Two years ago, startled astronomers at Cambridge University brought in radio signals from space in the form of fantastically regular pulses — far more precise in their timing than any ordinary clock. Since that time, a careful search on the same wavelength band has turned up about a score of these pulsars. It seemed that, for a time, man was at last tuning in on a beacon or signal from intelligent beings separated from earth by two light-years of space. However, earlier this year, scientists visually identified a pulsar on an astronomical photograph. This optically strong pulsar is in the famous Crab Nebula — which is the remains of a supernova, or colossal star explosion — seen on the earth in 1024. The light from the pulsar goes up and down at the same rate as its radio signals, and both are slowing, just perceptibly.

These observations tie in with the current theory of the nature of pulsars. Astronomers now believe they are natural objects — rather than intelligence-generated phenomena. Described as neutron stars, pulsars are the unbelievably dense cores of large stars that collapsed after a supernova. All the atoms in a pulsar are packed together so tightly that a



Chemical elements of a star identified by lines on a spectrograph.

matchbook would weigh millions of tons. The pulsing of its light and radio waves comes from the extremely rapid rotation of the star. The gravity and magnetic field of a neutron star must be billions of times as strong as anything scientists have dealt with before, creating a new and fascinating kind of physics.

All of these discoveries were made with new astronomical tools based on electronics. From the seventeenth century to the early twentieth, the optical telescope had been man's only means to study the universe. Now, radio, X-ray, infrared and ultraviolet telescopes have added new dimensions to the science of astronomy. They "see" many of the objects and events that are invisible to the optical telescope. Light is just a very thin slice of the electromagnetic energy emitted by objects in space. Yet, these space waves — broadcast by stars, nebulae, galaxies and interstellar particles — are the only source of knowledge of the universe beyond the solar system. They cover a vast range of wavelengths, from radio waves measured in centimeters and meters to X-rays and gamma rays, whose waves are only as long as a billionth or a trillionth of a centimeter.

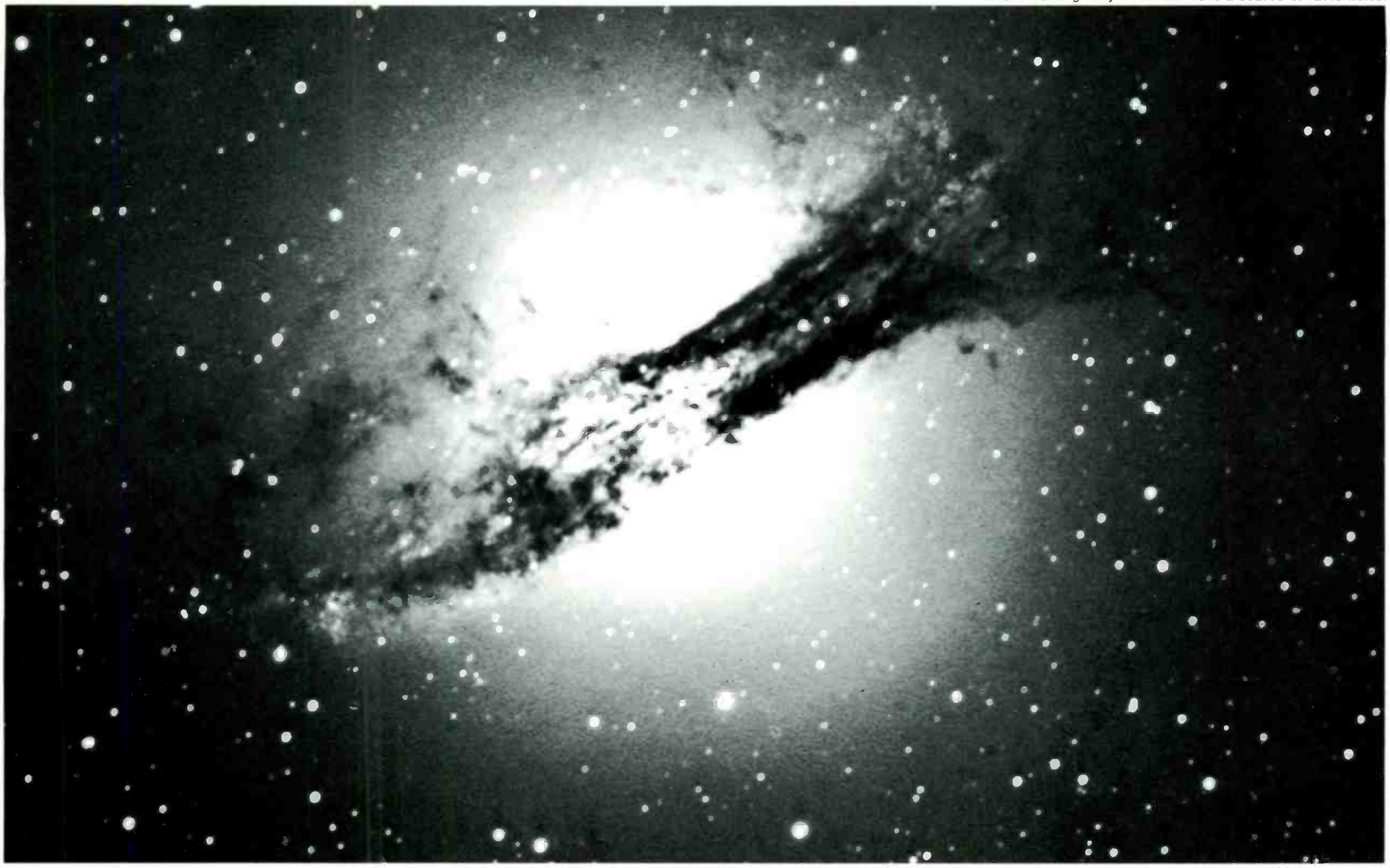
Each range of waves requires a different kind of primary sensing instrument to detect it. The radio telescope is simply an ultrasensitive radio receiver. For the infrared instrument, astronomers use a phototube or phototransistor, or other electronic device that puts out electric signals when infrared waves fall on it. Similar electronic sensors are used for the ultraviolet, while X-ray telescopes are based on Geiger counters, electrometers or other electronic devices sensitive to the penetrating, very short waves. However, radio telescopes, the oldest of the new astronomical instruments, are still the principal ones.

Central in a radio telescope is the radio receiver, which must have the lowest possible internal noise to minimize interference with the faint radio signals from space. Many complex radio-reception techniques are employed, including the use of masers, the radio counterparts of lasers. The overriding objective is to get the highest possible ratio of signal to noise.

But the great antennas of the radio telescopes are probably their trademark to most laymen. These enormous, steer-

Edward McIntyre is a freelance writer whose articles have appeared in various magazines.

This unusual galaxy in Centaurus is a source of radio noise.



able dishes—bowl-shaped reflectors that can be pointed toward any part of the sky — serve to focus into the receiver a large amount of the incoming energy, which is weak at best. The focusing property of the antenna also allows the astronomer to pinpoint the direction of the signals. They will be at maximum intensity when the antenna axis is pointed directly toward them. The larger the dish the more energy it brings in, and the more precise its direction-finding.

But building a steerable dish larger than about 300 feet across — the size of the largest now operating in the United States — is enormously expensive and difficult. Like the curve of an optical telescope mirror, the curve of the radio telescope dish must preserve its shape to focus at optimal sharpness. Keeping such a great mass of moving metal adequately rigid as it shifts from one orientation to another has seemed so difficult that larger steerable dishes as yet have not been built. (Plans for a 600-foot dish to be built by the U.S. government apparently have been shelved because of the enormous cost.)

So, radio astronomers have used other antenna arrangements to get a maximum of energy pick-up and directivity. At Arecibo, Puerto Rico, the United States has built a reflector 1,000 feet in diameter in a bowl-shaped valley. This stationary reflector is beamed in different directions, activating the receiver when the rotation of the earth has brought the beam of the telescope in line with the object to be studied.

For the early pulsar studies, Cambridge astronomers used an array of more than 2,000 interconnected small antennas spread over several acres. This, too, was steered electronically and by the rotation of the earth.

Even more spectacular are several systems using widely spaced antennas and the interferometer principle: signals picked up at two or more separate points are combined and compared in various ways to increase sensitivity and provide more precise direction-finding.

Very recently, radio astronomers used this technique of separated antennas to study radio signals from the clouds of oxygen-hydrogen (OH) molecules in space. Atomic theory specifies that these molecules should put out radio waves at certain particular wavelengths. A radio-telescope search of the sky, with the receiver set for those wavelengths, finally brought in astonishingly strong signals. But when the astronomers tried to pinpoint the sources, they found their radio telescopes did not have enough resolution. It was a little like probing for the location of a pin hole with a broomstick.

So, they turned to long-base interferometry, with radio telescopes separated at first by a few miles, then by hundreds of miles and finally by continents. They employed one telescope in California, two in the eastern United States and one in Scandinavia. This allowed them to define clearly the directions, and thus the widths, of a number of sources of the OH signals, which were tiny on the cosmic scale, extending only a few hundredths of a second of arc in the telescope beam.

Direction-finding was accomplished by comparing precisely the time of the arrival of the signals at the California telescope, say, with the arrival of the same signals in Sweden. The technique has a biological counterpart. Human beings are aware of the direction from which a sound is coming, in large part, by comparing the time it arrives at one ear with the time it arrives at the other. A sound to the right arrives at the right ear first. Man's intuitive timing system is good enough to tell how much to the right the sound is, down to a minute or two of arc.

Radio astronomers can use this technique because electronic recording systems, combined with one of the ultraprecise atomic "clocks," tell them, to fractions of one-millionth of a second, when a signal arrived at each antenna. By comparing the recording made in California with the one made in Sweden, they can determine the direction of the signal with the desired precision.

Recording and timing, carried out with precision down to billionth-of-a-second levels, are essential to a great many other astronomical studies. The exquisitely exact timing of pulsar pulses would not have been apparent without the precise electronic standards of the atomic clock.

Radio astronomers at Maryland Point, Md., even now may be witnessing the birth of planets in a newly evolving solar system somewhere in space. They have detected radio emissions from what seem to be rings of dust and gas circling around a central object. It is believed that this object may be a fledgling star and that the rings may be condensing into its planets.

Both radio and infrared studies are important tools for exploring the very nature of the universe. Astronomers always had been balked in their attempts to see the center of the Milky Way — the galaxy of which the earth is a part — because thick clouds of interstellar dust let through very little light. But radio and infrared wavelengths reaching earth have been monitored, and they indicate that the center is very thickly populated with stars. Events of extremely high energy are taking place there, as they are in the centers of many of the other galaxies visible in other parts of the universe.

A special telescope was built three years ago to allow California Institute of Technology astronomers to make an infrared map of the sky — to locate all the stars that put out infrared energy above a certain strength. They designed an instrument with a large reflecting mirror and infrared sensing equipment at its focus. This first infrared telescope scanned the sky automatically, driven by motors that moved it back and forth in a regular pattern while a continuous recording was made. One problem in such a scanning search for infrared sources is the ever-present background of infrared radiation that comes from nearly every object on the earth and from widespread sources. It tends to obscure the faint infrared beams from the stars.

The astronomers managed to segregate the signals from the stars by giving their telescope a slight, 20-times-per-second wobble, in addition to its slow scanning motion. Whenever an infrared star passed into focus, the telescope responded with a tiny, 20-cycles-per-second signal. The background infrared, being nearly continuous in strength, produced a much more slowly varying, virtually direct-current signal.

By rejecting the background signals, the astronomers produced a map of the "infrared sky" showing about 6,000 stars, roughly equal to the number of stars seen on a clear night with the naked eye.

These primary instruments, including the optical telescope, are backed up by a sophisticated array of secondary electronic instrumentation that defines and refines space signals. Computers, for example, dig signals out of masses of noise that would totally obscure them for ordinary analysis.

Basic to the new astronomy are the devices that reveal the wavelength, make-up and intensity of signals from space. These are the keys to the identification of the chemical make-up, temperature and other vital facts of celestial bodies beyond the solar system. An ordinary prism crudely breaks a beam of light into its constituent colors (wavelength). A spectrophotometer system, on the other hand, brings extremely high resolution to the analysis of light and measures strength at each wavelength. Each chemical element, raised to incandescence by the heat of a star, emits its own pattern of wavelengths — its thumbprint in light. The spectrophotometer lets the astronomer see those thumbprints.

Space probes and orbiting satellites are also beginning to find important roles in astronomy. The Orbiting Astronomical Observatory (OAO), launched earlier this year, is radioing back large quantities of data on the ultraviolet radiation from many stars. The OAO carries various kinds of telescopes, all of which can be aimed remotely at stellar targets from earth. The primary value of the OAO is that it is situated above the atmosphere, which ordinarily blocks out or disturbs almost all signals from space.

Radio-wave sensing equipment aboard the Mariner Venus space probe revised many theories concerning earth's nearest planetary neighbor. For example, there had been uncertainty about the temperature near the surface of Venus, with many scientists believing that it was cool enough to support life as it exists on earth. Optical telescopes had been unable to pierce the thick clouds in the Venusian atmosphere. However, analysis of radio signals monitored aboard the Mariner revealed oven-like temperatures of 500° F.

And on the more recent Mars probe, an infrared study was made to detect water on the red planet. Careful analysis indicated that all the water on Mars could be placed in a one-cubic-mile lake.

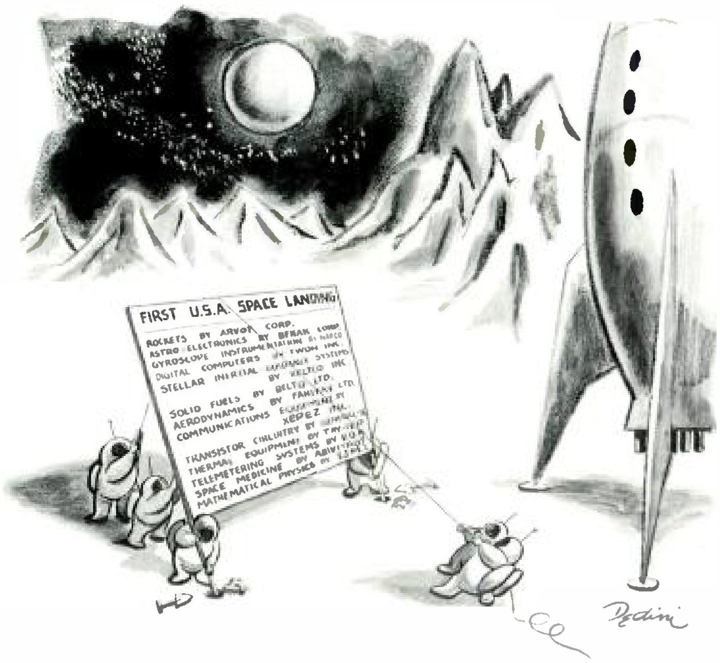
Radar is also proving valuable at solar system distances since it takes only 17 minutes to reach the sun and echo back. By bounding signals off the planet Mercury, astronomers have corrected a long-standing error. Photography and the optical telescope had suggested that the planet turns on its axis approximately once every 88 days. Radar echoes now make it certain that its rotation period is actually about 59 days.

The surface make-up of the inner planets has been determined to some extent by radar. Studies have indicated that the surface of Mercury is rough and crater-marked, like the moon, while radar reflections from Venus point to a surface covered with silicon-composition rocks.

One of the most important determinations made possible by solar-system radar was a more precise figure for the mean distance from the earth to the sun. Many important calculations depend on this mileage, including the navigation of both manned and unmanned space vehicles. Radar measurements have proven that the earth-sun distance is about 92,944,000 miles. Before, astronomers figured that it was close to 93-million miles but were uncertain about the exact figure.

The scientific study of the heavens that began with Galileo's crude telescope in the seventeenth century is now undergoing tremendous upheavals and enrichment. The application of electronics to astronomy has produced a decade of enormous accomplishments and holds even greater promise for the future. ■

This Electronic Age...



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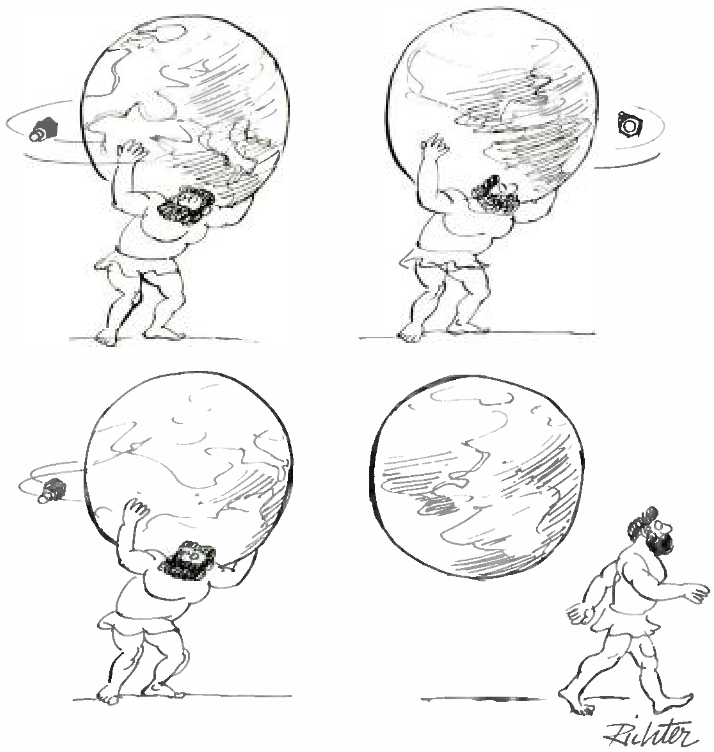
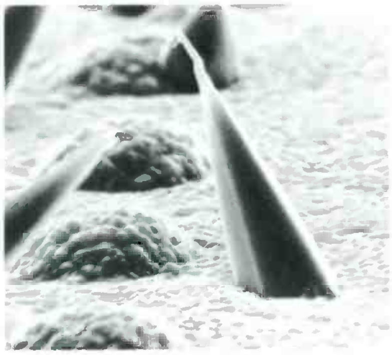


The World of Electronic Surfaces

Modern technology is based to a large extent on the surface action of electrons.

by Bruce Shore



Electronics, like beauty, is largely skin deep. Electron tubes, transistors, wave guides for carrying microwave signals, office copying machines, scanning electron microscopes and TV cameras and receivers are end results of electronic surface phenomena. All are based on the behavior of electrons at, near or on a solid surface, or at an interface, where two surfaces or states of matter merge.

In recent years, electronics scientists have been investigating several new species of surface phenomena. Among these are surface superconductivity, sound waves, light emission and the electronic properties of such atomic structures as surface states and interface states.

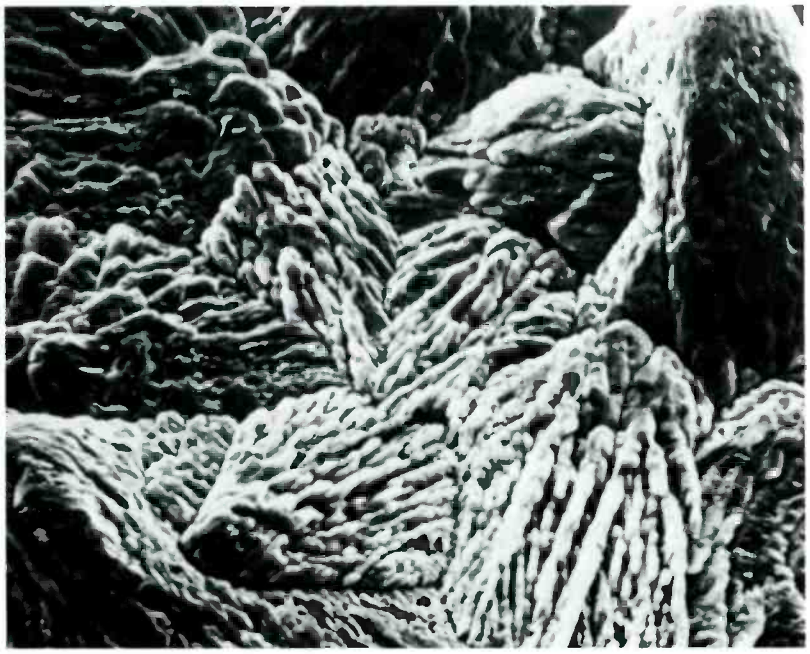
From these studies eventually may come longer-lasting electronic tubes that operate without heat (like transistors) and smaller and more rugged microwave circuits that process radar and TV signals by converting them to high-frequency sound waves. They also may result in materials that are superconductive at room temperatures — lose all resistance to the flow of electric power — and make possible cable that will carry electric power over long distances without loss. Surface research also may lead to integrated circuits whose functional complexity, per unit of area, one day may rival that of the human brain.

Such studies have already produced the insulated gate field-effect transistor, which is the solid-state counterpart of the electron tube, and a radically improved light detector. This RCA photomultiplier could greatly aid studies in the nuclear, astronomical and biological sciences, including revolutionizing efforts to map the structure of the DNA molecule.

A new kind of electron tube, which can store TV images for hours even with the power off, is another by-product of these studies. The tube could form the basis for a new type of electronic data processing memory or a long-term display device. Surface studies may also lead to the most compact general-purpose computer ever built.

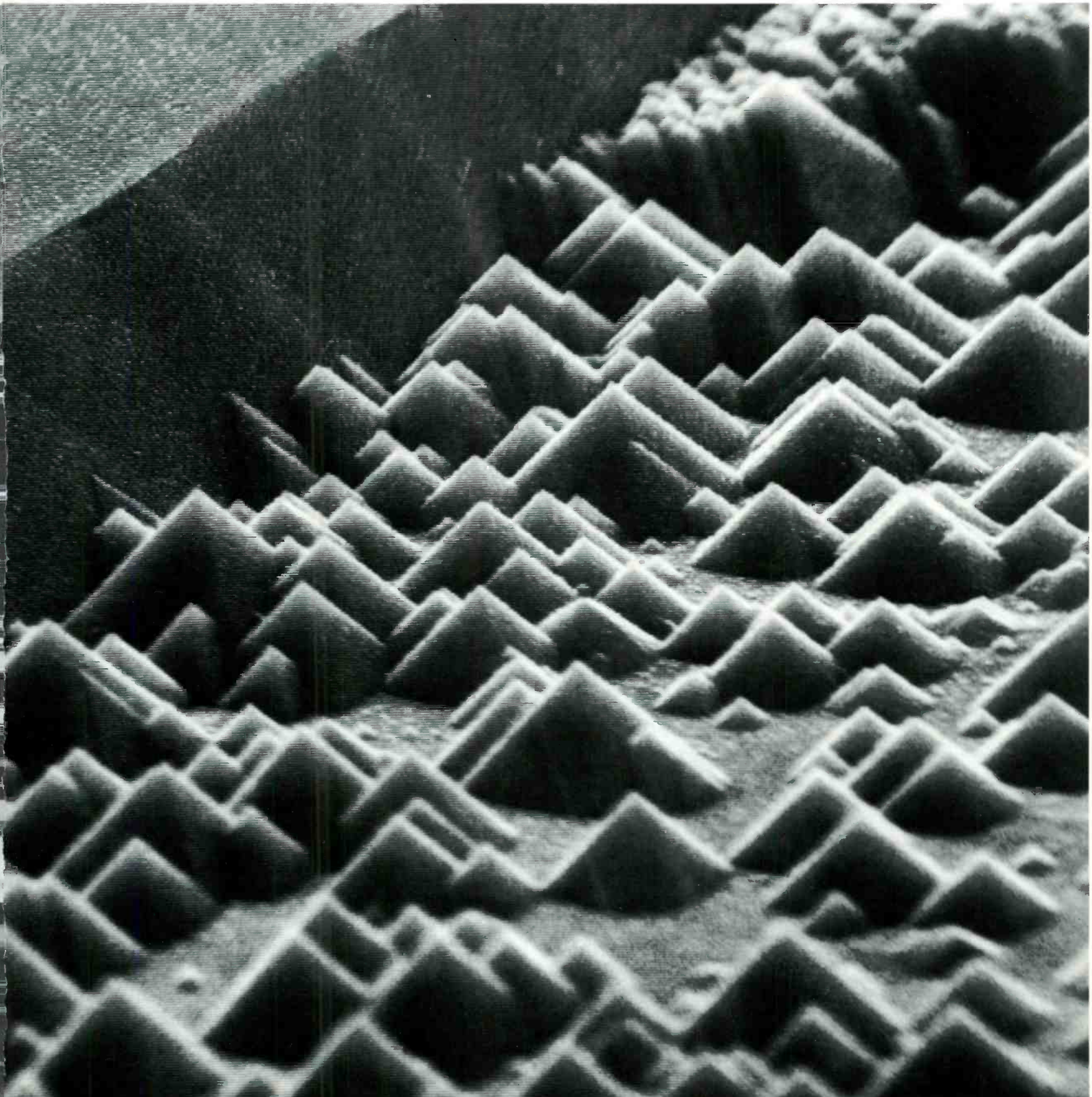
The surface nature of useful electronic phenomena was first revealed 240 years ago in London. Stephen Grey conducted an experiment that showed that two oak blocks of identical size, one solid and one hollow, stored the same amount of static electricity. Obviously, he reasoned, the interior of the solid block played no part in the storage.

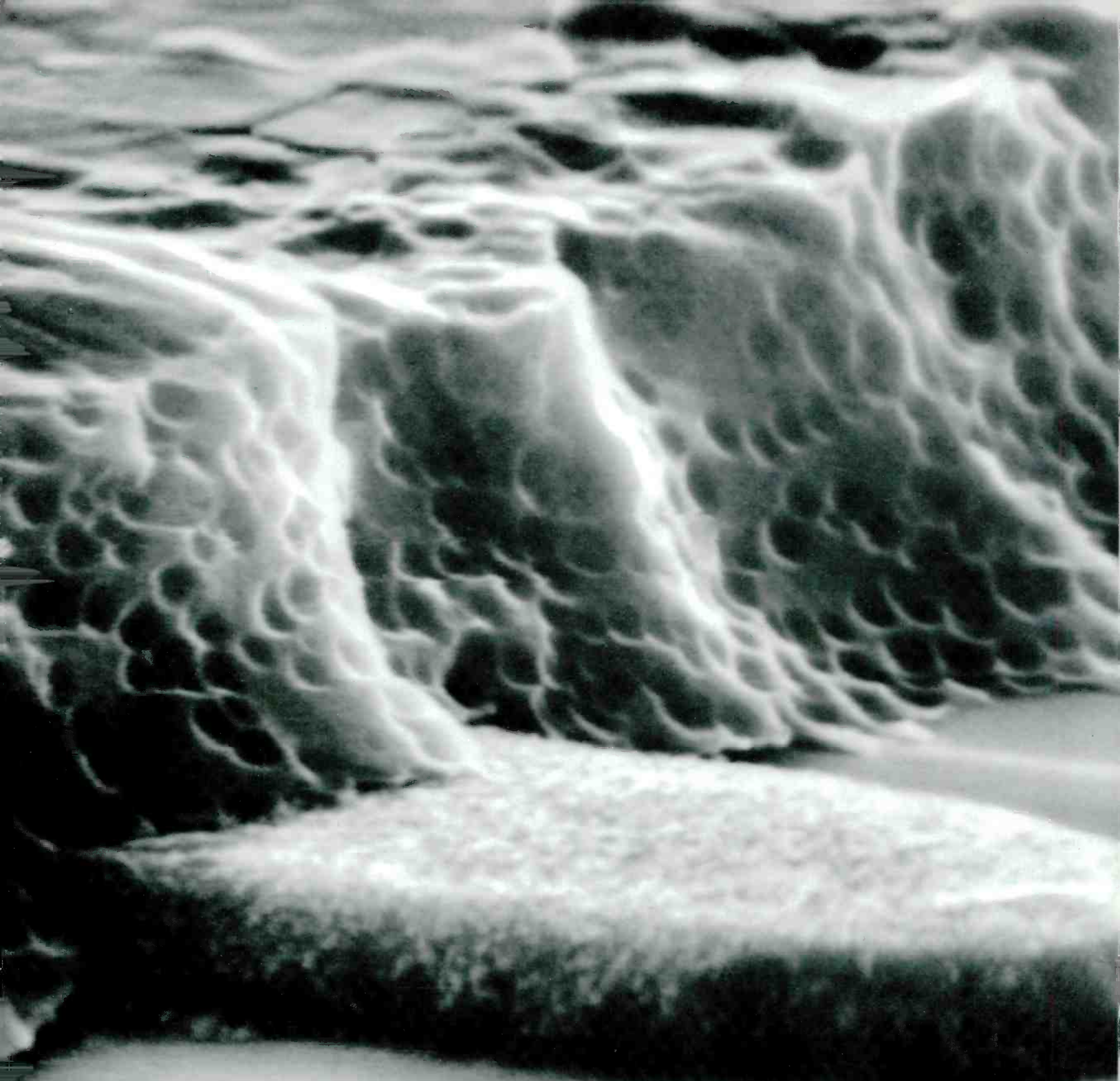
Another manifestation was seen in 1777 by the German scientist Georg Lichtenberg, when he accidentally discovered that dust collected in beautiful sunburst patterns on the surface of resin cakes that had been subjected to strong electrical discharges. Out of such an apparently trivial observation have come the electrostatic dust precipitator and the

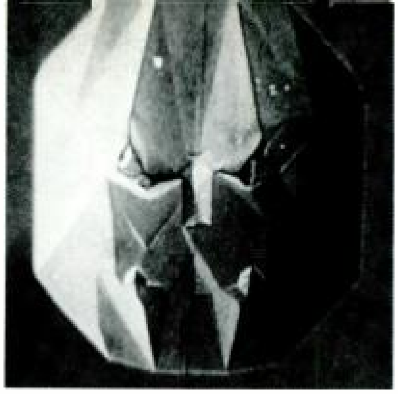


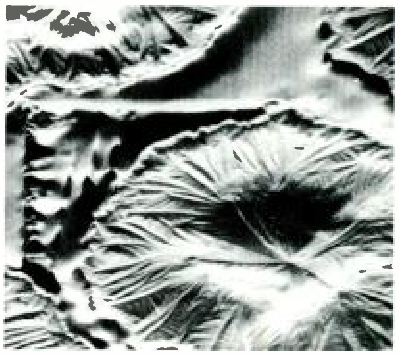
Electronically active surfaces seen through a scanning electron microscope: top, spontaneous growth of germanium whiskers, magnified 6,000 times; left, pressed zinc oxide powder magnified 3,500 times; right, crystals of silicon—magnified 8,000 times—grown on a sapphire surface.

Bruce Shore is on the RCA Public Affairs staff.









multimillion-dollar electrostatic copying industry.

The importance of surfaces was again confirmed in 1836 by the studies of Jöns Jacob Berzelius, in which he found that many chemical reactions take place only in the presence of a material that acts as a matchmaker. It promotes the reaction but does not participate in it. The Swedish chemist called the phenomenon catalysis. In addition, he discovered that often only the surface of the catalyst is involved in producing the reaction.

It is just such a surface catalysis that is exploited in the cracking towers of the petrochemical industry to extract gasoline, kerosene, ammonia and nitrates for explosives and fertilizers from crude oil. Berzelius could not know it, at the time, but catalysis has turned out to be an electronic phenomenon as, indeed, is all chemistry.

Surfaces also figured prominently in the thinking of Lord Rayleigh, the British pioneer in acoustical theory. In a major work published in 1877, he postulated the existence of sound waves that travel only on the surfaces of materials. These Rayleigh waves may be compared to the waves that travel on the surface of the ocean as distinct from those that travel through its bulk. Both waves are essentially acoustical since they represent the successive displacement and recoil of atoms or molecules in an elastic medium. However, they become differentiated owing to the fact that the medium changes spectacularly from a three-dimensional form, in the bulk, to a two-dimensional form at the surface.

Such sound waves can have very high frequencies — comparable to those of microwaves in the electromagnetic spectrum — though they propagate 100,000 times more slowly than the latter. Interest in Rayleigh waves was revived about three years ago, when it was learned that, like microwaves, they can be generated, guided, amplified and otherwise processed on the surfaces of various materials. As a result, several electronics laboratories are attempting to develop a new breed of integrated circuitry that will convert microwaves to their Rayleigh wave equivalents for subsequent manipulation in communications, radar and other high-frequency equipment. Such circuits would be more rugged, reliable and compact than anything yet achieved in the microwave field.

The exact nature and structure of solid surfaces, especially those of metals, became a matter of obsessive interest following the discoveries of Thomas Edison, Heinrich Hertz, Louis Austin and Hermann Starke at the turn of the century.

In the course of his efforts to develop an electric light bulb, Edison discovered that an electric current will flow between two unconnected wires in a vacuum, providing they are linked to an outside electrical source that causes one of them to get hot. The phenomenon was called the Edison effect for a time, but now is referred to as thermionic emission.

Hertz added to the confusion by finding that certain metal surfaces give off weak electric currents when irradiated with selected frequencies of light. This effect is called photoemission.

Finally, in 1902 — four years after the discovery of the electron by Joseph Thomson in England — Austin and Starke discovered the phenomenon of secondary

Above: Silicon—magnified 37,600 times—is etched to show honeycombed metal contact, tongue-like active area and supporting surface.
Top right: Defects on a crystal of gallium arsenide give the material a mask-like appearance when magnified 1,720 times.
Bottom right: Crystallized surface of selenium, magnified 1,720 times.

"Surface research may lead to integrated circuits whose functional complexity, per unit of area, may rival that of the human brain."

emission. They found that high-energy electrons bombarding the surfaces of certain metals cause them to eject more electrons than they absorb.

Electrical engineers rushed to exploit these strange phenomena and, in the course of the next 40 years, harnessed them to produce the vacuum tube triode and radio, the image orthicon and television, and the scanning electron microscope. As they did so, theoretical physicists throughout the world grappled with the basic question of why some surfaces emit electrons while others do not.

In 1903, Owen Richardson observed that the mathematical formula used to describe the emission of electrons from the surface of a material had a certain constant associated with it. He concluded that this constant must represent the amount of energy required by free electrons at the surface of a material to work their way off into space or into another material. Richardson called this escape energy the work function and noted that it would differ depending on the material.

Other scientists learned that certain man-made compounds of high and low work-function materials often had lower work functions than their separate constituents. It was the synthesis of such new compounds that led Dr. Alfred Sommer, of RCA, to develop a series of the world's most efficient photoemitters in the late 1930s, and Doctors Ralph Simon and Brown Williams, more recently, to build today's most efficient secondary emitter.

Still, work function was a descriptive term, not an explanation. What gave rise to it? The question could not be answered until something more definitive could be learned about the topography — the atomic landscape — of solid surfaces.

The first significant step in that direction was made in 1927 when Clinton Davisson and Lester Germer, of Bell Telephone Laboratories, performed their historic study of single-crystal nickel. They directed a beam of low-energy electrons against the crystal whose atoms diffracted the beam onto photographic film. The fact that it was diffracted (behaved like a light-beam) instead of scattered proved unexpectedly that electrons have the properties both of particles and of waves. Almost as surprising was the fact that the diffraction patterns registered on the film from deep within the crystal were strikingly different from those produced by the crystal surface. Obviously, there was a profound structural difference between the two.

Though unaware of this work at the time, Igor Tamm, in Russia, was also curious about the structure of single-crystal surfaces and, in 1932, applied the new mathematics of quantum mechanics to the problem. He quickly concluded that the electrical properties of crystalline surfaces also must be quite different from those of their interiors, largely because of something he called surface states — tiny architectural aberrations that develop as the surface is formed.

From these and other more recent studies has come an understanding of those differences. It appears that the electrical forces or "bonds" that hold crystal atoms together are perfectly balanced in the crystal interior but are unbalanced at its surface. This is because the surface atoms, having no atoms above them, are left with "dangling" electrons. These charges can be neutralized only by capturing vagrant charges in the surrounding environment or by rearranging themselves in a cooperative effort to reduce their exposed charges to a minimum. In doing so, however, the surface atoms are forced to break the electrical and architectural symmetry established by the interior atoms. The result is that they produce surface states—sites to which free electrons or other charged particles are attracted and by which they are trapped. It has even been determined that there are two types of surface states — slow and fast — depending on how long they can keep a charge trapped.

This theory won general acceptance as a result of work by John Bardeen of Bell Telephone Laboratories. He proposed that, in the case where a metal point is put in contact with a semiconductor surface such as that of silicon, surface states on the silicon should produce a charged layer (space charge region) just below the surface that will convert alternating current to direct.

Such an effect had been known to exist since the early 1920s, based on what occurred when a metal point (cat's whisker) made contact with a semiconductive galena crystal to make the crystal radio set possible. This was thought to stem from the fact that the metal point and crystal had different work functions.

Not so, said Bardeen. To prove it, he joined with a co-worker, Walter Brattain, to make and analyze point contacts on semiconductor surfaces. In one such experiment, they used two point contacts on the top surface of a germanium crystal and a conventional contact on the bottom surface. The result was the point-contact transistor — the first transistor ever built.

That same year, while trying to build a better transistor, William Shockley and Gerald Pearson, also of Bell Laboratories, decided to see whether they could indirectly control the flow of electrons through a semiconductor crystal. They applied an alternating electric field to a silicon crystal and attempted to use its changing values — positive to negative — as a valve to control how many electrons got through at any given moment.

The experiment failed. Only 10 per cent of the current moving through the crystal could be controlled this way. The reason? Electrons in the first onrush of current were captured by surface states and then acted to block further penetration of the silicon surface by the outside electric field. The reality of surface states had at last been demonstrated.

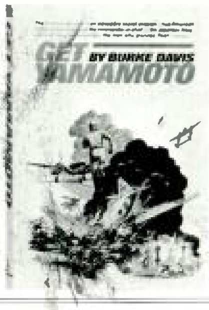
The failure of this "field-effect" experiment convinced Shockley that a better transistor would not be built until it could be made completely independent of its surfaces. Finally, in 1949, he succeeded in doing just that by developing the junction transistor, a device whose active regions lie well below their crystalline surface. It has since completely superseded the point-contact type.

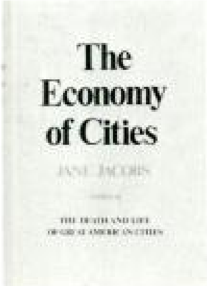
There the matter rested until 1959 when Martin Atalla, at Bell, discovered that the surface states on silicon could be greatly reduced, if not eliminated, by roasting the silicon in an oxygen environment. This caused a thin layer of silicon oxide to form on its surface. The effect of the oxygen was to neutralize most of the "dangling" electron bonds of the silicon surface atoms that gave rise to the surface states. Of those states that were left, the slow ones tended to retreat to the top of the oxide, while the fast ones remained — in reduced number — at the interface between the oxide and silicon.

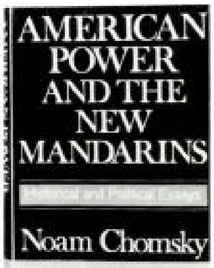
Could an electric field be applied through that oxide to control an electric current moving in the space charge region just below the silicon surface? Stephen Hofstein and Frederick Heiman, members of the research staff at RCA Laboratories, set out to prove that it could, and, in 1963, they reported development of the insulated gate field-effect transistor. It consisted of two metal contacts on the silicon and one on the oxide and showed that the original idea of Shockley and Pearson had been right after all. Insulated gate field-effect transistors are now competing strongly with their junction counterparts in everything from integrated circuits and computer memories to radios, phonographs and television sets.

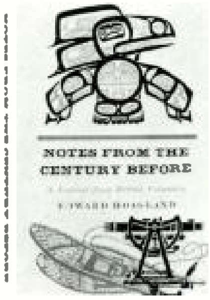
For the present, at least, it is from the shallows, not the depths, of the solid state that electronics scientists are finding the richest catch of new products and technology. ■

Books at Random...









Get Yamamoto
by Burke Davis (Random House)

This book is the first full, authentic account of the most important aerial encounter of World War II, in which a small group of American fighter pilots from Guadalcanal intercepted and shot down Admiral Isoroku Yamamoto, the top-ranking Japanese commander who planned the attacks on Pearl Harbor and Midway. The climax of the book is an extraordinary aerial battle, but it is more than an exciting re-creation of an encounter that may have changed the course of the War. It is also the story of Yamamoto himself as well as that of the American pilots who ambushed him.

The Economy of Cities
by Jane Jacobs (Random House)

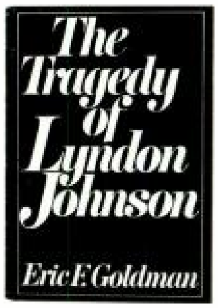
The question that Mrs. Jacobs asked herself when she began this book — Why do some cities decline and die while others live and grow? — is perhaps the most important question to be asked about civilization. The way she answers this question is at once simple and profound. She discusses the other factors, aside from established corporations and institutions, that mold the economy of cities.

American Power and the New Mandarins
by Noam Chomsky (Pantheon)

The central theme of this new collection of essays is the dual role of American liberal intellectuals in representing a society with incomparable wealth and power while, at the same time, sharing in the use of that power. This book starts with Vietnam but goes well beyond, touching on such unexpected problems as America's reactions to Japanese imperialism in the 1920s and 1930s and to the Spanish Civil War. Together, these essays reveal the liberal intellectual's design and justification of policy.

Notes From the Century Before
by Edward Hoagland (Random House)

In the summer of 1966, the author spent three months wandering around remote sections of British Columbia, intent on recapturing the feeling of the homestead era and the gold strikes. Altogether, he talked to 60 or 70 old-timers — trappers, riverboat men, prospectors and Indians — and collected in this volume their memories of a pristine world that is on the verge of extinction.



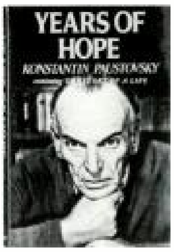
The Tragedy of Lyndon Johnson
by Eric F. Goldman (Alfred A. Knopf)

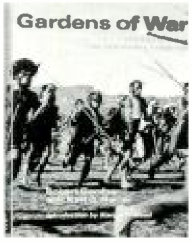
From the vantage point of his nearly three years' service as special consultant to President Johnson (from shortly after the assassination of John F. Kennedy until September, 1966), Mr. Goldman tells how LBJ and the men around him were affected by — and responded to — the events, large and small, of their time. Written with the immediacy of the memoirist and the appreciativeness of the scholar for the American political tradition, it chronicles the triumphs and failures of the Johnson administration.

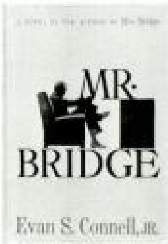
Bullet Park
by John Cheever (Alfred A. Knopf)

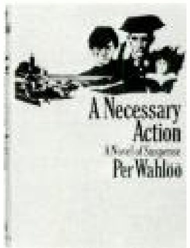
In his new novel, John Cheever turns from the familiar haunts of the Wapshots to a landscape at once more immediate and more universal. The time is this moment, in America. The principal characters — who meet, presumably by chance, one Sunday at church in Bullet Park — are two men, Eliot Nailles and Paul Hammer. The third crucial character, Tony Nailles, is the one who holds — and is in — the bag. How he got into it and how, in the nick of time, he appears to get out of it is the final fascination of Cheever's latest work.

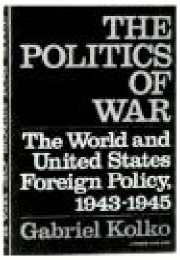
Other Recent Random House Books

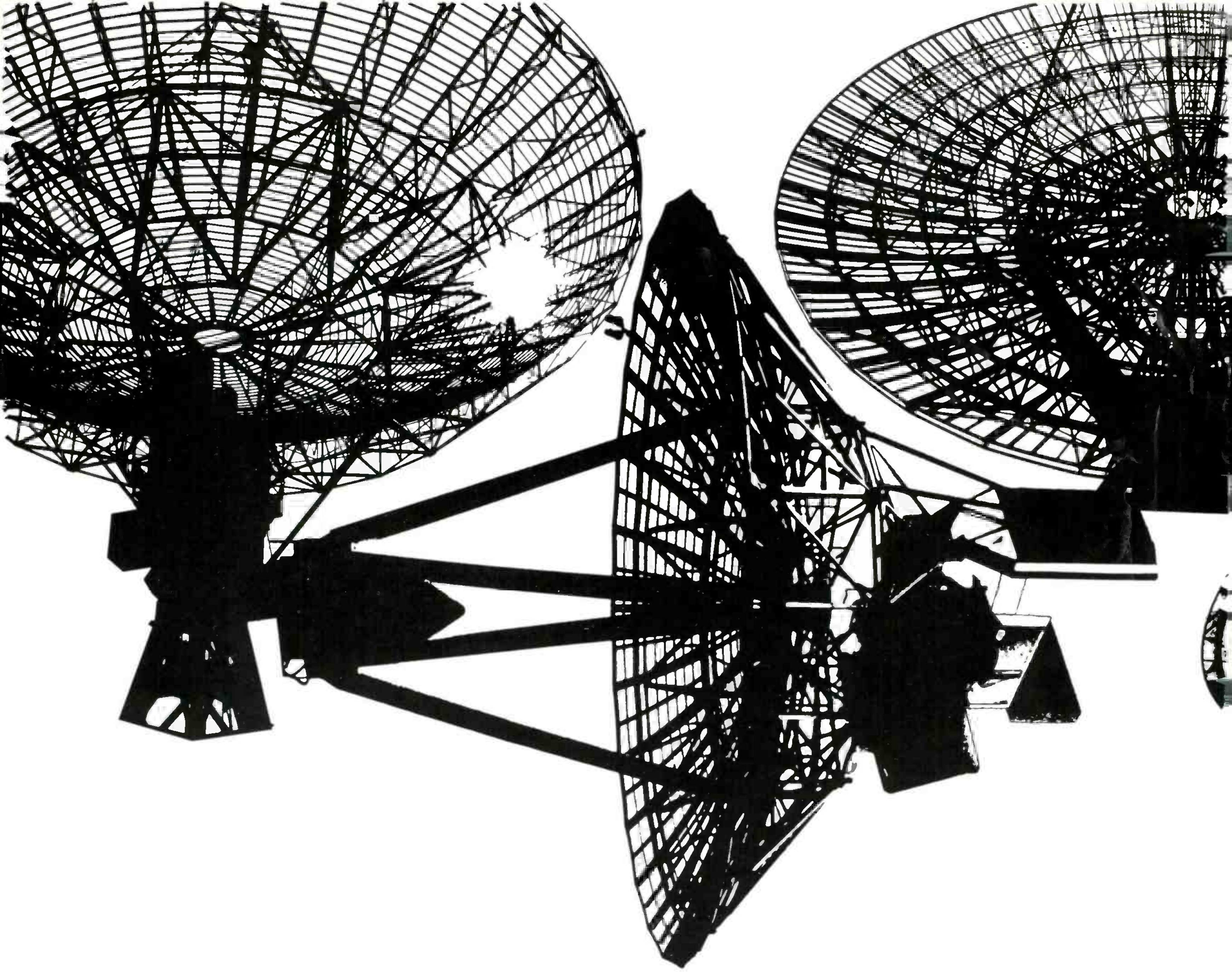












The Powerful Vision of Radar

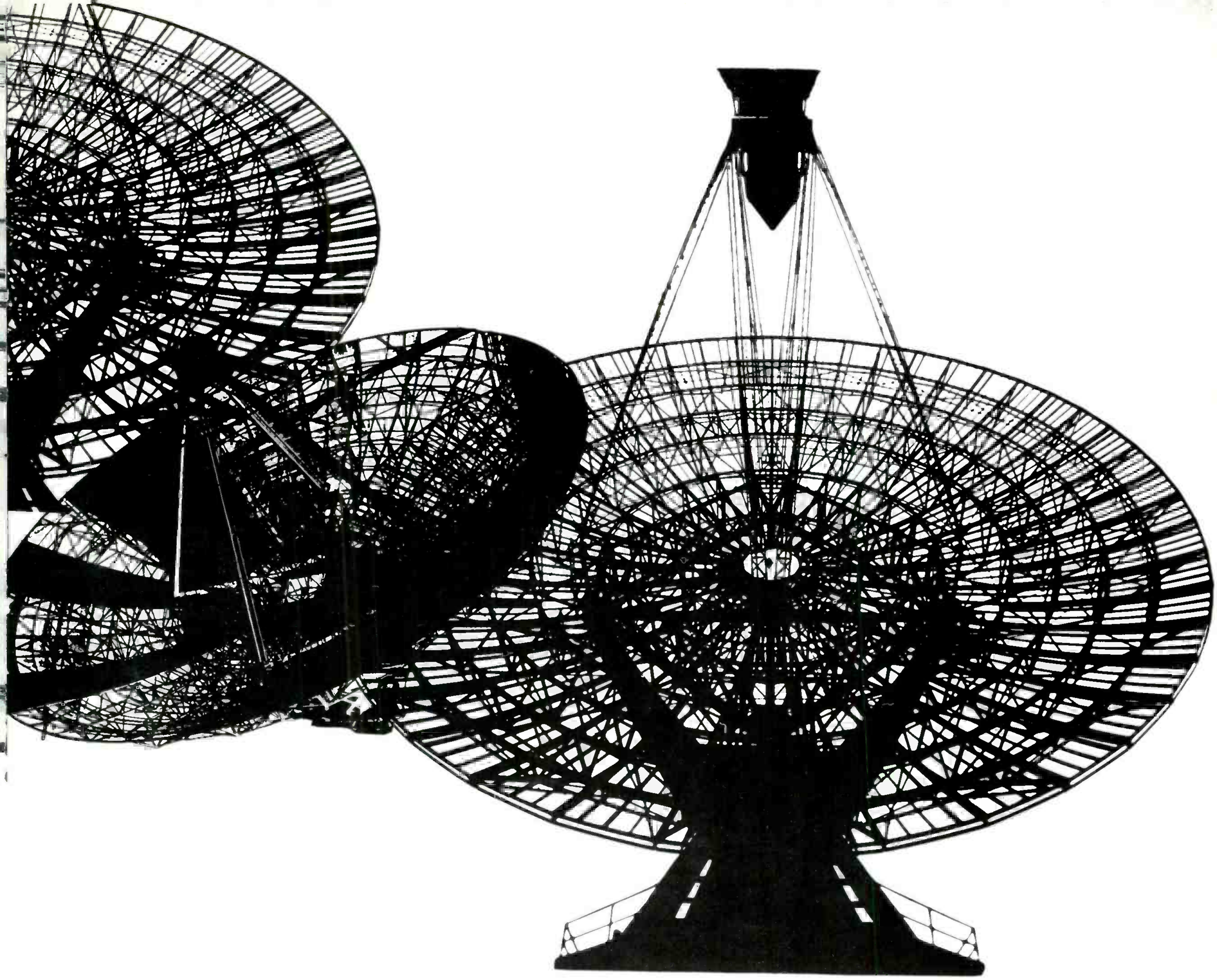
From outer space to the crowded airlanes over urban centers, radar is an invaluable extension of man's sight.

by Tom Elliott

During the Battle of Britain, airmen of the mighty German Luftwaffe learned very early that it was impossible to raid England by surprise. Time and time again, the RAF met them over the English Channel and dealt them stunning blows.

During August and September, 1940, their losses were so staggering that the Luftwaffe switched to night attacks, but with much the same results. Regardless of day or night, or of visibility conditions,

Tom Elliott is an RCA Public Affairs staff writer.



RADAR

the RAF always seemed to be waiting.

The key to England's ability to mobilize its relatively modest air forces so effectively against a numerically superior enemy was what the British called radiolocation. Transmitting-receiving stations along the coast were sending radio waves beaming out to sweep the skies and find the oncoming enemy in time for the RAF to make the interception.

America, with its affinity for acronyms, was to call radiolocation "radar," for radio detecting and ranging. However, regardless of its name, the use of radio signals to detect and locate targets was the premier achievement of radio science during World War II. Its importance to the struggle, and to national defense today, challenges measurement.

However, radar has long since graduated from sole use as a military instrument and has gone to work in many other applications as a powerful extender of man's sight. It guides commercial aircraft through bad weather with maximum safety and minimum discomfort to passengers. It enables busy airports to control planes during takeoffs and landings. Radar spans millions of miles to map the heavens and helps guide scientific spacecraft toward distant planets with incredible accuracy. It is a navigational aid for ships and shows promise as a means to avoid collisions between automobiles. Speed limit violators are all too familiar with radar's role in law enforcement.

Radar operates by sending out signals that are reflected, or "echoed," by objects back to the source of transmission. By measuring the time between the transmission of a radio pulse and its return, the distance of a target from the instrument can be ascertained. Additional measurements of the radio beam reveal the direction and height of the object relative to the radar. Two types of signals are emitted by radars. The most common is pulsed, whereby the energy is sent out in very rapid bursts. The second is continuous wave, which, as the name states, operates with uninterrupted waves of radio energy.

In principle, however, radar is as old as radio itself. As early as 1900, the eminent scientist Nikola Tesla declared that, by transmitting radio waves, "we may determine the relative position or course of a moving object, such as a vessel at sea, the distance traversed by the same, and its speed." However, it was the mid-1920s before any real experimentation began, and another decade passed before significant progress was made toward operational applications. This lag was primarily owing to technical limitations that denied engineers of that day the type of wavelengths, power and frequencies needed for radar. Thus, radar has reached its present level of sophistication in a relatively short time.

For example, one of the most fascinating aspects of modern-day radar is signature analysis, pioneered at the RCA Missile and Surface Radar Division in Moorestown, N.J. This is the method of analyzing radar returns from an object to determine its physical configuration. Signature analysis was first demonstrated successfully in 1958, when RCA radar experts accurately determined the contours of Russia's Sputnik II long before such data were released. This proved that the complex radar patterns of an unknown target could be studied to define behavior and mission.

The analysis of radar reflections from Sputnik II also revealed other important data. For example, it was learned that the satellite was equipped with corner reflectors for maximum return of tracking signals. As a result, it was assumed that the Russian tracking network of that time included a number of low-powered radars of World War II vintage.

Recently, signature analysis proved a valuable trouble-shooting tool on a U.S. scientific spacecraft. Radar revealed that an electricity-producing solar panel had not deployed, which explained power loss after the satellite had achieved orbit.

Another ingenious application of radar is a technique called side-looking radar. It permits an airplane to make a continuous map of the terrain to either side of its flight path — a map that looks very much like a photograph.

Such a system, carried in an orbiting satellite, could provide a valuable chart of the earth's geological features. When tuned to outer space, radar performs in an equally spectacular manner as a mapping tool. Cornell University astronomers have used the 1,000-foot radio telescope at Arecibo, Puerto Rico, to map one-third of the planet Venus, whose face is shrouded by a cloud cover that optical instruments cannot penetrate. Similarly, scientists at MIT have employed radars developed for ballistic missile tracking to study the moon and planets, and to investigate effects of the sun's activity upon radio propagation.

Closer to earth, radar allows airline pilots to thread their way along the calm corridors that weave among storms and other bad weather. By using airborne weather radar to view conditions up to 300 miles ahead, pilots can choose the fastest, safest and most comfortable routes amid less-than-ideal weather. Before airborne weather radar, lengthy and time-consuming detours around entire fronts were often necessary, resulting in delayed arrivals, missed connections and considerable passenger irritation.

New military applications also continue to be found for radar. RCA recently developed a small, hand-held radar for detecting men and vehicles obscured by darkness, weather or foliage. The instrument transmits signals that are transformed into sounds varying in pitch and intensity according to the motions of a target. Thus, an operator wearing headphones can quickly identify objects by the pattern of their characteristic sound, even to the extent that he can distinguish whether a target is a man or woman.

Besides its obvious military uses, such a radar has potential in other areas. Since its principle of operation is based on relative movement of the target, radar someday may be utilized in an instrument to sound an alarm in a moving car when it is closing too fast on an automobile ahead. The same type of instrument also could warn a boat operator of unseen obstacles in darkness, fog or rain.

A particularly interesting facet of radar is the way in which old principles continue to be put to work in new ways. For example, the first actual use of radar was by two British scientists who measured the height, as well as proved the existence, of the ionosphere by bouncing a radio signal off it. Currently, RCA is developing and manufacturing radar that can "see" over the horizon by bouncing radar signals off the ionosphere in much the same manner. When the signals strike a target, a portion of the energy is reflected back over the same path. These returns then are extracted by the signal-processing equipment of the radar unit. The reflecting properties of the ionosphere are utilized by using radar frequencies far below those of other radars. These are readily reflected, whereas high-frequency signals pass through the ionosphere and limit the coverage of conventional radars to what can be observed in a direct line of sight.

Military requirements have been the catalyst that sparked the continual sophistication and development of radar since its inception. Very early in World War II, radar was put into operation not only for search and detection but also to

Radar tracks spacecraft . . .

. . . as it blasts off from launching pad.

track objects and direct weapons fire against them. The maturing of the space age in the 1950s brought radar into even sharper focus as a critical instrument of military might. The threat from the ballistic missile, with its awesome weapons delivery capability, demanded more powerful, precise and versatile warning systems. The most prominent response to this threat was the Ballistic Missile Early Warning System, or BMEWS. In one of the most complex systems management tasks ever undertaken, RCA, as prime contractor to the Air Force, marshaled its resources and those of other major U.S. electronics firms to install mammoth radar surveillance sites in Greenland, England and Alaska. These sites, equipped with radars whose antennas are larger than football fields, now peer unblinkingly over the top of the world to guard against a surprise missile strike at the free world.

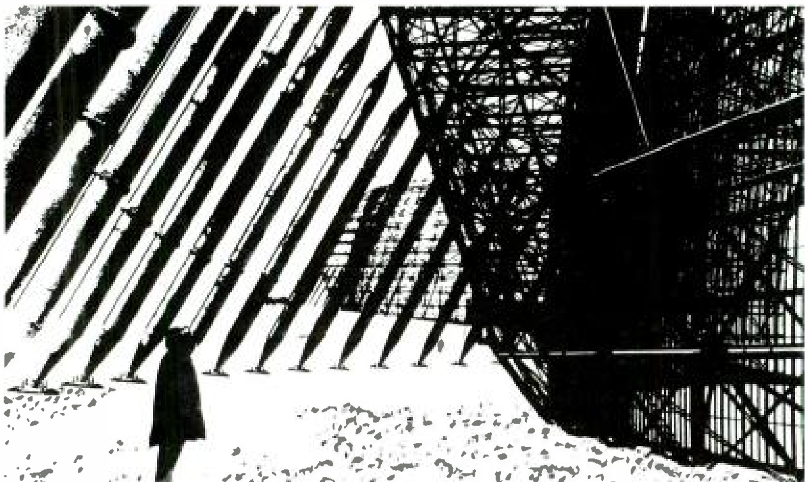
Another demand that the space age placed on radar was for greater precision, particularly for assessing the performance of missiles and rockets during tests, and for tracking orbiting satellites and spacecraft speeding on interplanetary missions. Thus, a major milestone was the development of the monopulse radar by the U.S. Navy and RCA. This made it possible to find a target's center with only one pulse of radio energy, as opposed to the hundreds of pulses that were required with the previously used conical scanning method. Monopulse opened the way for tracking radars that now can pinpoint an object to within an arm's length of its true position.

The ballistic missile also rendered inefficient many of the radar concepts that served so well during World War II. During the War, for example, many separate instruments were used for different tasks. One radar would be used for search and detection, a second for height finding, another for tracking, and perhaps a fourth for fire control functions, such as aiming antiaircraft fire against the target. Obviously, it would be preferable to have a multifunction radar, which is a single instrument capable of search and detection, height finding, precision tracking and fire control. This need gave birth to phased array radar in which the beam of radio energy is steered electronically rather than relying on the physical movements of the antenna. A radar antenna of this type is controlled by hundreds of transmitter-receivers imbedded in it. By complex electronic techniques, such as shifting frequencies to introduce phase delays or varying time delays in the application of transmitting power to the elements, the radar can be made to switch its beam of radio energy in different directions in less than a millionth of a second while the antenna remains stationary. This makes even the fastest rotating antenna lumbering by comparison. Because it can change its pointing angles so rapidly, phased array makes possible a truly multifunctional radar that can find targets, track them precisely, and, if necessary, direct countering fire power against them. And all these functions can be performed by the one instrument on many targets simultaneously. This capability is making phased array radar the heart of many advanced defensive and offensive weapons systems now under development, such as the Navy's Advanced Surface Missile System.

The newest wave of radar technology is the application of solid-state design techniques to increase reliability, shrink size and lower costs by replacing vacuum tubes with transistors, integrated circuits and similar devices. Such efforts very likely will dominate radar development over the next decade. RCA already has built a radar that employs integrated circuits, so that a majority of its electronic hardware will fit into one-tenth the space required for previous systems of like capability. Similarly, the RCA hand-held radar for detecting men and vehicles is an all-solid-state instrument, which accounts for its small size and light weight. Even in the extremely high-power systems, solid-state techniques are challenging the vacuum tube as a source of power. Engineers now visualize phased arrays with tens of thousands of tiny transmitters able to produce power previously possible only with vacuum tubes.

Engineers of at least one large company see a challenge in the program recently commissioned by the U.S. government to study the design and cost effectiveness of an all-solid-state phased array radar. They are convinced that the eventual outcome will be instruments whose expense over a lifetime will be dramatically reduced by their ability to operate for long periods without failure or extensive maintenance. Such systems will be ideal for operation in the field where repair and the supplying of replacement components often are exceedingly difficult.

This new wave of applying solid-state design is consistent with the history of radar. The art has not been characterized by spectacular breakthroughs but rather by the creative harnessing of old principles to new tasks to extend the vision of man both on earth and through the heavens. ■



View of BMEWS radar in Alaska.

Radar antennas for aircraft.

Communicating Science to Youngsters

The pervasiveness of modern technology is as much a part of science education as blackboards, chalk and test tubes.

by David Dietz

Science is a personalized, three-dimensional subject to today's young people growing up in an age in which technology dominates their environment as well as their education. The modern child is no longer bound to traditional studies of pulleys and levers in a world of space travel and nuclear power. Color television, stereophonic radios and phonographs, and jet aircraft set the tempo of his thinking.

Classroom methods, for instance, are much more laboratory oriented than they were a generation ago. Almost from kindergarten, the student learns science by performing his own experiments — with increasingly complex equipment — instead of just listening and memorizing. The first-grader learns nutrition by feeding white rats. The third-grader experiments with various circuits to understand the difference between lamps in parallel and lamps in series. The sixth-grader builds and works with his own model wind tunnel.

In fact, all 140 elementary schools in one major city — Cleveland — have special science laboratories with up-to-date equipment including small electric generators and motors, electroscopes, meteorological instruments, Geiger counters, chemical apparatus and microscopes. In many cities, the teaching of science in elementary schools is coordinated in varying degrees with local educational TV programs. These programs make use of sophisticated and expensive equipment, such as solid-fuel rockets, that could not be duplicated in a classroom.

Laboratories have always been a part of junior and senior high school science courses, but until recently experiments were mainly designed to enable the student to verify principles that he had already learned. Now, youngsters are not told what to find — only to report what they have found. In effect, the student becomes a research scientist.

Industry is providing an increasing

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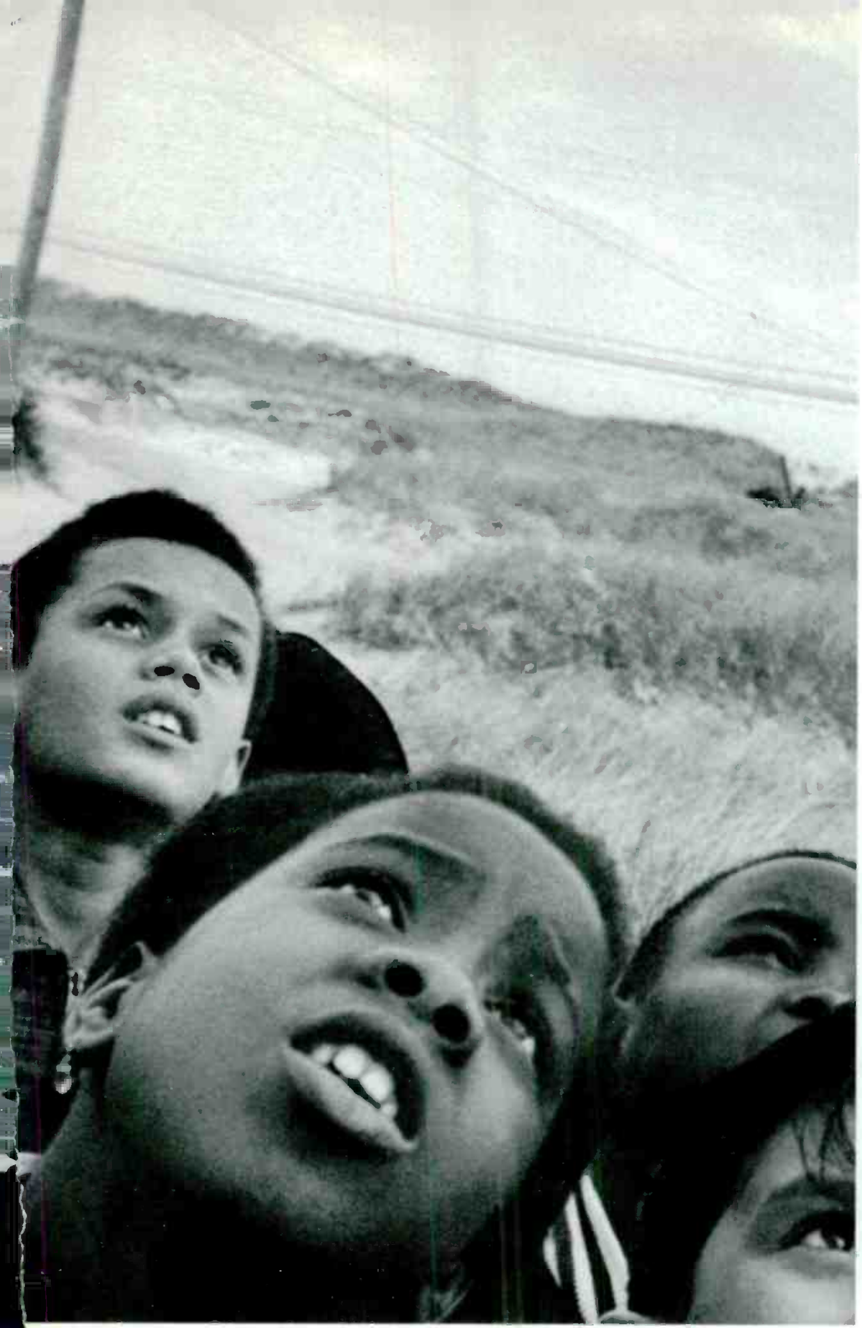


number of sophisticated instruments for such experiments. For example, RCA Limited (Canada) has developed an educational helium-neon gas laser, complete with auxiliary apparatus, to demonstrate the behavior of light, both as rays and waves, for the high school student. Another kit electronically illustrates certain aspects of the new math by means of a matrix board with push buttons for mathematical functions.

Advances in the teaching of science began after World War II and received great impetus in 1957, when Russia launched Sputnik I. This event dramatically awoke the nation to the need for more scientists and engineers at a time when the percentage of technical graduates was declining. Since then, much work has been done to modernize science curricula at all levels — fundamentally aimed at establishing learning-by-doing methods. Many high school physics courses were altered radically as a result of work by the Physical Sciences Study Committee at MIT, under the chairmanship of Dr. Jerrold R. Zacharias. For example, the PSSC recommended the use of textbooks that guide the student toward discovery, rather than simply listing facts and theories in encyclopedic form, and the increased use of supplementary classroom materials such as films and educational TV.

Another study, sponsored by the American Geological Institute, resulted in a course that replaces the traditional general science class — so often just a duplication of what the student had already learned in elementary school. The new laboratory-oriented interdisciplinary course correlates basic ideas of astronomy, meteorology, geology, oceanography and physical geography and relates them to concepts of physics, chemistry, biology and mathematics.

Extracurricular science functions are no longer limited to occasional visits to museums and planetariums. They now include tours of industrial research and development laboratories, in addition to school-sponsored activities such as science fairs.

Science fairs, in which youngsters build their own scientific exhibits, recently have boomed in popularity. These fairs develop interest by encouraging individual initiative, investigation and problem-solving. Industry has also stimulated interest by sponsoring science talent competitions and awarding scholarships.

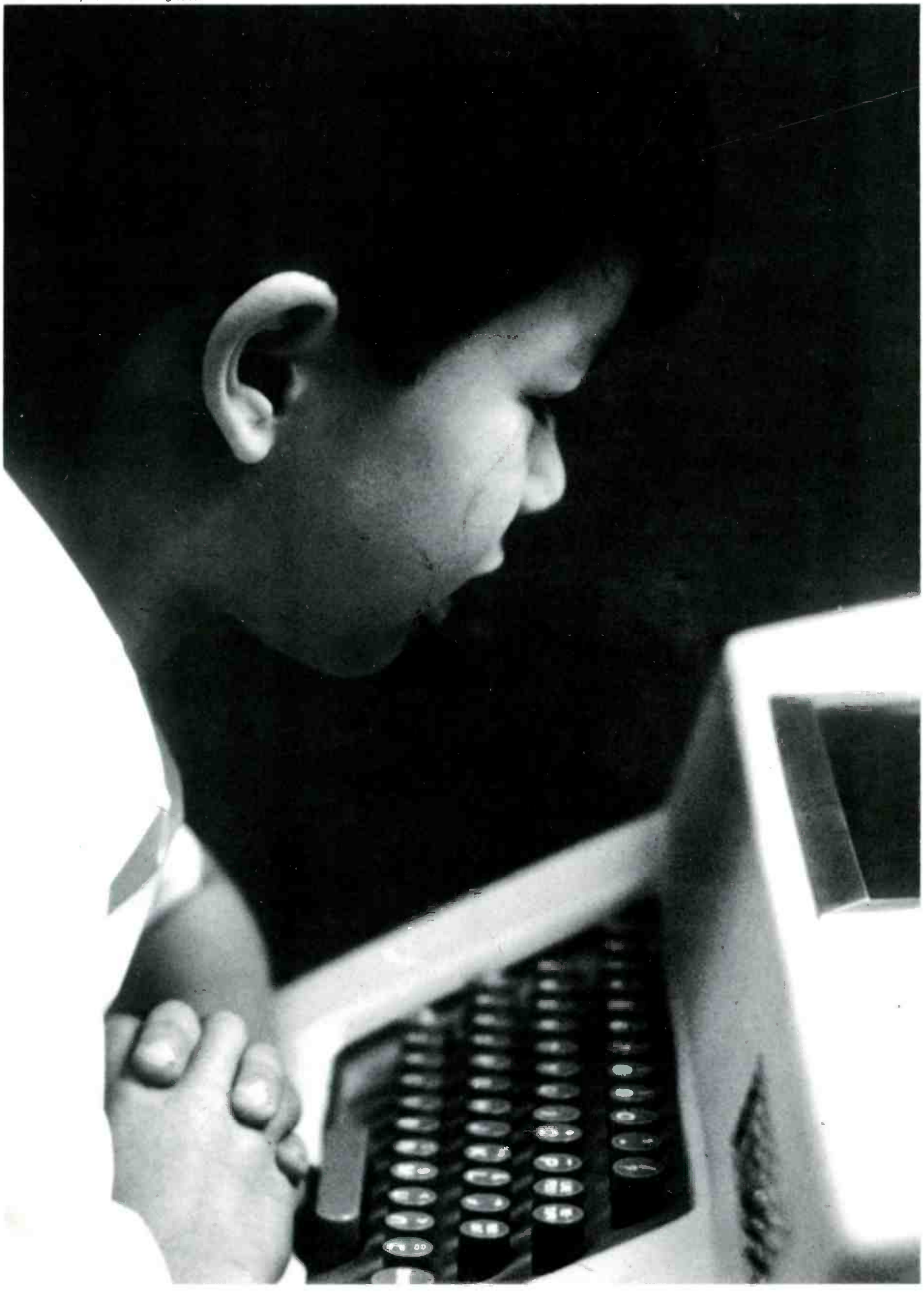
Both educational and commercial network television are scheduling programs that are part of the scientific education

of American youngsters. For example, this season, NBC is presenting a series of one-hour, prime-time science specials in cooperation with the National Academy of Sciences.

Young people also find the pervasiveness of science in their magazines, books and even in the games they play. To them, science is no longer a classroom subject — it is a part of their lives.

"The modern child is no longer bound to traditional studies of pulleys and levers in a world of space travel and nuclear power."

Youngster at an RCA student terminal unit ponders a science drill question. The electronic machine first tests the student to determine his level of understanding and then gears questions to his specific learning rate.



For the Records...

Tchaikovsky: Symphony No. 5 in E-Minor, Op. 64
Moussorgsky: A Night on Bare Mountain
Seiji Ozawa conducting the Chicago Symphony Orchestra LSC-3071

Two of the great staple orchestral works have been paired for the fourth Red Seal collaboration between this exciting young conductor and the Chicago Symphony Orchestra. Mr. Ozawa's approach to these works, which were recorded in Chicago's Symphony Hall, was for a taped performance with an absolute minimum of rehearsal to maintain a freshness unaffected by overfamiliarity with the work.

Bless Its Pointed Little Head
Jefferson Airplane LSP-4133

This album is the first live recording featuring concert versions of many of the Airplane's hits of the past. In addition to Marty Balin's "Plastic Fantastic Lover," "It's No Secret" and "3/5's of a Mile in 10 Seconds" and Grace Slick's "Somebody to Love," the group highlights its own compositions, "Bear Melt" and "Turn Out the Lights," and the old blues standard "Rock Me Baby."

The Heifetz-Piatigorsky Concerts: Spohr: Double String Quartette in D-Minor, Op. 65, and Dvŏrák: Piano Trio in E-Minor, Op. 90 ("Dumky")
LSC-3068

This album is the tenth in a series of Red Seal recordings of Heifetz-Piatigorsky chamber music concerts. The artists are joined in the Spohr work by six musicians who have performed in previous Heifetz-Piatigorsky recorded concerts. The Dvŏrák Trio, perhaps the most characteristically Slavic of his works, features Jacob Lateiner, a frequent performer with Heifetz and Piatigorsky in both their live and recorded concerts.

Wheatfield Soul
The Guess Who? LSP-4141

In their first Victor album, this young quartet from Winnipeg introduces to the United States pop market the sound that has made them one of Canada's top rock groups. The album features their hit single, "These Eyes," and includes nine other original numbers written by two of the group's members, Randy Bachman and Burton Cummings.

Classic Guitar
Julian Bream LSC-3070

Julian Bream's latest album features a collection of works by widely known eighteenth- and early nineteenth-century composers of music for the guitar. There are works by Giuliani, Sor, Diabelli and Mozart. The first two composers were guitar virtuosos and the third was a teacher of the instrument. Mozart, however, neither played nor wrote for the guitar, and the work included comprises Bream transcriptions from two movements of the second of Mozart's five Divertimentos for Two Clarinets and Bassoon.

Barber: Two Scenes from *Antony and Cleopatra*, Op. 40, and Knoxville: Summer of 1915, Op. 24
Leontyne Price, soprano
Thomas Schippers conducting the New Philharmonia Orchestra LSC-3062

For her first RCA album of contemporary music, Miss Price has chosen two arias from Samuel Barber's *Antony and Cleopatra* and one of the composer's earliest works, *Knoxville: Summer of 1915*, based on a prose fragment by the late James Agee. From the opera, Miss Price has chosen the Act I aria, "Give me some music," and the last act death scene, both of which have been prepared in special concert version by the composer.

Other Current RCA Releases

Electronically Speaking...

News in Brief of Current Developments in Electronics

World to Get a Ringside View of the Apollo Moon Mission

A sophisticated Lunar Module (LM) communications system will enable the world to share in the drama of Americans landing on the moon later this year. Designed to beam everything from live TV to an astronaut's pulse rate from the moon to earth, it will link the LM to ground controllers and to its lunar-orbiting sister spaceship, the Command/Service Module (CSM).

The system will transmit voice communications, telemetry and astronaut biomedical data to earth during the LM's descent to the moon and its lunar stay and as it rises to rejoin the CSM for the return to earth. At the same time, it will provide voice communications and range between the LM and CSM.

It also will beam live TV pictures of astronauts exploring the lunar surface and will relay their voice communications to earth as they work outside their spacecraft. In addition, it will receive and retransmit ranging signals from the Manned Space Flight Network to ascertain the position of the LM in space.

The LM communications system actually is comprised of two parts — very high frequency transceivers that link the LM and CSM and an S-band system for LM-earth transmissions.

Five major U.S. electronics and communications companies built key components for the system, whose development is managed by RCA for Grumman Aircraft Engineering Corporation.

New TV Camera Tube Gives Higher Resolution and Sensitivity

An integrated silicon circuit "eye" and an electron beam "optic nerve" are incorporated in a new TV camera tube to give far higher resolution and sensitivity than are obtained with conventional tubes of the same vidicon type. This is the first mercial camera tube to combine vacuum technology with solid-state.

In its present form, the new RCA Silicon-Target (S-T) Vidicon is designed primarily for use in closed-circuit TV systems such as in banks, schools and airline terminals and for the military. With refinements, later versions may find important applications in both film-pick-up and live black-and-white and color broadcasting cameras.

The S-T Vidicon has extremely high sensitivity in the infrared as well as throughout the visible spectrum. As a result, it has the unusual capability of being able to see in the dark.

In addition, the new tube has a target that is impervious to damage from its own electron beam and can even be exposed to direct sunlight without harm. And there is no signal discharge lag (highlight hang-up) after extreme overexposure. The target is an array or mosaic of several hundred thousand photodiodes, a structure first developed by Bell Telephone Laboratories.

Public Officials to Monitor Emergencies on Television

State and municipal officials in Denver, Colo., will soon be able to monitor TV pictures of disaster scenes and other disturbances from 32 remote locations and take immediate action via two-way radio communications.

As conceived by Denver authorities, the long-range plan calls for equipping a helicopter with a small RCA TV camera, fitted with a zoom lens, for making close-ups of trouble spots. On the ground, the TV van would carry another RCA camera capable of being used in a fire-fighting "cherry picker" bucket.

The broadcasts will be made over a 2,500-megahertz frequency that, in effect, makes the system closed circuit, since TV signals at those frequencies cannot be picked up by a standard receiver. A down converter at each receiving point will change the incoming signal so it can be viewed on a standard TV receiver.

Tailor-Made Books for Teachers

Teachers can have material from the Encyclopaedia Britannica's new *Annals of America* series of original documents converted into custom-made books for their own classrooms by means of an advanced electronic composition system. They can select any data — down to a single paragraph and combined in any order — out of the more than 2,200 articles in the series.

The heart of this system is an RCA VIDEOCOMP typesetter that sets *Annals* pages — complete with headlines, subheads, footnotes, page numbers and even rules — at an average rate of one page every 25 seconds.

When an educator decides exactly what is needed, his request is keypunched and fed into a computer, specifying which selections and which portions of selections are to be printed and in what order. The information is sorted to a master magnetic tape that is then sent to the Poole Clarinda Company for typesetting. There, the tapes are translated into proper formats and necessary composition controls are added. Page proofs are created on the VIDEOCOMP at speeds of up to 6,000 characters per second. An entire 400-page book of *Annals* selections can be composed in less than a day.

This new combination of computers and electronic composition equipment makes it possible for school systems to select exactly what they want to teach in such areas as history, social studies and political science.

Expanded Center for Wall Street

An expanded Wall Street Data Center, built around five Spectra 70/45 computer systems, is processing the mounting volume of stock market transactions. This complex of computers provides a five-fold increase in capacity over the existing Center, which had handled nearly one-half of all computer center transaction processing for New York's financial community.

Later this year, a time-sharing system will be installed at the Center, simultaneous with the start of a pilot operation in remote batch processing for brokers. Eventually, it will link main and branch offices of brokerage firms directly to computers via high-speed communications lines. Customers will be able to transmit information to the Center and receive finished statements and reports on remote video display terminals and teleprinters in the office.

Besides processing market transactions, the RCA Center furnishes brokers with a broad array of special services — including order matching, on-line transmission of market data, and information retrieval for bond houses, investment bankers and commission brokers.

Small Institutions to Share Computer

This summer, the campus of Franklin and Marshall College will become the hub of a computer time-sharing network extending to seven other educational and research institutions in Pennsylvania.

A third-generation RCA computer and a new building will be leased to a recently organized nonprofit corporation, the Middle Atlantic Educational and Research Center (MERC). This organization is believed to be the first attempt by a group of small institutions to join together as a cooperative in order to provide members with computer facilities generally found only in larger institutions. Eventually, MERC may become one node of an interrelated complex of centers in which facilities throughout the country will be linked to each other through computer-communications networks.

Tiny Sensors Could Lead to Cameras That "See" in the Dark

An integrated circuit sensor, smaller than a dime, will be developed for the U.S. Air Force as part of a program that ultimately could lead to tiny, TV-like cameras that "see" in the dark. Such all-solid-state cameras would be sensitive to near infrared radiation — a component of heat.

These cameras could be used to detect the presence of objects or persons in the dark, or actually to produce an image of them. Applications could range from aircraft and satellite reconnaissance to missile guidance.

The sensor will be designed by RCA to detect infrared radiation in the 0.8- to 3.0-micron spectral region. It will be an array or mosaic consisting of 16,384 elements, each containing a lead sulfide photoconductor and a planar junction silicon-diode switch. When radiation strikes the array, each photoconductor will produce an electrical current proportional to the infrared energy striking it. Scanning will be achieved by switching the photoconductors. The resulting electrical values from the photoconductors can be read out sequentially and processed to produce a video signal.

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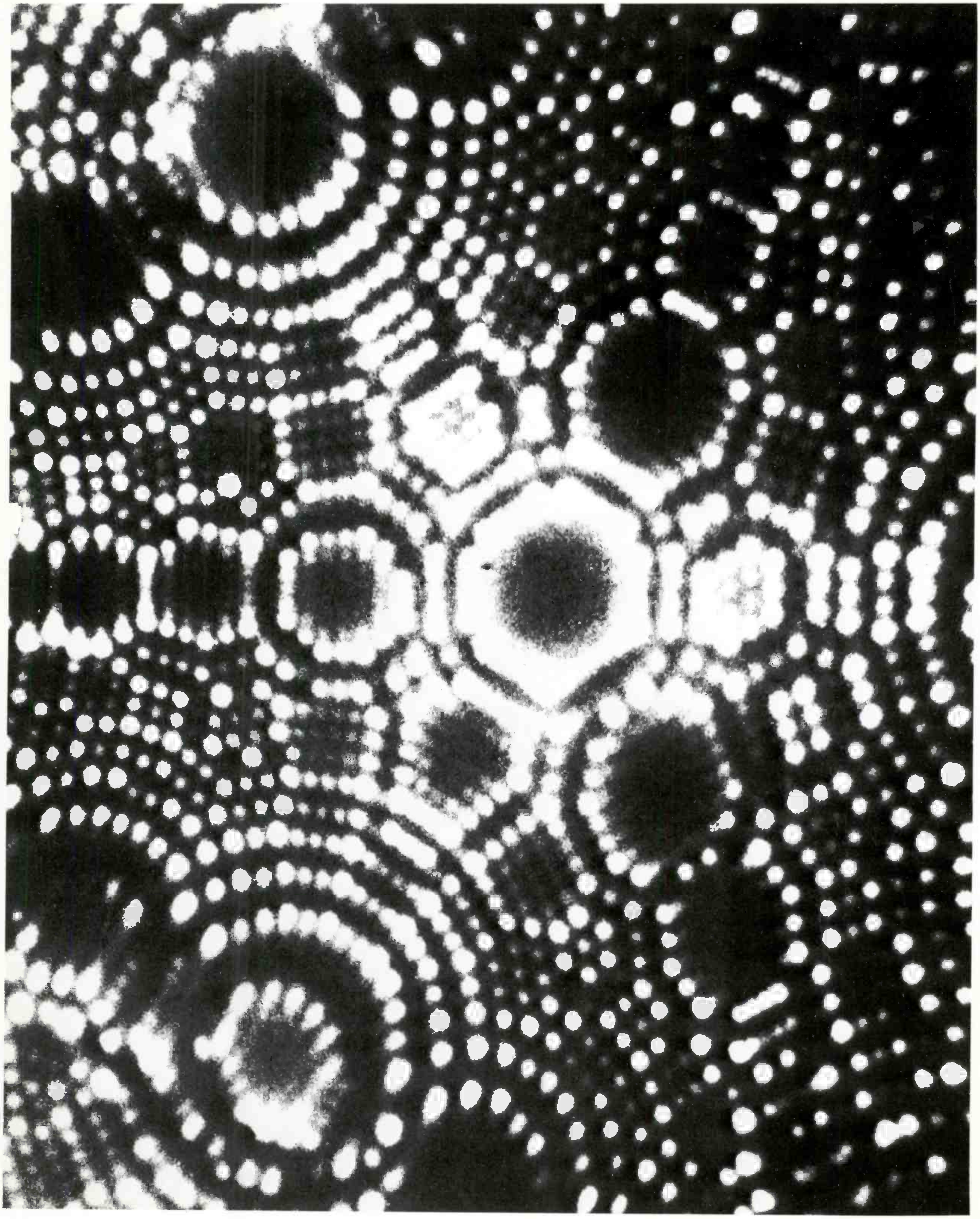
Atomic surface structure of tungsten magnified several million times is resolved by the field ion microscope. An article on "The World of Electronic Surfaces" begins on page 22.



Electronic Age

Spring 1969