ELECTRONIC AGE

RCA Spring 1967

Searching the Atomic Labyrinths

A scientist at RCA Laboratories points a tweezer at a novel FM radio transmitting device so small it is almost invisible. The "transmitter" is a tiny speck of gallium arsenide centered between and attached to the two electrical terminals on the disk-shaped holder above. When plugged into an electrical circuit and activated, the experimental device makes it possible to generate microwaves and to transmit voice and sound. It has been used to broadcast high-quality music across a laboratory room. The device could lead to new types of hand-held, ground-to-ground, and ground-to-air communications systems.

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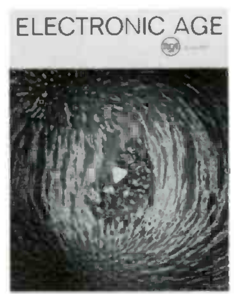

Cover: Set like a jewel against a magnetic field is a cluster of cadmium-chromium-selenide crystals grown at RCA Laboratories, Princeton, N.J. Electronic scientists use such crystals to investigate new energy forms and quasi particles within the atomic structure. Out of such research is expected to emerge a number of new solid-state electronic devices more advanced than the transistor. *An article on electronic research begins on page 6.*

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RCA Vol. 26/No. 2 Spring 1967

The Systems Man Looks at Society

by Robert E. Tolles

The Lockheed Aircraft Corporation, a firm normally devoted to the construction of military and aerospace systems, recently recommended to the State of California that it institute a computerized system of statewide data exchange that will enable a resident, when he moves, to report a change of address to only one instead of six or seven state agencies.

What is most interesting about this event is not so much the proposal itself but the fact that a huge aerospace firm suddenly finds itself dabbling in the problems of a state government. The instance is not isolated. For example, the Rand Corporation, a firm created by the U.S. Department of Defense to study military systems, has recently undertaken a study on the subject of "How to Decrease Travel Time for the Freeway User." Another of the defense-oriented "think factories" is similarly engaged in a systems analysis of medical care practices.

All three studies are symptomatic of a ferment that is currently stirring the nation's scientific and technological community. From one end of the country to the other, research and engineering firms that for the past several decades have been designing and building military and space systems are now turning their attention to problems formerly thought to be an exclusive concern of government. Armed with a management and problem-solving technique called systems analysis, they are examining a broad range of complex social ills—from air and water pollution, to traffic congestion, urban blight, crime and delinquency control, and school and hospital shortages.

Part of this interest has been dictated by necessity: to prepare for the day when dwindling defense expenditures may force the "think factories" and military/aerospace firms to seek other outlets for their energies. The principal reason, however, is that the technological community strongly feels that greater use should be made of its unique talents and techniques in attacking society's unsolved problems.

Persuasive arguments have been offered in support of this view. Since World War II, the United States has created a

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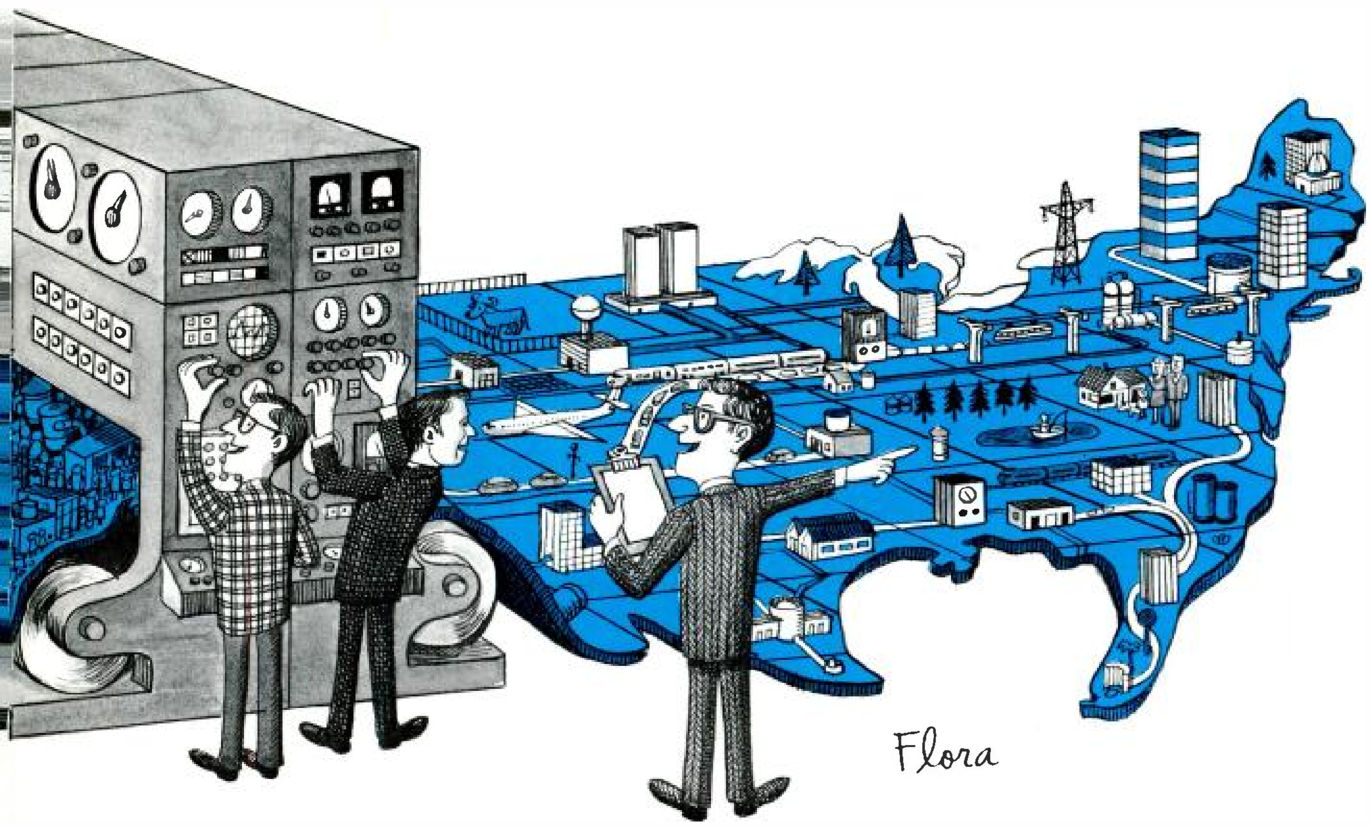


Can the management and problem-solving techniques known as systems analysis be successfully applied to the cure of complex social ills?

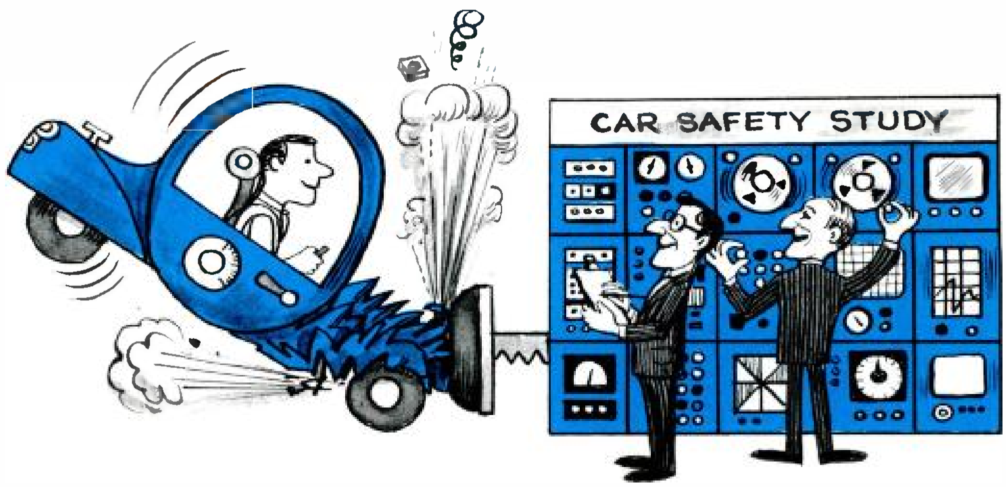
technological establishment that has built continent-spanning missiles, harnessed the energy of the atom, and launched spacecraft to the moon and beyond. This same expertise, applied with equal diligence and resources to the problems of society, could make an immense contribution in providing people with decent jobs, homes, schools, and hospitals.

Recently, government authorities have been paying greater heed to these arguments. Beginning in 1961, Secretary of Defense Robert S. McNamara, with the advice of experts from Rand, instituted a far-reaching planning, budgeting, and procurement procedure for the Department that is essentially an application of the systems approach to public management. All other federal departments have since been directed by the President to adopt the procedure.

Two years ago, the State of California brought in four aerospace contractors to make systems engineering studies in the fields of waste disposal, transportation, crime control, and information services. According to the then Governor Edmund E. Brown, the studies that were submitted "demonstrated compellingly that the concept of systems analysis could in fact be applied creatively to social problems."

More recently, a group of Republican senators and congressmen introduced legislation to establish a National Commission on Public Management as a first step toward instituting the modern "systems management" approach and technology to develop and administer a comprehensive solution to urgent social problems. Senator Gaylord Nelson of Wisconsin had earlier introduced a bill that would authorize the Secretary of Labor to spend $125 million to help states and universities apply systems techniques to their problems.

In essence, the systems approach is an organized method of analysis in which all the components of a problem are weighed and considered in relationship to a stated objective. For instance, if the systems approach were to be applied to professional football (as was done recently in a paper presented at a meeting of the American Institute of Aeronautics and Astronautics), the objective would be to design a team and method of play that would have the best chance of winning the championship. The components of the systems design would be not only the players but coaches, the manage-



ment staff, equipment, field conditions, the opposing team, and so on. These elements working in concert comprise the system, and their relationships are delineated in a sophisticated system of analysis leading to the desired goal—the winning of the championship.

One of the earliest applications of the systems engineering approach was RCA's development in the 1930s of the first practical television service. Abandoning the piecemeal approach that had characterized earlier efforts, RCA assigned groups of specialists to work on all the various components of a high-quality TV service, including transmission, reception, relay, tube development, and programming. This coordinated engineering effort went on for nearly a decade before an acceptable system was developed.

Not unlike professionals in other fields, the systems men have tended to veil their techniques in a jargon that is incomprehensible to most laymen. But there is no great mystery to systems analysis. Charles J. Hitch, former Defense Department comptroller, has described it as no more than systematic and comprehensive thinking.

Since many of the relationships between the various elements in a system can be stated in mathematical terms, the computer has become an indispensable tool in systems analysis. In the reduction of a system to quantitative terms, the key is found in the fact that the behavior of each element in the system can be understood as a range of uncertain events. Probabilities are assigned to these events, and a mathematical model is drawn up of the interrelationships between events. The computer then can predict over-all system performance based on a shift or change of the behavior of a particular system element.

The input-output models that the economists have constructed for the economy of the United States is a simple illustration of how the computer is utilized to predict system performance. The nation's economy is a maze of interlocking industries that buy and sell products and services from one another for eventual sale to the consumer. An increase in automobile sales, for instance, will affect hundreds of other industries that supply, both directly and indirectly, the automobile manufacturers. A complex model of all these relationships, quantified in terms of correlation coefficients, is then constructed and committed to the computer. Through manipulation of this model, the effects of a particular change in any one of many variables, whether it be an increase in the gross national product or an increase in government expenditures or a consumer preference for more automobiles, can be predicted for every other element in the entire economy.

Handling problems in the political and social spheres is considerably "messier" for the systems analyst because many of the individual elements are not subject to easy control. It is relatively simple, on the one hand, to predict the effect of the atmosphere on the re-entry of a ballistic missile. It is much more difficult, on the other hand, to assess the economic impact on a particular area of a redesigned mass-transportation system.

The principal element of unpredictability in the analysis of social problems is people. Analysts characterize those systems where it is hard to anticipate the reaction of particular elements or variables as higher entropy systems. But the greater disorderliness of problems in the civilian sector does not discourage them.

Says Sidney G. Miller, Manager of RCA's Systems Engineering Evaluation and Research activity in Moorestown, N.J., "Paradoxically, the problem of unpredictability tends to diminish with the large numbers of people characteristic of social situations, rather than increase. The statistical laws of large numbers begin to set in. The real problem is in estimating where the new equilibriums are going to settle when the system is disturbed by a major innovation."

Another large constraint in proposing solutions to social problems is the fact that the boundaries of a particular problem frequently exceed the boundaries of the decision-making unit. Air and water pollution are an illustration of this. Pollution created in one state is not susceptible to control of the electorate of the adjoining state where the pollutants may eventually flow.

Several of the California studies came up against this jurisdictional problem when making recommendations for more rational systems of public management. In surveying the way the state handled its waste disposal, Aerojet General Corporation recommended that all statewide waste management problems be placed within the purview of a single agency. Legislation would also be introduced to require local or regional government units to comply with statewide requirements.

Another California study, which was conducted by Lockheed, examined the state's information-handling requirements. The dimensions of this problem are vast: every 12 years the number of filing cabinets in state offices must double to accommodate the avalanche of paper work that flows between the various jurisdictions in the state. Lockheed recommended a statewide system of data exchange and computerization that over 10 years would cost about $100 million. One of the first steps to be implemented is a system for simplifying a resident's reporting requirements when he changes his address.

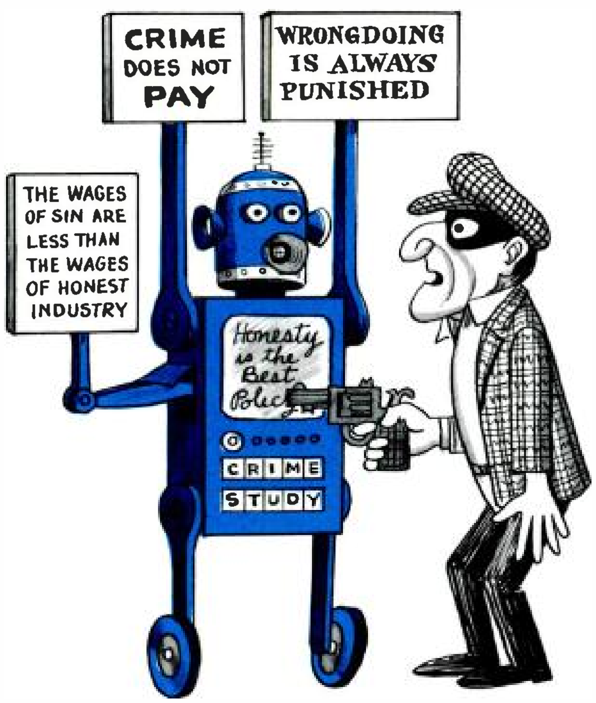
The systems technique of first defining mission, environment, and functions to be performed, prior to fabrication of hardware, is illustrated in a study that the Republic Aviation Division of Fairchild-Hiller did for the State of New York.

Concerned over mounting automobile accidents and injuries, the State Legislature commissioned Republic to conduct a feasibility study of the design of a car that would bring about a substantial improvement in automobile safety. The program emphasized the systems approach, which viewed the problem as an integrated whole and in which all safety methods and techniques are integrated into the design rather than treated as added features to a styling concept.

Republic came up with a design concept for a car that would withstand the impact of a head-on collision at 50 miles an hour, a speed that encompasses about 75 per cent of all injury-producing accidents. This was achieved largely through the design of a protective structure surrounding the passenger compartment.

As part of the study, Republic made a systems analysis of the car's braking function, tracing the sequence from the driver's decision to slow or stop, his body response, the brake pedal geometry, distance and direction from accelerator to brake pedal, and the various linkages from brake actuation system, drum mechanism, tire configuration, and finally road surface. The purpose of the analysis was to predict exactly the effect of all component variations in the braking function so that the optimal set of characteristics could be determined.

The Convair Division of General Dynamics Corporation attacked an equally pressing problem in a six-month feasibility study for the National Institutes of Health. This was the development of a totally implanted artificial heart—a program, the firm commented, as complex as any Department of Defense hardware project. Using the systems approach, Convair identified seven basic tasks to be accomplished and then assigned a large multidisciplinary group—including biologists, physiologists, physicists, mathematicians, chemists, plus a wide assortment of engineers and management men—to prepare a "road map" for a 10-year development program. The price tag for such a program was estimated at $1.8 billion or some $3,000 per patient.

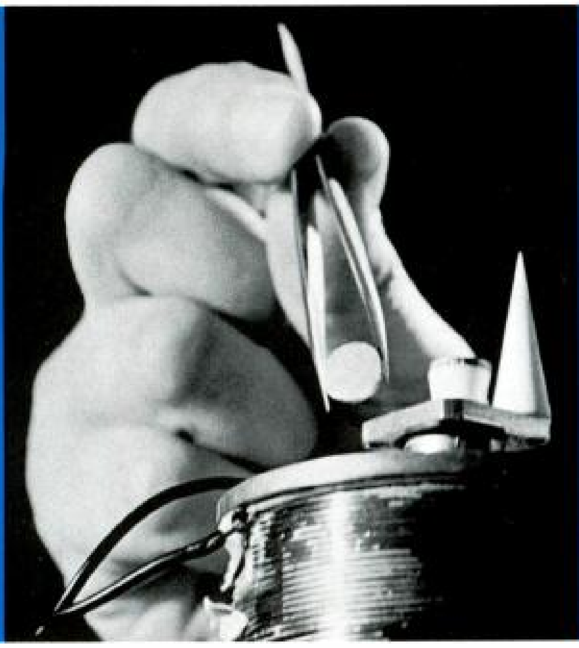


A systems approach that involved only human beings was utilized by the RCA Service Company in devising a training program for a tribe of disadvantaged Choctaw Indians in Philadelphia, Miss. The objective of the program—the complete integration of all members of the Indian family into urban society—is to be accomplished by training them in basic vocational, educational, and social skills, securing jobs for them, and then following up repeatedly to ease their transition into urban living. The Bureau of Indian Affairs of the U.S. Department of Interior has awarded a contract to RCA for the program and will be watching it closely to see if a similar technique can be applied to the rehabilitation of other Indian tribes.

Further up the entropy scale is the study that the Department of Commerce, with the aid of various aerospace firms, is undertaking to plan a comprehensive system of transportation for the Northeast Corridor for the next 20 years. Here the problems become incredibly complex, owing to the competing character of the various individual transportation systems, the difficulties in ascribing costs and benefits to improved systems, and the uncertain expectations of new and more efficient modes of transportation. The systems man's so-called optimizing or best-solution criterion also seems to have limited usefulness in such a situation. The best solution would be that which results in the greatest increment to the public welfare. But public welfare is an illusive concept, and one group's interpretation of it might be at considerable variance with another group's.

Few persons have suggested that these difficulties seriously limit the use of the systems approach. The difficulties do suggest, however, that there will still be a large subjective element in the evaluation of alternative solutions that can be resolved only through the political process. The expertise of the systems analyst will help sharpen both the official and public understanding of the issues at stake, but the decisions will continue to rest on what the elected representatives of the nation and their appointees conceive to be the greater public good.

One advance seems sure to emerge from this growing dialogue between the scientific community and civil authorities, and that is an increased understanding of each other's methods and problems. The scientists and engineers, although inured to struggling with complexity, are going to become more appreciative of the disorderliness that necessarily accompanies problems in the social sphere. By the same token, the orderly and comprehensive thinking of the systems analyst should exert a profound influence on the way the civil authorities manage the public's business. ■



Beyond the Transistor

by Bruce Shore

The impact of the transistor on society—on communications, on defense and industrial technology, on data processing equipment and space research—has been so spectacular that its humble origins in the quaint, almost amusing idea of electric currents composed of positively charged "holes" and negatively charged electrons traveling in a semiconductor have almost been forgotten.

For the average man, at least, this is true. But not for the electronics scientist whose continued "spelunking" in the atomic labyrinths and molecular catacombs of the solid state has now produced a population explosion of strange energy forms and quasi particles that could one day lead to devices even more sensational than the transistor.

Among these exotic entities are:

Excitons—Positively charged "holes" and negatively charged electrons that travel in pairs and have already spawned a new kind of laser that emits coherent light in a 360-degree arc instead of a narrow beam. Such lasers may eventually lead to a new type of television display.

Double excitons—Combinations of two "holes" and two electrons that travel in foursomes and may one day be used to smuggle heat, light, and other forms of energy from one point in a material to another without leaving "tracks" in between.

Polarons—Free electrons acoustically handcuffed to some of the atoms making up certain crystals. These may make possible a new kind of infrared light detector for use in seeing in the dark.

Phonons—Very high-frequency acoustic waves that vibrate constantly along the microscopic "jungle-gyms" of atoms composing the solid state. They have already been

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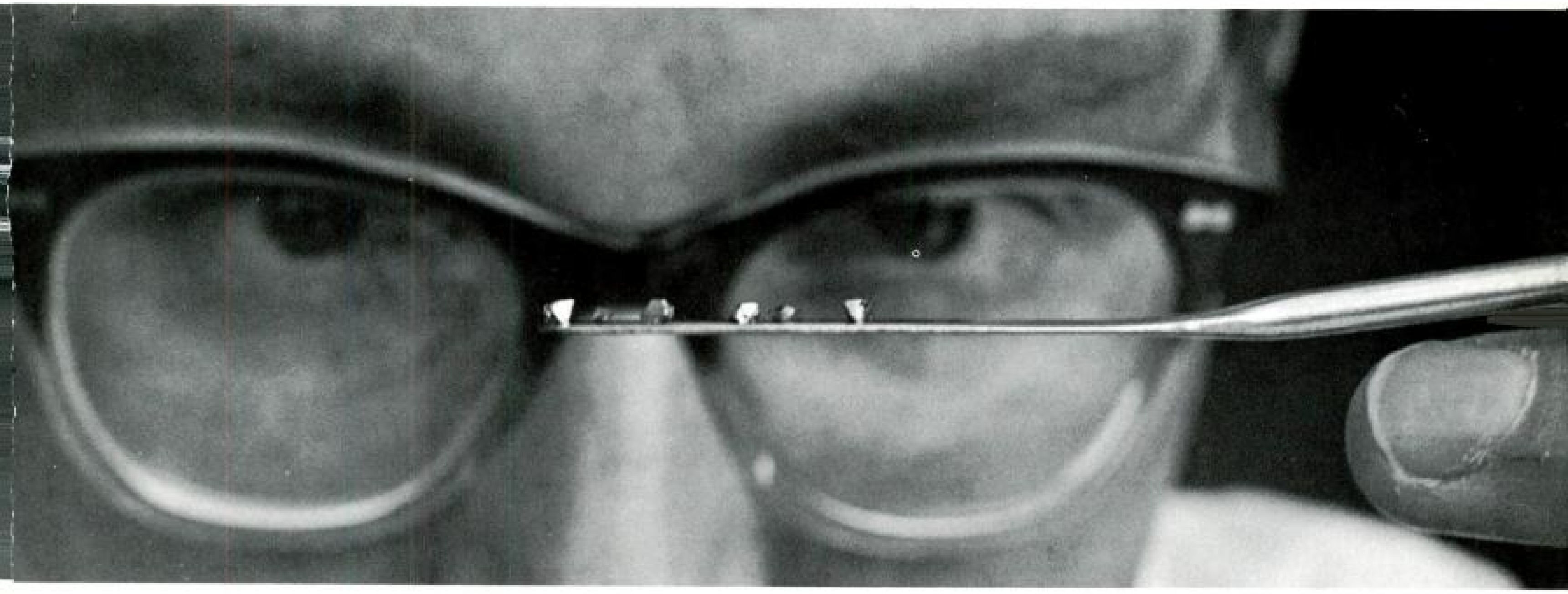


Two new types of exotic semiconductors that are being used in the investigation of electromagnetic phenomena. On the left, a disk of indium antimonide that allows radio waves to pass through it in a corkscrew fashion. Above, a scientist holds on a spatula several crystals of cadmium-chromium-selenide that propagate a form of energy known as spin waves.

Electronic research into solid matter is revealing a number of strange new energy forms and quasi particles that may lead to devices more sensational than the transistor.

used to realize superconductive magnets 275,000 times more powerful than the earth's magnetic field and may also be employed eventually in a single chunk of material that will amplify your voice directly when you speak at it.

Plasmons—Vibrations that ripple through large clouds or "plasmas" of free "holes" and electrons in certain crystals. They may soon give birth to a whole new family of components that will operate in very high-frequency microwave and millimeter wave communications systems.

Helicon waves—Electromagnetic energy, including light, that travels as slowly as one foot per second and moves corkscrew-fashion through ordinarily opaque substances containing solid-state plasmas whose electrons are trapped in a magnetic field. Helicon waves make it possible for microwaves to penetrate metals and, by the same token, may make it possible for them to penetrate the plasma sheath that ordinarily surrounds spacecraft returning to earth from orbit and temporarily blacks out their radio communications systems.

Spin waves—Magnetic energy propagated through a crystal by means of atoms whose magnetic poles oscillate in response to certain radio waves like wheat stalks in a wind. Such waves may eventually be used to amplify radio and radar signals magnetically.

These are just some of the quantum chimeras that scientists now have at bay in such unfamiliar solids as gallium arsenide, indium antimonide, cadmium-chromium-selenide, and the like. Though their existence, in most cases, had been predicted for many years, it is only recently that they have revealed themselves in the results of highly sophisticated laboratory experiments. To appreciate how they were found, it is worth while to sketch briefly the picture of solid matter as physicists currently view it.

It began to be formed in 1879 when Edwin H. Hall, a Fellow at Johns Hopkins University in Baltimore, passed an electric current through a metal strip stretched between the poles of an electromagnet. To his surprise, when the magnet was on, he found that part of the electric current was diverted to the edges of the strip at right angles to the main current, like river water into an irrigation trench. He found further that he could tap this right-angle current to do work simply by attaching wires to the opposite edges of the strip.

What he had shown, in fact, was that some kind of negatively charged "fluid" was moving through the atoms of the metal to produce a flow of current. In recognition of this discovery, the phenomenon has since been designated the *Hall effect*.

Eight years later, in Germany, Albert von Ettingshausen and Walther H. Nernst performed the same experiment but used a piece of bismuth spiced with tin as their sample material. Everything went as expected with the exception of one small anomaly—the Hall current produced at the edges of the bismuth had a positive, not a negative, sign. Not surprisingly, they called what they had observed the *anomalous Hall effect*.

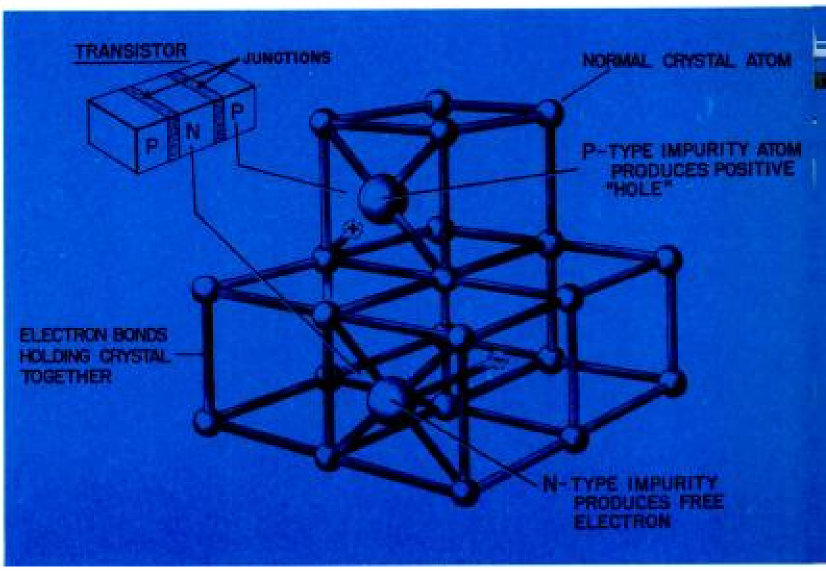
Both experiments gave rise to much head-scratching in scientific circles until 1897 when the British physicist Sir Joseph J. Thomson succeeded in identifying the carrier of negative electric charge as an infinitesimal particle which he chose to call the electron. This explained Hall's results, but what had Nernst and Ettingshausen seen? Scientists shrugged. They had an even bigger problem. Where were the electrons when they were not conducting current?

In 1913, the Danish physicist Niels Bohr answered that one. They were in orbit around the atoms making up the solid, he said. Actually, of course, his answer was more subtle than that. Because of the invention of the "quantum" by Max Planck in 1900 and the brilliant use which Einstein had made of it in 1905 to explain the photoelectric effect, Bohr had to postulate an atom with many orbits in order to accommodate the many electrons of differing energies needed to cancel the positive charges (protons) lodged in the atomic nucleus. Only in this way could atoms be rendered stable and electrically neutral, as we usually find them in nature. Furthermore, he said, no electrons could exist between these orbits (now called shells) because they could never have energies that were fractions of a quantum.

The quantum, according to Planck and Einstein, is the smallest unit of energy that can exist in any given form, though there may be size differences between forms. Thus, a particle may acquire one quantum of energy or many quanta, but never half a quantum or a quantum and a half. The situation is reminiscent of the distinction made between grades of gravel. There is a unit size for each grade—fine, coarse, stony, and the like—and obvious size differences between grades, but none within grades. The concept leads inevitably to the conclusion that the universe and all its wonders could not have been carved or poured. They are the handiwork of a quantum stone mason.

With the promulgation of Bohr's theory of atomic structure, it was now possible for scientists to work out the architecture of solid matter. It must consist of crowds of atoms linked arm-in-electron-arm at their outermost orbits in almost uncountable numbers. The fact that such crowds would tend to form into striking, symmetrical patterns, like swimmers in an aquatic ballet, was also duly noted and helped explain the existence of crystals. But Bohr's model explained little else. Why these crystals had certain optical and thermal properties, why some were electrical insulators while others were electrical conductors or semiconductors remained a mystery.

Great light was shed on all these puzzles in 1925, however, when Wolfgang Pauli, in Germany, enunciated his famous *exclusion principle*, which embodies the surprising idea that no two electrons anywhere in an atom, or aggregation of atoms, can occupy the same energy state at the same time. Here, at last, was a rule which helped explain not only why atoms have orbits but why these orbits contain certain fixed numbers of electrons and, as a consequence, produce certain unique properties in substances made up of them.



ATOMIC STRUCTURE OF SEMICONDUCTOR CRYSTAL

Then, in the period between 1925 and 1930, three theoretical physicists—Werner Heisenberg, Erwin Schröedinger, and Paul Dirac—invented a new form of mathematics called *quantum mechanics* and, with it, the basis for uniting all these findings under one mathematical umbrella. It is the essence of this mathematics that all phenomena in nature can be quantized—treated as consisting of hods of quantum gravel borne on the rounded shoulders of three-dimensional space. In its equations, there is no essential difference between light and matter except the number and grade of energy quanta involved.

This seemingly perverse concept led immediately to some rather fantastic ideas such as Dirac's audacious proposal that a positive electron should exist, or Heisenberg's equally brash suggestion, made in 1931, that a positive "hole" capable of carrying current in certain solids should exist. Both men have lived to see their predictions verified, nonetheless.

In fact, Heisenberg's idea not only explained what Nernst and Ettingshausen had seen some 44 years before in their anomalous Hall experiment but it gave Alan Wilson at Cambridge University in England the last clue he needed to fashion his now famous theory of electron-hole currents in semiconductors.

Simply put, when some electrons holding a crystal of solid matter together receive enough energy from heat, light, or some other source to break free, they begin to drift through the architecture of the crystal like dust motes through a light ray. This leaves the vacated atoms slightly positive and, though they are generally unable to recapture their escaped electrons, their slight charge is sufficient for each to pull an electron over from an adjacent atom. Thus, in effect, they transfer their electron holes from themselves to their nearest neighbors which immediately do the same thing to their nearest neighbors and so on. The net result is that many escaped or free electrons are left drifting around just outside the capture distance of the atoms composing the crystal, even as the atoms are stealing bound electrons from each other to give the impression of positive holes being passed among them.

Finally, when an electrical potential or voltage is applied at opposite ends of such a crystal, the free electrons are sucked toward the positive end while the free holes feel irresistibly drawn to the negative end. Thus, a current is made to flow whose strength is a function of the number of holes and electrons free to move in opposite ways in the crystal.

Atomic Structure of Semiconductor Crystal

A transistor is a single-crystal material like germanium or silicon containing impurity atoms that give a slightly negative or positive electrical character to the region in which they appear. In the typical transistor, (a simplified model of which is shown at the left), there are three such regions with two junctions separating them. The regions are labeled p- or n-type depending on the presence or deficiency of electrons. In the p-type region, the crystal atoms (which have four electrons for bonding with other atoms) are mixed with impurity atoms that have only three electrons for bonding. The impurity atom steals an electron from a nearby crystal atom creating a hole or electron deficiency, which is then propagated throughout the lattice. In the n-type region, the impurity atom has five electrons for bonding. These electrons link up with the four bonds of the regular crystal atoms, leaving a fifth or "free" electron to drift away the moment it acquires any additional energy. When a few electrons are introduced at one end of the transistor, a great many more electrons move out the other end, providing what engineers call "gain"—the measure of how much the incoming current (electrons) is amplified.

Based on an observation first made by the German physicist Bernhard Gudden in 1930, Wilson also inferred that the number of free charges in a semiconductor could be altered by incorporating certain impurity atoms directly into the crystal structure of the material. Depending on what these were, their effect could be to increase either the number of holes available or the number of electrons. This would be so if the impurity atoms were either better electron thieves than the atoms natural to the crystal (in which case they would produce holes) or atoms that would drop one of their outer electrons at the first sign of an energy quantum even more readily than the natural atoms (in which case they would produce more free electrons).

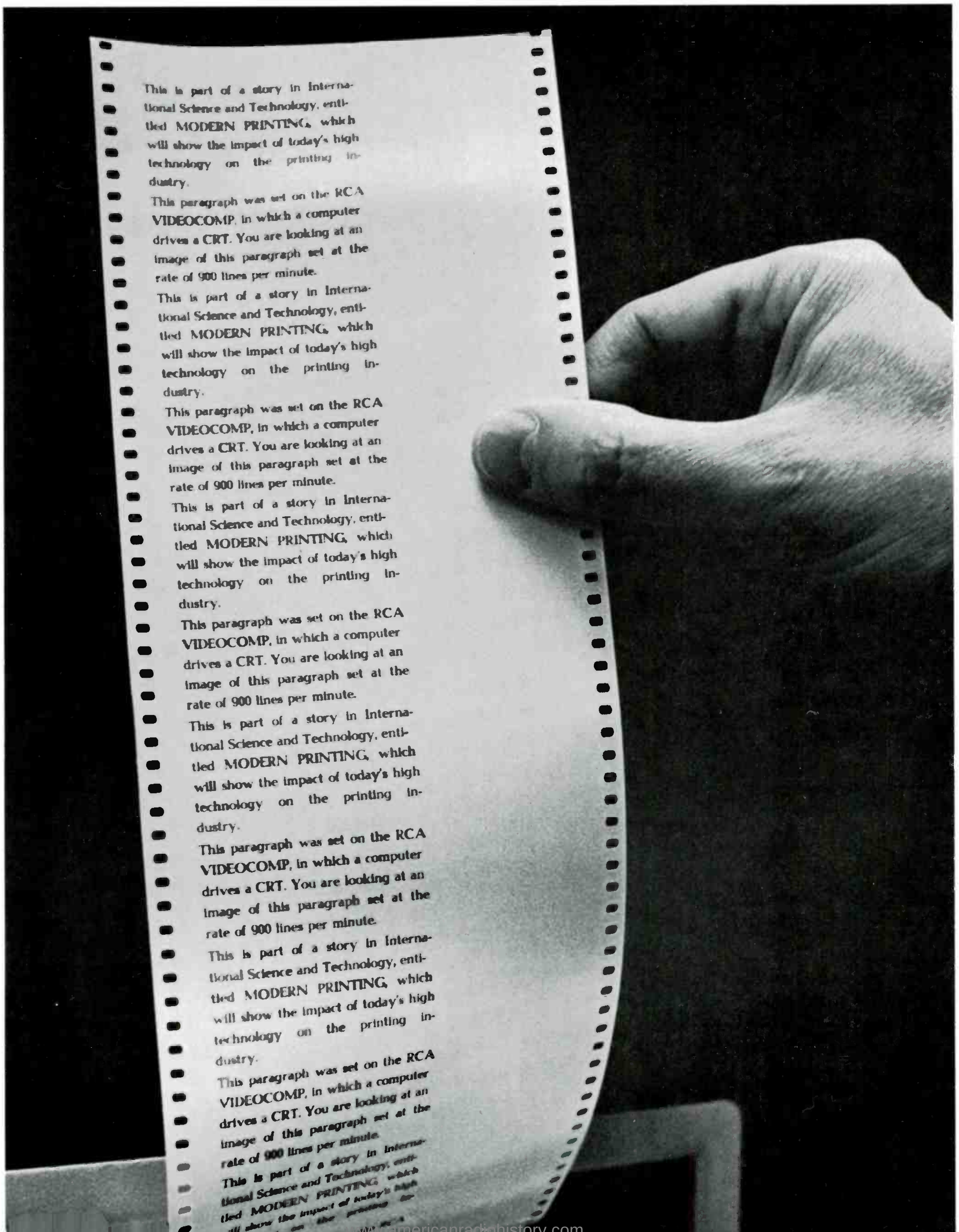
Intrigued by the originality and elegance of these ideas, the renowned Russian physicist Boris Davydov, in 1938, set himself the task of explaining theoretically what would happen if a hole-saturated region (p-type) in a semiconductor abutted on an electron-saturated region (n-type) in the same crystal. After some very involved thought, he concluded that an electric field would be formed inside the crystal precisely at the junction of the two regions and would be of opposite polarity to the free charges. This would prevent the charges from moving over into each other's domain, under normal circumstances, even though there would be an electrical attraction between them. Unfortunately for Davydov, he did not go on to ask himself what would happen if two such junctions existed in the crystal. Had he done so, we might have had the transistor 10 years earlier than we did. As it was, it was not until 1949, one year after the announcement of the point-contact transistor by John Bardeen and Walter Brattain at Bell Telephone Laboratories in Murray Hill, N.J., that William Shockley, also of Bell, thought to ask and answer this crucial question. The result was the invention of the junction transistor—the standard transistor of today.

Of course, the transistor is not the only useful device to which the hole-electron theory has given birth. This same theory has been used over the past 17 years to produce at least five classes of diodes for blocking or controlling alternating electric currents in a circuit—or generating high-frequency microwaves—including standard- and silicon-controlled rectifiers, Zener diodes, tunnel diodes, and avalanche transit time diodes.

It has also fathered such specialty items as the solar cell for converting light directly to electricity, the semiconductive thermocouple for converting heat to electricity or electricity to cold, and the "injection" or semiconductor laser for generating intense rays of coherent light directly from electric current.

Now, however, in addition to new solid-state devices, the theory has even given birth to new and more sophisticated theory. It is in the light of this latter development that the new quasi particles and new energy forms have been discovered. Whether any or all of them will eventually complement or supersede the simple hole and electron in terms of value and usefulness is a moot question for the moment. Chances are they will. If they do not, however, it is certain that solid-state theorists and experimentalists will continue to rummage in the quantum mechanical hope chest of the solid state until they find something that will. ■

The type on this strip of paper was composed electronically through video composition.



Electronics and the Printed Word

New advances for the graphics industry are promised through video-composition techniques that combine the speed of electronics, the image-making abilities of television, and the organizing capabilities of the computer.

by E. L. Campbell

"Breakthrough" is a tired word, often abused by people who get overly excited about small improvements. But it does describe the new role of electronics in the graphic arts.

The breakthrough is a new way to compose the printed word electronically with a new order of speed and flexibility. Called video composition, it begins with a tiny electronic dot that is smaller than a period or flyspeck yet large enough to overshadow all the mechanical and photographic techniques in common use today.

For almost five centuries after Gutenberg put together a printing system featuring movable type, the printed word was the most economical and efficient means of distributing information—the *only* means of mass communication. Then, in the first half of the 20th century, new communications tools—radio, photographs, television, motion pictures, and computers, one by one, and then jointly—threatened the primacy of print.

All the new media were basically electronic. Each provided more rapid means of spreading information. And, predictably, as each new medium arose, there were prophecies of doom. Publishing would be destroyed or, at least, reduced to a feeble cripple.

These reports of printing's death, to paraphrase Twain, were grossly exaggerated. In the last decade, the number of books published annually has tripled, as has the dollar volume of the business. The printing and publishing industries as a whole have grown throughout the 1960s at a rate faster than the national economy.

The reasons for this growth are simple. Although the electronic media can provide almost instantaneous communication to large numbers of people, the communications themselves are transmitted slowly. (A fast radio or television announcer speaks at 150 words per minute; a fast reader can take in 1,500.)

Moreover, the person receiving electronic communications cannot pace himself. He cannot speed through the uninteresting, skip the unimportant, or think carefully and slowly about the vital. The message is given, and then it is gone.

As a result the media do not really compete, they complement. And because they do, man has been able to cope reasonably well with the information needs of the first part of the 20th century.

But not fully. Over the years, an information gap has developed. Knowledge—and man's need for knowledge—has been growing too fast for the communications media to keep up. Textbooks are needed in vast quantities to train the proliferating specialists of society—doctors, lawyers, engineers, scientists, teachers, accountants, technicians—but they can no longer be produced in the customary time frames. Telephone books, parts lists, catalogues, encyclopedias, dictionaries change almost daily.

Technological progress itself is multiplying man's need for the printed word. The nation's space program alone adds more than a million pages of technical data a year. Scientists and engineers turn out more than a million reports, articles, and publications annually. This total (which does not include the more than 100,000 patents filed annually) is expected to double in the next five years.

Man's appetite for timely and complete information has become enormous, and Gutenberg's mechanical techniques, no matter how refined, are incapable of satisfying it. Nor can television and radio, no matter how widespread, be expected to fill the gap.

Thus, there is a paradox. On the one hand are the electronic media, able to operate at fantastic speeds but limited by the fact that information can only be absorbed by relatively slow face-to-face or voice-to-ear communication. And

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the communication itself, unless transcribed, lasts no longer than its transmission.

On the other hand are the print media, permanent by nature and infinitely faster at the moment that communication actually takes place, but dependent on slow, mechanical reproduction methods.

Gutenberg's method of type composition and printing was, in effect, the first mechanical assembly line in which paper, ink, movable type, and printing press were combined into a coordinated system. But today, movable type just does not move fast enough. Although the system has undergone vast improvement, the original concept has not changed. In fact, if Gutenberg walked into a print shop today, he could master the changes of the last half millenium in a few days.

The natural solution to this problem was to combine existing elements—the speed of electronics, the image-making abilities of television, and the organizing capabilities of computers—with the flexibility of print.

The technology was already available. A method of writing words on television screens had long since been perfected. All that was needed was higher resolution and a means of taking the image off the screen in a permanent form, and of graphic arts quality, at speeds of hundreds or even thousands of characters per second.

Computers have been helping set type since the early 1960s—primarily hyphenating and justifying columns of text. The punched paper tape output of the computer was used to drive mechanical linecasters. Over-all speed was improved, but not nearly as much as it could have been. Spinning wheels and gears were just too slow and wasted the fantastic capabilities of the computer to organize, sort, store, merge, and manipulate information.

The ultimate result was video composition, an all-electronic system matching the speed and capability of the computer to the speed and capability of TV's cathode-ray tube. The output is captured instantaneously and permanently on film or paper.

With this method of setting type, characters are simply collections of electronic dots that have been projected onto the face of the cathode-ray tube. An electronic matrix is set up, and a letter is composed by writing dots at the proper position in that grid.

Since the grid is electronic, many things can be done that are impossible with metal or photographic type. Shrinking the grid horizontally will produce a condensed character. Extending it horizontally will result in an expanded character. Tilting the grid will produce an oblique (italicized) character. Shrinking or enlarging the grid in both directions produces smaller or larger type sizes.

The characters themselves are stored in a computer-like memory that, in effect, tells which position to write and not to write dots. As each letter is needed to set copy, it is brought out of the memory and displayed on the tube where it exposes either sensitized paper or film.

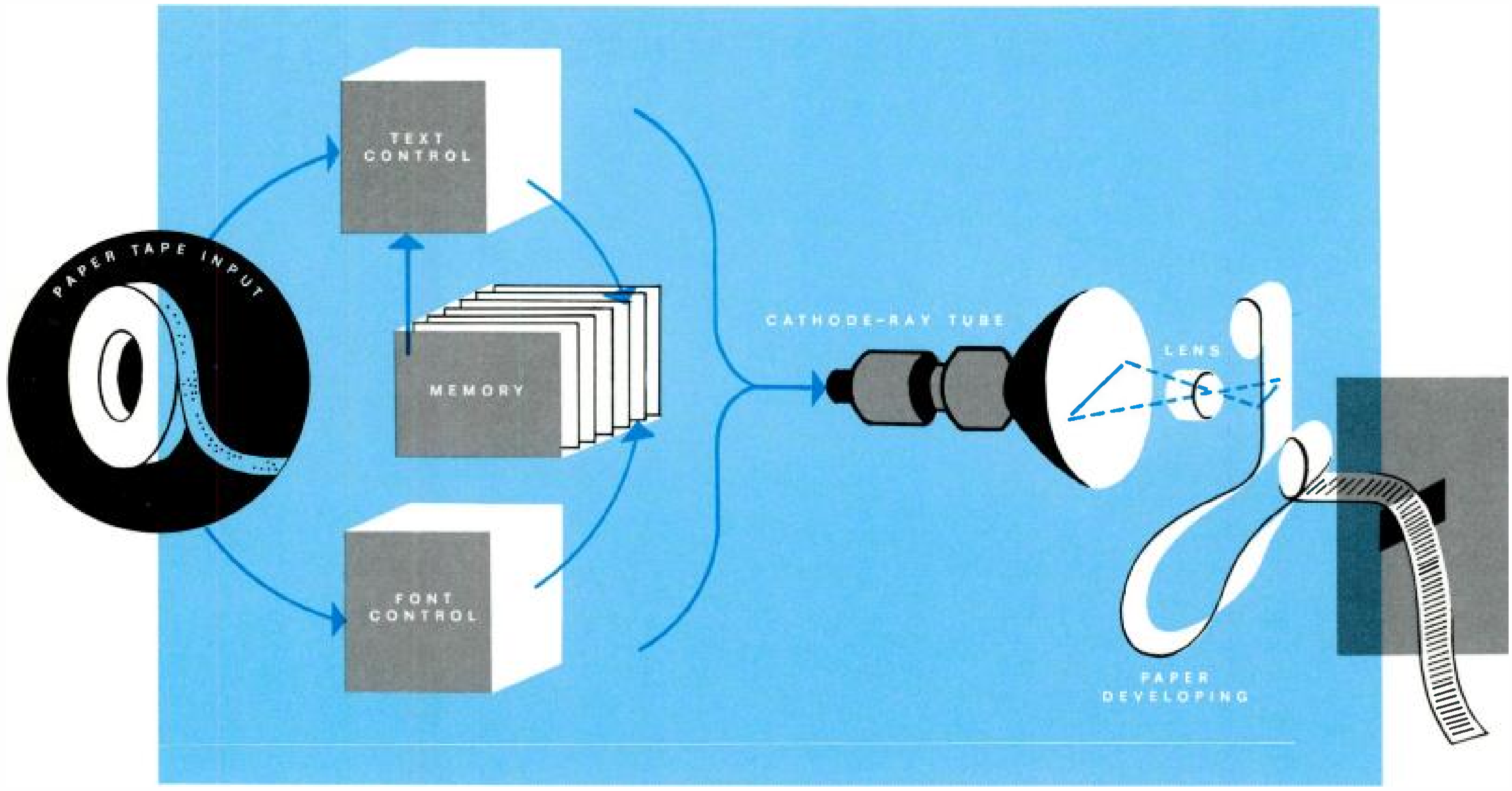
Such video type composition systems are faster and more versatile than any type-setting system ever made. RCA's Videocomp system, for example, can set up to 650 characters a second, more than 100 times faster than manual linecasters. Videocomp has already set text for a complete page of newspaper classified ads, in a variety of typefaces and sizes, in less than two minutes.

To show the extent of the improvement video composition can make in printing, one need only look at the work that goes into publishing the symbol of our growing dependence on information—the encyclopedia.

These massive, multivolumed compendiums of the dull and the exciting, the commonplace and the arcane have been hard hit by the information explosion. Not too long ago, an encyclopedia was good for several decades, and new information could be published in annual supplements. Now, however, major revisions must be undertaken annually or biennially because of the vast changes taking place, particularly in science and world politics. A five-year-old encyclopedia is of little use today to a person seeking information on Vietnam or lasers.

Some of the information in encyclopedias, such as material on Socrates, the War of the Roses, Michelangelo,

RCA's Videocomp system produces printed material at the rate of 650 characters a second.



A schematic diagram of the video method of type composition. Copy is converted to punched paper tape, which instructs the memory portion of the machine to display the characters on the face of a cathode-ray tube. The characters are then exposed onto sensitized paper or film.

Descartes, Boyle, and the like, does not change. Other material, for instance the changing importance of Boolean algebra and Euclidean geometry, needs periodic revision and re-emphasis. Finally, there is the mass of new information that must be inserted each year.

Putting this material into type, revising it, and storing it for future use requires huge expenditures of time and money using conventional printing techniques. A much more efficient and less costly way of reproducing this material is available through the computer/video method of type composition.

Using this method, material for a new edition of the encyclopedia is prepared and put on magnetic or paper tape. The tape, with text, directions for type style, size, indents, and other instructions, would "set the type" for the next edition in a mere fraction of the time that would be required through mechanical methods. The RCA Videocomp, for instance, could be used to set an entire encyclopedia in three days and in a variety of typefaces and sizes. In fact, where needed, the typeface or size can be changed within a single word.

Any character or symbol can be stored in the typesetter's memory, including chemical and mathematical equations, musical notations, Arabic and Roman numerals, and Oriental ideographs.

The original tape is then set aside, to await the printing of the next edition. As corrections, additions, and deletions are made to the material for the next edition, they too are put on tape. When the time for publishing the next edition arrives, the master tape and corrections are fed to the computer which sorts and merges the information, producing a completely up-to-date master automatically.

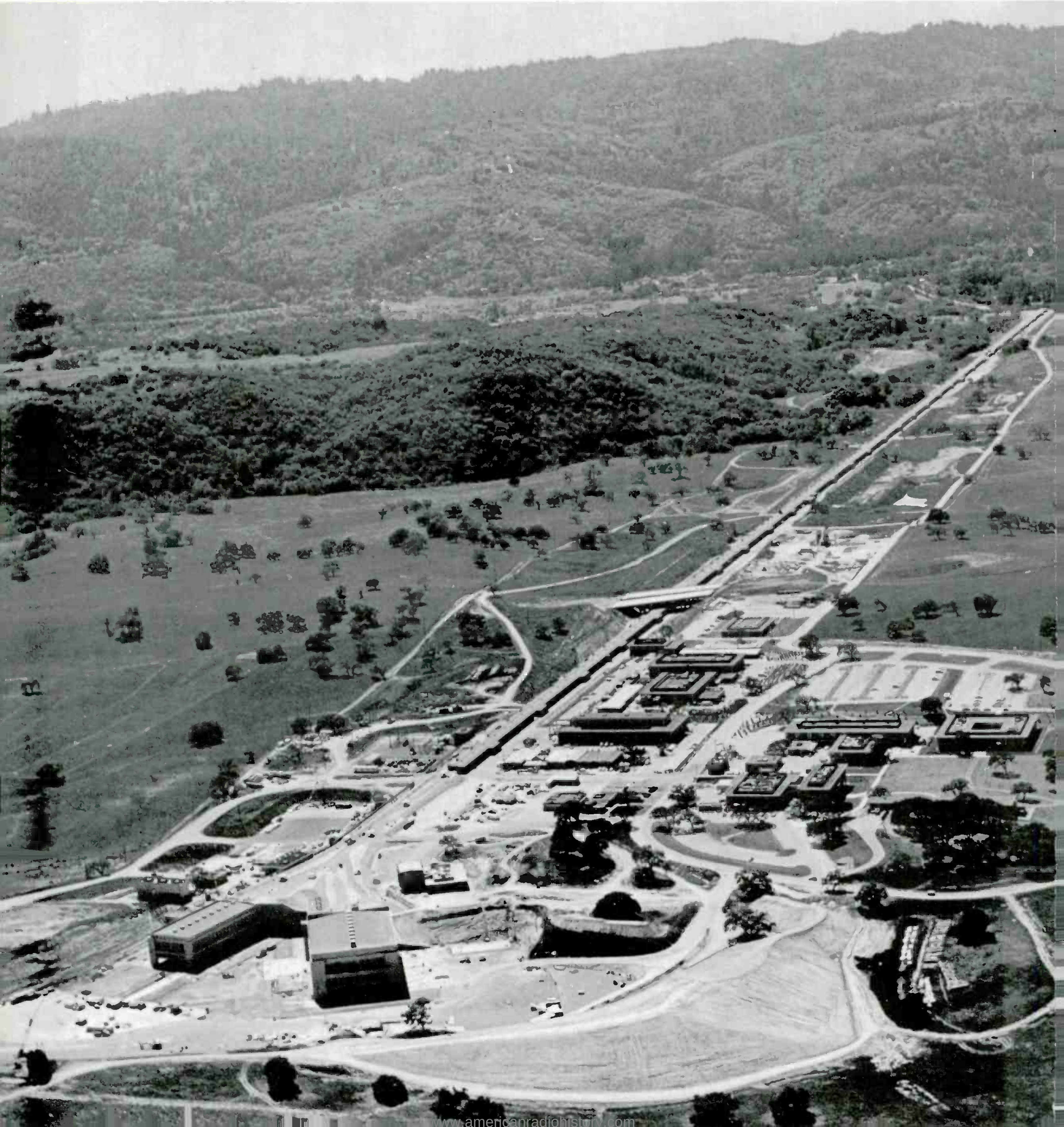
At the moment, video composition is type-and-symbol composition, with the material fed into the system by conventional keyboard techniques. In the future, all material—text, line illustrations, and photographs—will be fed into the computer/video system simply by placing them into optical scanning devices.

With both graphics and text in the machine, it will be possible to lay out each item on the television screen in the proper size. The editor, by applying computer light-pen techniques, will be able to make changes electronically—right on the face of the tube.

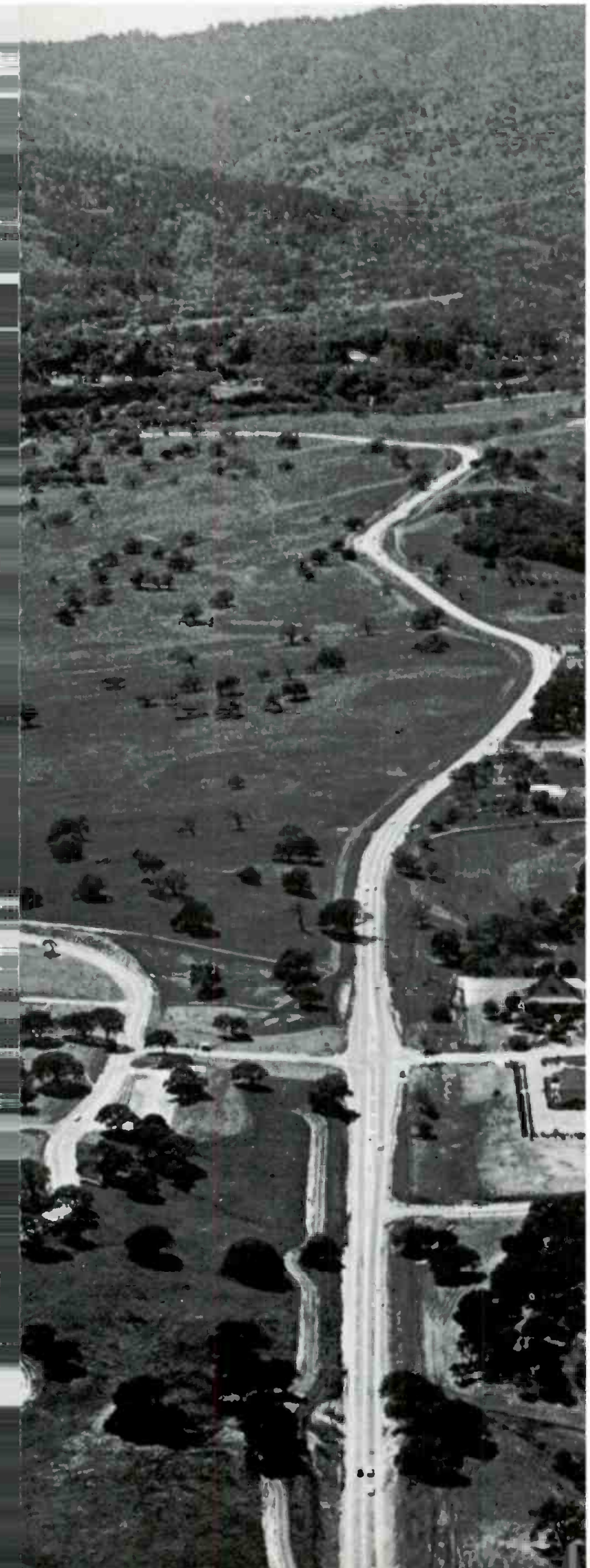
The system would thus combine all the materials into one output: printing-plate-ready material for a complete book, newspaper, or magazine. Gutenberg's cumbersome methods of type composition, like other obsolete technologies, would then be relegated to no more than a reference in encyclopedias that are published almost as quickly as knowledge changes. ■

A "Monster" Probes the Atom

The two-mile-long accelerator at Palo Alto, Calif., where physicists are probing the innermost secrets of the atomic nucleus.



Atomic physicists are gaining new insights into the ultimate structure of matter with the powerful new linear accelerator at Stanford University.



by David Perlman

On a mild April evening in the southern suburbs of San Francisco 11 years ago, a group of physicists and engineers gathered at the home of Dr. Wolfgang K. H. Panofsky, professor of physics at Stanford University, to discuss an extraordinary idea.

The 14 men proposed to build nothing less than the largest—and almost certainly the most expensive—scientific tool that history had yet seen: an underground electron accelerator no less than two miles long. With this tool, they hoped to explore the interior of atoms more intimately than anyone had ever done; to examine atomic nuclei at distances unimaginably small; to burst those nuclei apart; and to probe the nature of the unpredictable particles and forces they knew they would find inside.

Today, their hopes are proving out solidly, and man's scientific progress is attaining another milestone.

Those men, all faculty members at Stanford, were in the atom-smashing business. They had been developing an exciting new breed of linear accelerators, designed to bombard matter with high-energy beams of electrons. Armed with a relatively new invention called the klystron—a device to amplify microwave radio power—they had already built a 210-foot-long accelerator that achieved energies of 600 million electron volts. With this machine, one of the group, Professor Robert Hofstadter, was to win a 1961 Nobel prize in physics for deducing from the scattering of electrons by atomic nuclei the intricate structure of protons and neutrons.

At their 1957 meeting in Panofsky's home, the scientists dreamed of far greater achievement than a mere few hundred million volts. The two-mile machine they conjured up would bombard atoms with bursts of electrons accelerated to energies of at least 15 billion electron volts and that might be boosted as high as 40 billion or more. It would be far and away the largest, most powerful accelerator of its kind in the world. It would be devoted to fundamental physics research and would be available to scientists of all nations; its experiments were to be free, open, and unclassified.

For week after week, the Stanford scientists met, drew plans, and worked out details—all on their own time and with no official support. They called their brain child "Project M"—and none of them today remembers whether the "M" stood for multi-billion volts or for monster.

Within a year, the enthusiastic Project M group had drafted formal proposals for the Atomic Energy Commission, and on September 15, 1961, after four years of political and scientific debate, Congress authorized creation of a national facility to be called the Stanford Linear Accelerator Center—at a cost of $114 million.

During the Congressional hearings, there were several site proposals. Representatives from the State of Washington, for example, tried to advance the merits of an abandoned

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railroad tunnel near Seattle as the site for the two-mile-long accelerator; Nevada enthusiasts proposed an old silver mine deep in the fabled Comstock Lode at Virginia City. But Stanford won out, and the final site was a 480-acre tract of campus land, leased to the government for $1 a year.

Dr. Panofsky, who was host to the early planners of Project M, became its director and guiding genius. Short, stocky, ebullient, merry, and brilliant, Panofsky is a five-foot-two-inch package of informality, unquenchable energy, and dedication. He led a team of men who could design with skill, schedule with precision, invent with originality, and improvise with boldness and dash. Panofsky even managed to commute regularly to Washington for service on the President's Science Advisory Committee while he kept a tight hand on costs, manpower, and time schedules at the Accelerator Center.

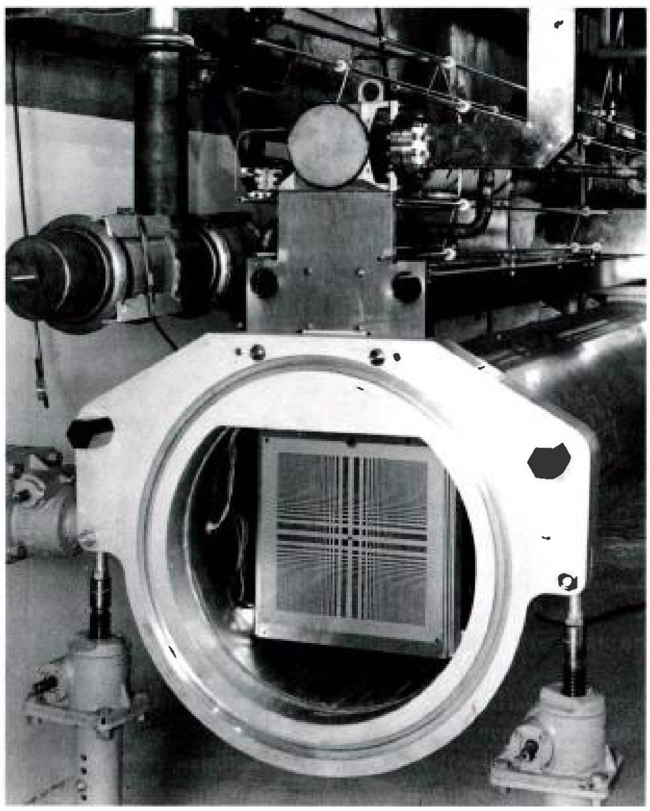
Today, the Center is a going concern. Completed last fall six months ahead of schedule and right on budget, the accelerator's beam has already pushed past 20 billion electron volts. Experiments that cannot be duplicated anywhere else in the world are in progress. A staff of 1,100, including more than 300 scientists and technicians, is at work.

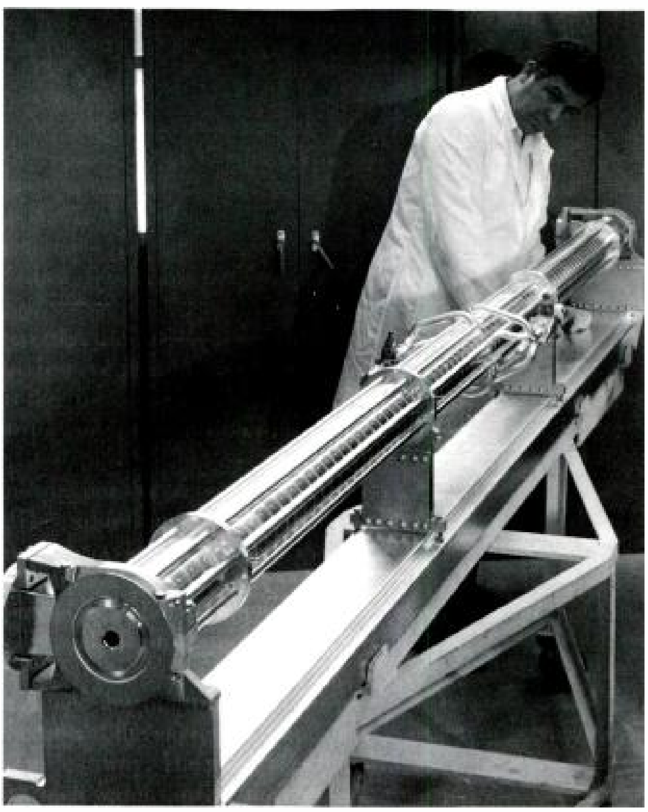
For many years now, the world of subatomic physics research has seen an international high-energy race. America has its 30-billion-volt proton Synchrotron at Brookhaven, N.Y. The nations of Western Europe have pooled their resources in a jointly built machine of similar size at Geneva. The Russians are pushing construction of a 70-billion-volt behemoth, and American physicists have replied with proposals for a 200-billion-volt super-behemoth—which, if Congress ever approves its $370 million price tag, is to be built in Weston, Ill., near Chicago.

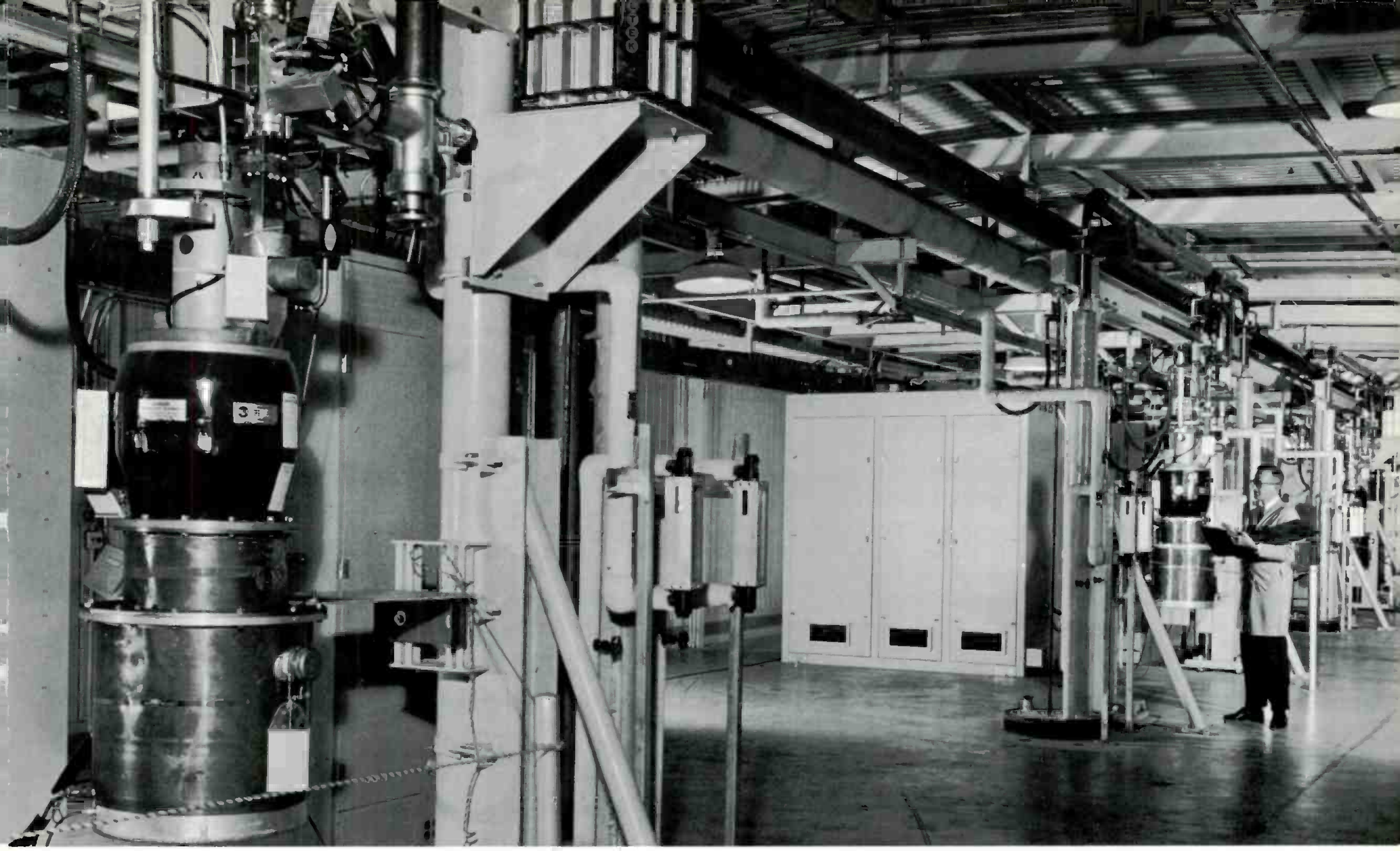
Why all this high energy? The answer lies in the impenetrably tiny size of nuclear particles. If they were only large enough, an optical microscope might examine them. But ordinary microscopes can never see anything smaller than the wave length of light—objects a thousand times the radius of an atom, a hundred million times the size of an atom's nucleus. But with high-energy beams of atomic particles—like protons or electrons, for example—a physicist has a probe of extremely short wave length that can "see" at atomic dimensions. The shorter the wave length, the smaller the object that can be "seen," and the key to short wave lengths is high energy.

Such a high-energy beam can knock an atomic nucleus apart; with appropriate detection devices it can enable physicists to infer the nature of the interior of the nucleus. It can liberate all sorts of short-lived particles from a nucleus, and these cascading particles offer even more sophisticated clues to the nature and ultimate fine structure of all matter.

In Stanford's new accelerator, electrons boil off a heated tungsten filament at the "injection end" of the machine and flash in bunches down a four-inch-diameter copper tube to their target two miles away. Along their precisely steered path, 240 klystron tubes feed radio-frequency energy to the electrons through a web of wave guides spaced 10 feet apart. Each pulse of the electron beam, less than two millionths of a







Above: High-power klystron tubes boost the energy of the accelerator's electron beam to more than 20 billion electron volts.

Far left: A retractable plate in the interior of this supporting aluminum girder is used for precise alignment of the accelerator's path.

Left: One of the 10-foot sections of the accelerator. The electrons travel in bunches down the copper tube in the interior of the section.

second long, is fed a burst of new energy from the swiftly cycling klystrons every 10 feet.

Since the electrons start their two-mile journey at almost the speed of light, they can pick up very little more velocity as they go. Instead, the energy from the klystrons beefs up the mass of the electrons—just as Einstein predicted in his famous equation—until the tiny negative particles have become massive bundles of energy that can burst nuclear targets into showers of revealing particles.

The scientific development of the accelerator had its beginnings at Stanford in the 1930s when the late Professor William W. Hansen and a graduate student, Russell Varian, were roommates. Together, they conceived two seminal devices: one was a resonant copper cavity that, by oscillating under the impact of radio-frequency power, could accelerate a burst of electrons as they passed through holes bored in the front and rear plates of the chamber. They called this device the "Rhumbatron" because of its hippy oscillations. Later, stringing the cavities together in a segmented length of pipe, Hansen developed a technique for sending a traveling wave of radio-frequency power down the device along with the electrons. The wave infused the electron beam with continuously added energy—like an ocean wave speeding a surfer atop its rapidly moving crest.

The years just before World War II brought a great burst of scientific energy in radio-frequency power, for radar was to be one of the high-priority keys to victory. Russell Varian and his farsighted airline pilot brother, Sigurd, set out to find a device that would amplify feeble rf power to the formidable levels needed for radar detection. The klystron tube was the answer.

At one end of a klystron, a stream of electrons is injected into a cavity called a buncher, which is excited by a small microwave signal. This oscillating cavity bunches the electrons together and sends them down a drift tube. And when these bunched electrons enter a second cavity—known as the catcher—they excite it into powerful oscillations that can be transformed into highly amplified microwave power.

The klystron, which quickly became a major tool for radar and physics research, was to prove the basis of continually larger and more successful linear accelerators at Stanford. Hansen died in 1949; Russell Varian a decade later, and Sigurd Varian in 1961. Laboratories and an industrial corporation bear their names; but the achievements of Stanford's accelerators are their most enduring monuments.

Out of the first Rhumbatron has evolved the two-mile pipe of the new accelerator, with 80,000 copper cavities separated by 80,000 copper disks—their central quarter-inch holes so precisely lined up that the electron beam never wavers a hair as it courses down the entire array.

And out of the first klystron have come the 240 sophisticated tubes that pulse their power to the accelerator beam. RCA manufactured the largest number of the klystrons in the new accelerator; Litton Industries, Inc., and Stanford's own laboratories at the Linear Accelerator Center also supplied them, as did Sperry Rand Corp., and Eitel-McCullough, Inc.

The accelerator itself is an intriguing structure. Its long copper tube lies deep underground in its two-mile concrete tunnel, topped by 25 feet of solid earth shielding to absorb any possible traces of radiation. At ground level directly above the accelerator tunnel is the 10,000-foot-long steel shed known as the klystron gallery. Here stand the klystron tubes like an interminable file of squat barrels, gobbling up 25,000 kilowatts of electricity and feeding their pulses of amplified microwave power down through the earth shielding to the accelerator pipe below. Some day, when the accelerator's energy is boosted to 40-billion electron volts, it will be a simple matter to add more klystrons in the gallery to do the job. And while the accelerator's peak power requirements today are already a massive 25,000 kilowatts, future plans for full-scale operation foresee a need for 100,000 kilowatts for the accelerator alone, and as much as 300,000 kilowatts for the whole laboratory.

At the far eastern end of the accelerator, beneath an area that will soon become parklike as planted trees mature and lawns flourish, lies the beam switchyard where huge electromagnets bend the accelerated electron beam and send it into two massive target buildings. The switchyard can concentrate the entire beam at a single target in one building or split it so that experiments in both buildings can operate simultaneously.

The target buildings are radiation-shielded outside by high earth embankments and inside by 50,000 tons of scrap steel and lead. Chunks of armorplate from the dismantled cruiser *Vicksburg*, sawn-up segments of 16-inch gun barrels from the Navy's once-proud battleship *Indiana*, and a scattering of metal from ancient 155-millimeter field pieces comprise much of the shielding.

The accelerator beam was first turned on last May and dazzled its builders by performing almost flawlessly from the start. It achieved energies higher than early expectations and quickly reached 18.4 billion electron volts. Experiments began almost at once, and the accelerator is now running better than two shifts a day. In the next few months, as the research tempo speeds up even more, a dozen experiments in fundamental high-energy physics will be undertaken. Teams made up of scientists from Harvard, Massachusetts Institute of Technology, the University of California Lawrence Radiation Laboratory, California Institute of Technology, and Stanford have been assigned to share beam time and experimental space during this first year of operation.

One experiment has already been completed: a detailed study of the production of short-lived particles such as Pi mesons, K mesons, and anti-protons out of nuclei under bombardment by the electron beam. These high-energy particles poured out in abundant quantities, providing data that will yield valuable new insights into nuclear structure and auguring a successful future for the great machine.

In another experiment, physicists have been measuring the scattering of electrons as they strike proton targets. In this case, the probing beam is aimed at a bottle of liquid hydrogen, whose atoms each contain a single proton for a nucleus. The scattered electrons, flashing off in all directions, are trapped and sorted out in an elaborate array of spectrometers, scintillation counters, and other detectors. This classic type of scattering experiment illustrates just how physicists use an accelerator to "see" into the heart of an atom—not by direct vision but by inference. Tracing the paths and energies and numbers of the scattered electrons, a physicist can infer much about the structure and properties of the original target protons that scattered the beam. All the varied families of nuclear particles will be studied in Stanford's new accelerator, and the beam is already on the hunt for new and hitherto unpredicted atomic particles that may populate the "subnuclear zoo."

For this is the great mystery and challenge of high-energy physics: to discover, if possible, the most fundamental constituents of matter and the basic laws that govern its form and structure.

In the days when Stanford's accelerator was still no more than the name "Project M," a panel of Presidential advisers headed by Dr. Emanuel R. Piore evaluated the significance of high-energy physics to mankind. Like poetry, their report was profound and true.

"Physicists," they said, "now not only comprehend the structure of stars, the motion of our own and other galaxies, the curvature of space, the possible ways in which our universe has evolved but also matter on a finer and finer scale: from familiar objects to molecules; then to the atoms of which molecules are composed; the internal structure of the atom with its electrons orbiting around nuclei; the nucleus itself, made of protons and neutrons and the mesons which bind them together; and lately even something of a picture of the inside of the proton itself, complex and containing yet other particles.

"We are peeling an onion layer by layer by layer, each layer uncovering in a sense another universe; unexpected, complicated, and—as we understand more—strangely beautiful."

And Professor Panofsky, the Accelerator Center's chief, speaks to the urgency of the research:

"All other physical sciences, and probably all life sciences," he says, "must ultimately rest on the findings of elementary particle physics. It would indeed violate all our past experience in the progress of science if nature had created a family of phenomena which governs the behavior of elementary particles without at the same time establishing any links between these phenomena and the large-scale world which is built from those very particles.... We cannot afford to be ignorant of the most fundamental type of structure on which everything else depends." ■

A microwave "dish" goes up on a Cleveland office building to become a link in Western Union's transcontinental communications system.

Microwave: Supercarrier of Communications

Little more than two decades old, microwave is meeting the vastly expanded communications needs of railroads, pipelines, utilities, and other private users.

by Edward J. Dudley

Exceptional reliability, huge capacity, and lightning-like speed have made microwave the supercarrier of communications in little more than two decades. Half of all long-distance telephone calls move over its beams. Computers "talk" to each other via microwave. A technician uses it to command a pump to start, many miles away. Police and turnpike authorities rely on it to keep traffic moving, tolls tabulated, and criminals cowed.

Microwave messages are transmitted over dishlike antennas that are spaced some 25 to 30 miles apart over the terrain. Lately, antenna towers have been sprouting in hundreds of new locations across the land, signifying a communications surge for the railroads, pipelines, utilities, and other users of private two-way microwave systems.

The rail carriers, for example, are turning increasingly to private microwave in order to handle a growth in data communications alone that some industry sources estimate

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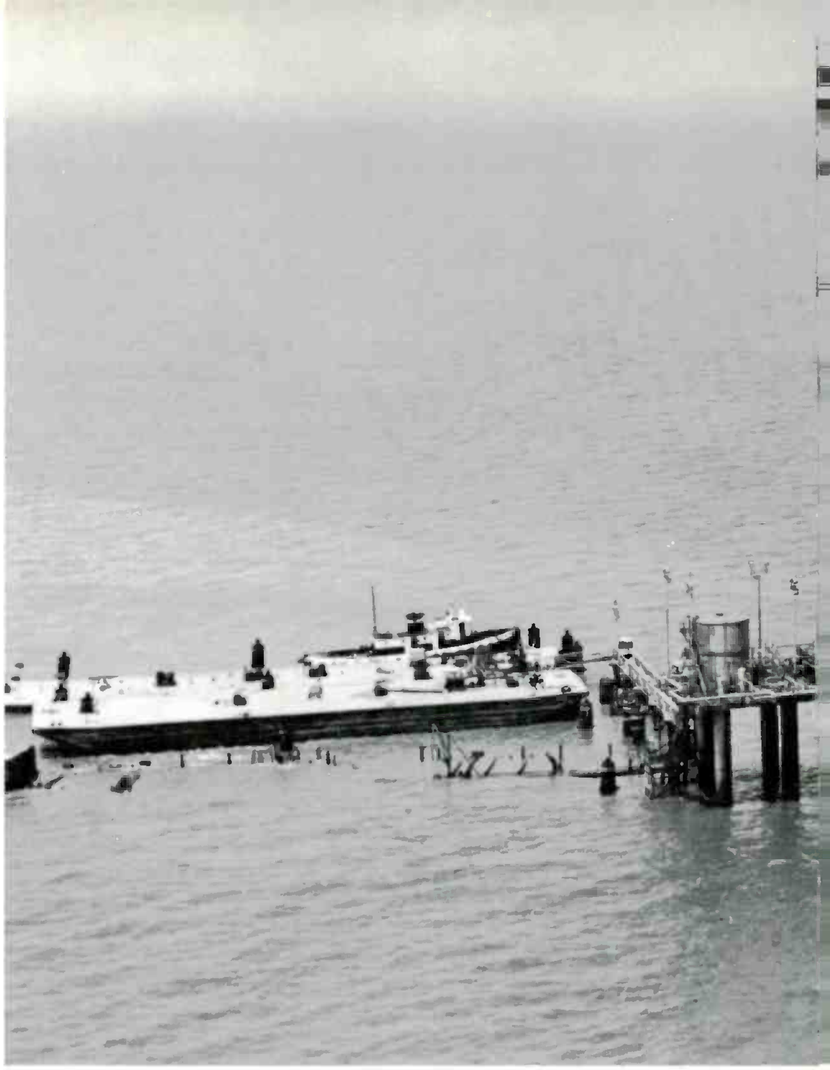
at 40 per cent annually. Microwave is relatively new to railroads, yet 22,000 route miles already flank their rights of way. And within 10 years, they are expected to be operating more than 50,000 route miles of microwave systems.

While data-handling growth is more spectacular, the railroads look to microwave to meet increased needs in teletype, facsimile, and other communications areas. And with 150-mile-per-hour trains and more automated control of rolling stock on the way, communications requirements are likely to rise further.

Relatively few privately operated microwave systems existed before 1957, the year the Federal Communications Commission set aside frequencies in the 6,000-megaHertz range for pipelines, railroads, utilities, and other right-of-way organizations. Then, as now, the telephone and telegraph companies and other common carriers—with nearly 800,000 route miles currently in operation—were the major users of microwave.

Microwave historians generally fix 1931 as the year when it was discovered that high-frequency radio waves could be focused into narrow beams somewhat like light for point-to-point communications. But the microwave field lay essentially fallow until World War II when the development of radar, which also makes use of high-frequency radio signals, was to reveal its communications potential.

In 1945, the Radio Corporation of America designed and built for Western Union the microwave radio equipment used to establish the nation's first two-way commercial microwave system, which linked New York and Philadelphia. A piece of that equipment is now on exhibition in the Smithsonian Institution as an early relic of microwave technology.



This snow-encrusted microwave antenna above the clouds in Utah beams TV programs 136 miles to a receiving station in Idaho.

The New York-Philadelphia system covered the 85 miles in three hops and could transmit messages at the then satisfactory rate of 60 to 100 words a minute. By contrast, Western Union in 1964 placed in operation a new $80,000,000 transcontinental microwave system capable of handling a million data signals in one second in each direction.

The basic radio equipment of the Western Union network was developed by RCA specifically for high-capacity, long-distance service. Its channels are 40 times as wide as those available in the original system, giving the new network its tremendous appetite for business data, voice, facsimile, telegraph, television, and other services. Such huge capacity has given rise to the description of microwave as "big pipe" communications.

Like other big microwave installations, the Western Union system is made up of a series of repeater stations located within the line of sight of each station. A transmitting parabola at the originating point focuses the microwave energy into a narrow beam that is aimed at the receiving dish. Upon arriving at the relay station, the signals are amplified and sent to another transmitting antenna where the process begins all over again. Thus, messages flash from

Shell Oil Company pumping station nearly 20 miles out in the Gulf of Mexico is connected by microwave to company offices.

coast-to-coast in a fraction of a second. Any kind of intelligence that can be reduced to electrical impulses can be "fired" as a microwave radio beam.

Microwave relays both color and black-and-white TV programs to stations in virtually every corner of the nation. Receiving dishes atop theaters and auditoriums bring in the pictures of championship boxing bouts and other sports events. Microwave jumps lakes and broad rivers; it stands up against sleet storms that often knock out pole lines. It can even cook a roast in a fraction of the usual time, and before long housewives are promised microwave ovens priced for the home kitchen.

As the name suggests, microwaves have extremely short wave lengths, as little as a half-inch at ultra-high frequencies. Their abbreviated length led to the solution of a problem that occurred several years ago when a private microwave operater installed a large "passive repeater" in expanding his system. The passive repeater, which looks like a metallic billboard, is to a microwave signal what a backboard is to a basketball. It reflects the signal in a predetermined direction.

As soon as the repeater was erected, neighboring TV viewers complained of severe "ghosting" in their pictures. The trouble was quickly traced to the repeater, which was reflecting TV signals as well as those intended for it. The engineers' remedy was to install a facing of "hog fence" in the front of the repeater. The fencing allowed the short microwaves to pass through but reflected the TV signals skyward, where they could not cause secondary images on the home screens.

In one of the most rugged parts of the Rockies, a local telephone company chose microwave relay to replace wire lines destroyed by flood. But the line-of-sight paths between the mountain passes would permit only one- or two-mile hops, making the cost prohibitive.

The solution lay in hauling passive repeaters to the mountaintops by helicopter. The radio frequency equipment then could be installed near highways at lower and more accessible elevations and its signals aimed at the reflecting surfaces. The reflectors bounced telephone conversations from peak to peak and finally back down to the receiving point.

In Missouri, impulses beamed by microwave from a power company headquarters control the energy output of a hydroelectric plant some 100 miles away. The plant uses the pumped storage principle in which water flowing through a

"Today, and for a long time to come, microwave will be indispensable in helping to harness the information explosion."

1½-mile tunnel from a mountaintop reservoir to a lower point turns the plant turbines. The generating cycle occurs during periods of peak power use. When it is completed, the turbines are reversed to pump water back up to the storage reservoir to await the next big demand for electricity.

Besides controlling the operation, the microwave system carries telemetering information measuring the megawatt load being generated at the power plant, the volt-amperes of its two generating units, and the water levels of both the upper and lower reservoirs.

Another big power company uses an RCA 26-station microwave system to link a new computer center with two of its operating divisions. The computers provide centralized customer billing and accounting as well as automatic load dispatching and other operations control, with all of the information moving swiftly over microwave's unseen "pole lines in the sky."

Within the last two or three years, educational television has begun making increased use of microwave frequencies, largely as a result of the FCC's action in 1963 to set aside 31 channels in the 2,500-megaHertz band for educational systems. The new service makes it possible for a school or college TV facility to put up to four different lesson programs on the air at the same time.

The low-power and short-range TV signals are radiated like those carrying conventional TV programs, yet transmitters used in the educational service are considerably less expensive. Since broadcasts are on microwave frequencies, such programs cannot be picked up by the home TV receiver. This gives 2,500-mHz broadcasting the same advantage of privacy enjoyed by closed-circuit TV systems carried by wire.

Microwave dishes atop the school receiving locations collect the incoming signals and relay them to a converter which makes them capable of being viewed on a standard TV set.

The nation's largest system of this kind, recently put in operation by the Catholic Archdiocese of New York, uses a combination of point-to-point microwave relay and omnidirectional broadcasting to reach its 400 schools in 10 counties. Programs are relayed from studios located in Yonkers, N.Y., to six broadcasting locations where the signals are radiated in a pattern covering schools within the limited range of the transmitter.

In the Gulf of Mexico, microwave transmitters at oil drilling rigs 100 or more miles offshore enable a land-based geologist to follow drilling progress almost as well as though he were on the scene. The microwave circuits send digital and facsimile information on earth strata being penetrated back to the home office for evaluation, effecting a substantial saving in engineering manpower and travel time. Once the oil well is in production, its meters are read and pumps, valves, and other equipment controlled remotely by microwave.

Microwave plays an equally important role in helping commercial aircraft pilots plan flights from the New York City area. Transmitting antennas atop the RCA Building, where the New York Weather Bureau is located, beam images produced by the Bureau's weather radar directly to the city's three major airports.

There the images are electronically converted to television pictures viewable on a closed-circuit system. By watching TV monitors in flight-briefing rooms, the pilots can observe existing weather patterns within a 280-mile radius of New York as they are painted by radar. Before the system was devised, meteorologists in the RCA Building analyzed the radar pictures and prepared the data as teletype messages, which were transmitted to the airports and there interpreted for flight planning.

The growing acceptance of microwave for privately operated communications systems stems in large measure from the sophisticated, new-generation equipment now available. Its all-solid-state construction, a design pioneered by RCA's type CW-60 microwave, has pushed operating reliability to the near-perfect mark. For example, a CW-60 transmit-receive system in RCA's Camden, N.J., microwave laboratory has been in constant operation for the past five years. During this period, there have been no component failures, and the equipment needed only minor adjustments.

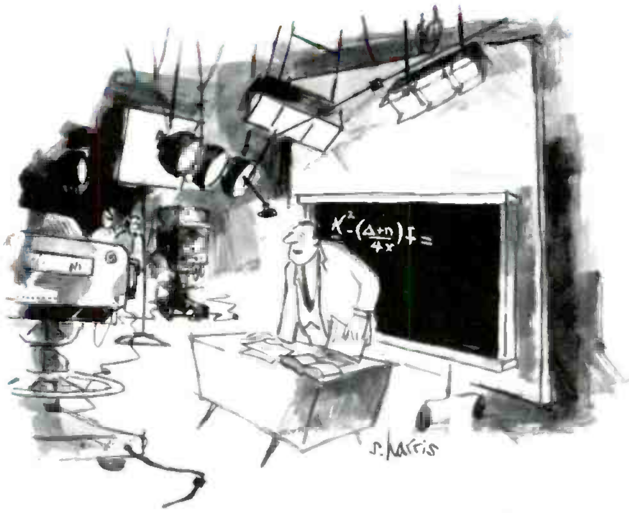
One railroad using such microwave equipment reported "down time" of only 32 seconds for a full year. Another microwave system operated by a gas pipeline was "out" only one hour during the year, for a 99.99 per cent reliability record for its 13,000 route miles.

Reliable performance is a prime requisite of microwave systems whose relay stations often must be located at remote points to take advantage of high elevations. Equipment without tubes to change or mechanical relays to get out of order can keep maintenance visits to unattended relay stations to a bare minimum. Transistorized circuits also require low power for operation, assuring the continued operation of a remote station on its stand-by batteries if the regular power supply should fail.

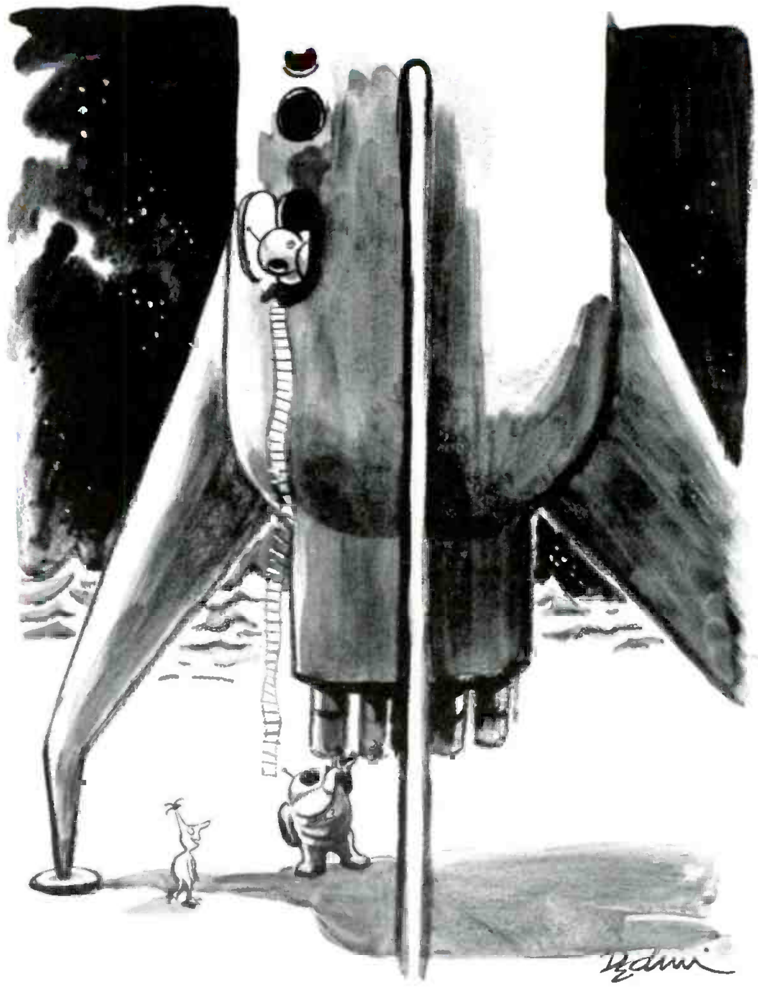
Such techniques as frequency diversity and space diversity contribute materially to the performance record of microwave. With the former, identical signals are sent over two separate frequencies and the receiving equipment automatically selects the one giving the best transmission at a particular instant. This minimizes the fading effects of microwave signals which sometimes occur over water.

Space diversity makes use of two receiving dishes separated by some 35 or 40 feet to give a difference in microwave path length of about one-half wave length. The principle here is that when fading occurs on one microwave path it rarely occurs on another at the same time. As in the other technique, the receiving equipment makes an instantaneous switchover from the signal that is fading to the better one.

Laser beams and other new forms of communications may challenge microwave in the future. Yet today, and for a long time to come, microwave will be indispensable in helping to harness the information "explosion" and the pressures for social and economic progress that it is releasing. ■

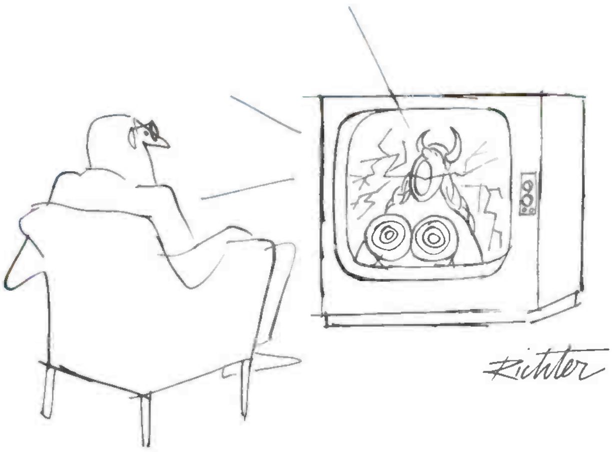


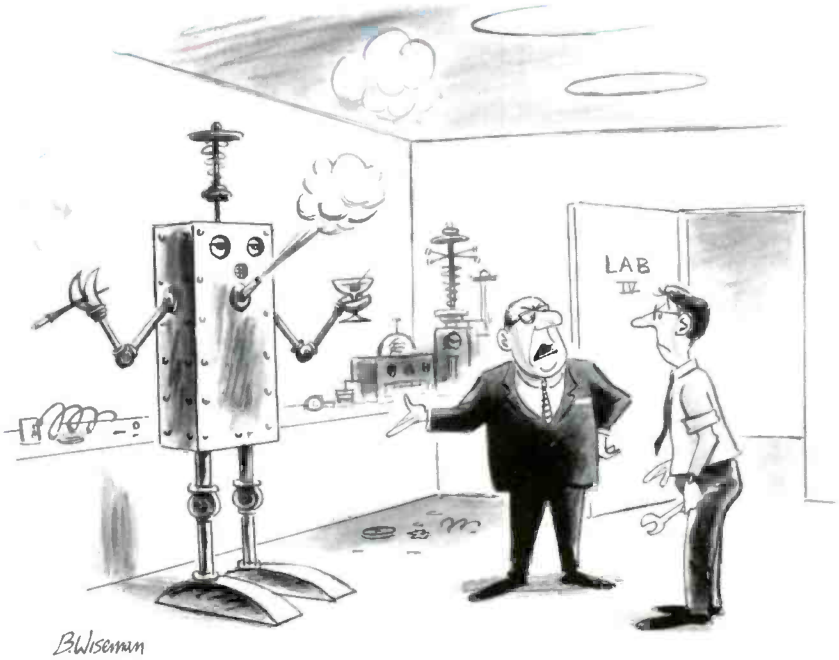
"Will the formula offer a clue to the structure of the atom, or will it merely equal zero? Tune in tomorrow..."



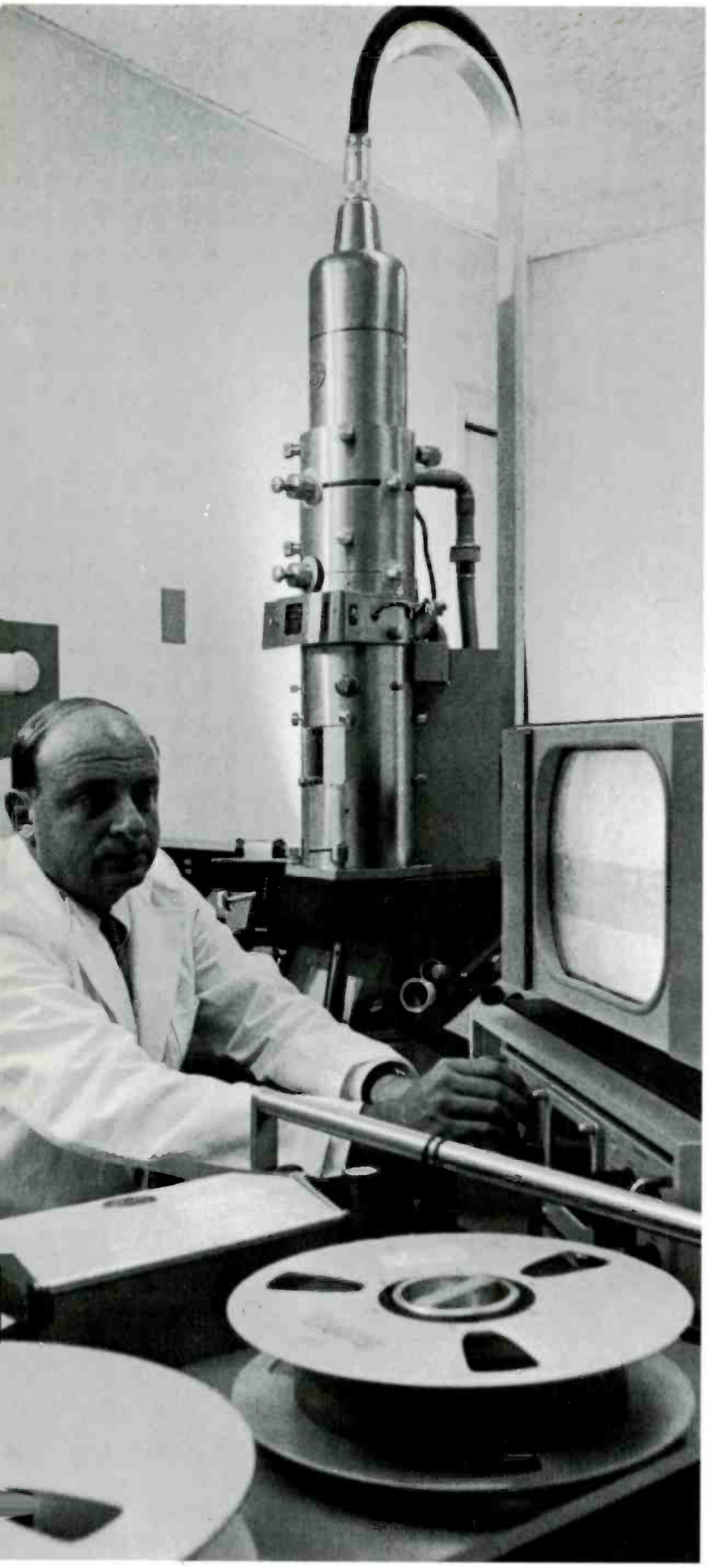
"Maybe you flooded it."

THIS ELECTRONIC AGE...





"Compton, I don't think you quite understand what I mean by 'sophisticated hardware'."



A light-sensitive tube called an image intensifier boosts tenfold the magnification of specimens viewed by this RCA Electron Microscope.

New Life

In spite of its age and the incursions of the transistor, the versatile vacuum tube continues to exhibit extraordinary vigor.

by Jan Syrjala

In a research laboratory on the West Coast, experimenters produce an electron tube so small it takes a microscope to see it. In another laboratory, tube engineers fashion prototypes of television camera tubes that can "see" perfectly well by starlight. A third kind of tube, called an image converter, helps to make photographs at exposures of billionths of a second.

These three examples, chosen more or less at random from the frontiers of the electron-tube art, offer proof that this time-tested, versatile electronic device continues to exhibit extraordinary vigor in spite of the incursions of newer devices. Engineers are reaching out in a bewildering variety of new directions to extend, diversify, and enrich the technology that was founded with the electron tube 50-odd years ago.

This new-found vigor may have been obscured for many nonprofessionals by the onsweep of the transistor, born as recently as 1948 and now coming into broad use. The transistor and its sister solid-state devices have, of course, taken over large areas that used to be the province of the tube, and they promise to absorb even more functions as time goes on.

But the immense family of techniques that make up electronics is expanding so fast that the capacities of both tran-

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JAN SYRJALA is an engineer who has written frequently on electronics for the *New York Times* and other publications.

for the Electron Tube

A group of supersensitive RCA television camera tubes used in the Navy's air-to-surface "Walleye" weapon near completion.

sistor and electron tube are needed in ever new varieties. There is constant pressure on manufacturers for more ingenious, more sensitive, and more powerful tubes.

Because of their enormous and growing variety, it may be useful to state what an electron tube is. The essential idea is the release of a stream of electrons into an interior space that is more or less free of air (hence vacuum). The electrons travel from one electrode to one or more others, on the way constituting an electric current that is responsive to the most delicate control. The sensitivity of this current-in-space is responsible for all those extraordinary powers of perception and communication that electronics has come to mean.

In the transistor and related devices, the current moves through the molecular interstices of solid crystals.

An additional element must be added to those vacuum tubes that treat of light: a surface that releases electrons when struck by light (a photoelectric surface), or one that glows when struck by electrons (fluorescent screen).

A brief tour of the expanding world of the vacuum tube can touch only a few highlights, but they suggest the broad scope and reach of today's tube art and practice. To start with the familiar, there is the picture tube in the ordinary television receiver. Inside the set are a number of tubes of the receiving type, the same that are so familiar from radio. It seems likely that over a period of time many or all of these inside tubes will be replaced by more reliable solid-state electronic devices. But the reproduction of the television picture, at least for the moment, is the unchallengeable property of the large vacuum tube at the face of the receiver.

This same tube, generally called a cathode-ray tube, is the heart of an instrument that is essential in a thousand different roles in research and development—the cathode-ray oscilloscope. Without the oscilloscope, a large percentage of the research laboratories in the world, in many branches of science, would come to a near-standstill. This fantastic tool will tell at a glance whether some event lasted a thousandth or a millionth of a second or which of two millionths-of-a-second events came in first, and by how much. It will "freeze" in a stationary light pattern the fastest vibrations in nature or man-made devices, or permit the closest examination of any tiny section of the vibration. In physics, in biology, in medicine, as well as in nearly every branch of engineering, the oscilloscope is something like a universal super-eye. Men would be blind without it.

The cathode-ray tube turns electrical signals into corresponding light patterns. A whole family of vacuum tubes—the image orthicons and photo tubes—is at the other end of the process, converting light patterns into corresponding electrical signals. The most prominent member of the family is the tube in the television camera that wondrously takes a picture apart, bit by tiny bit, and sends the bits on, one after the other, for reassembly in the picture tube.

Camera tubes of special design are found far from the broadcast studio. They were on the moon, for instance, as the eyes of Ranger 9, originating those marvelous close-ups of the moon surface that came back to earth over the radio link.

A similar camera tube, a special vidicon made by RCA, went under water in a U.S. Navy unmanned research submarine and allowed the operators on the surface to "see" the H-bomb lost off the coast of Spain.

Add one of various forms of intensification, and vacuum tubes can be made sensitive to infinitesimal amounts of light. For instance, there is the new camera tube, mentioned previously, that can reproduce a scene illuminated only by starlight. Then, there is the photo tube in the nose cone of a rocket that seeks out the light of a particular star and thus informs the vehicle's guidance system, and the men who anxiously follow the flight, how close the rocket is to its intended course.

A vacuum-tube light-sensitive system called an image intensifier, which presents a viewer with a much brighter picture of the object or scene being studied, has many uses in research, in electron microscopy, in X-ray work, and elsewhere. One of its most far-reaching jobs is as a kind of expander for large astronomical telescopes. The image intensifier uses light more efficiently than does photographic film. Placed between telescope and film, the intensifier makes it possible to detect much fainter stars than can telescope and film alone. The gain can make a 60-inch telescope the equal of one 180 inches in diameter. The Carnegie Institution of Washington recently acquired a large number of RCA intensifiers which will be supplied to astronomers around the world.

This does not exhaust by any means the list of vacuum tubes that interact with light in one way or another. Radar display tubes, for instance, are a large and essential class without which aircraft and ship navigation would be intolerably crude.

Passing beyond photoelectronic tubes, there is another huge class of tubes that produce and amplify high radio frequencies, particularly at very high power. There is tremendous activity here, in quantity, in ingenuity, in variety. Radio and television broadcasting depend absolutely on the large power tubes that raise the signals to high power before they are flung into the air. So do many point-to-point radio communications systems such as the military's highly varied and elaborate worldwide communications networks; the common-carrier systems that transmit telephone and telegraph signals all over the world; and the literally thousands of privately owned radio systems.

Manufacturers are constantly striving for tubes that produce more power at extremely high frequencies, and in this effort the famous klystron tube is carrying the main burden at the moment. In the klystron, the electron stream is bunched into "packets" by the incoming signal, like cars on a one-way street with progressive traffic lights. In this way, the very powerful stream is made to take on the frequency and other information of the tiny signal. This greatly enlarged replica of the signal is then fed out of the tube through a tuned cavity. Manufacturers, among them RCA, are now turning out klystrons that handle pulses up to millions of watts in power (most domestic broadcasting stations put out less than 50,000 watts).

Radar transmitters and the increasingly important tropospheric scatter radio systems use many klystrons. The "tropos" manage highly reliable radio communications over distances ranging from 70 to about 600 miles. At these distances, high frequencies tend to take off into space because of the curvature of the earth. The tropo technique is to send a very-high-power, directed beam toward the receiver; most of the energy does go on into space, but a very small proportion is "scattered" downward. Naturally, the more power in the beam, the stronger the trickle that reaches the receiver.

Klystrons are apt to be on hand, too, when large amounts of high-frequency power are needed for some noncommunications purpose, as in electronic cooking, induction heating, and in many research projects. Perhaps the most spectacular use of the klystron in the research category is in the new linear accelerator at Stanford University.

A high-frequency power tube of a different breed is the traveling-wave tube or TWT. In this tube, the incoming signal passes through a long, helical conductor that curls around the electron stream, encircling it many times. The patterns of the signal are impressed on the much more powerful stream. Power levels are much lower than those of the biggest klystrons, but the band width of the TWT, or the space in which the signal is carried, is extremely large. So it is very popular for microwave relay service, the cross-country system that sends sharply focused beams of high frequencies over short, line-of-sight paths from tower to tower. In the Bell System, which uses microwave relay for a good proportion of its long-distance service, a single beam, put out by a wide-band TWT, can handle simultaneously hundreds of telephone calls and one or more television programs. Microwave relay systems are growing in effectiveness and in the number of agencies that make use of them.

The exciting atmosphere surrounding the extreme front edge of electron tube technology is suggested by the following examples. At RCA, a photoelectric surface has been added to a traveling-wave tube to form an experimental detector for laser beams—possibly an important step toward the era of laser communications systems in which the immense information-carrying capacity of the laser's coherent light can be put to use.

In a number of laboratories, experimenters are trying out a radically new way of generating high-frequency waves in a vacuum tube by controlling a plasma so that it emits the required radiation. The plasma is a gas that has been raised to such a state of electrical excitement, by pumping in electrical energy, that the electrified molecules rush about, generating a bright glow and a great deal of heat. An intensely hot plasma is at the heart of attempts to produce controlled nuclear fusion. In microwave electronics, it is the radiation of electromagnetic waves by a plasma that is sought.

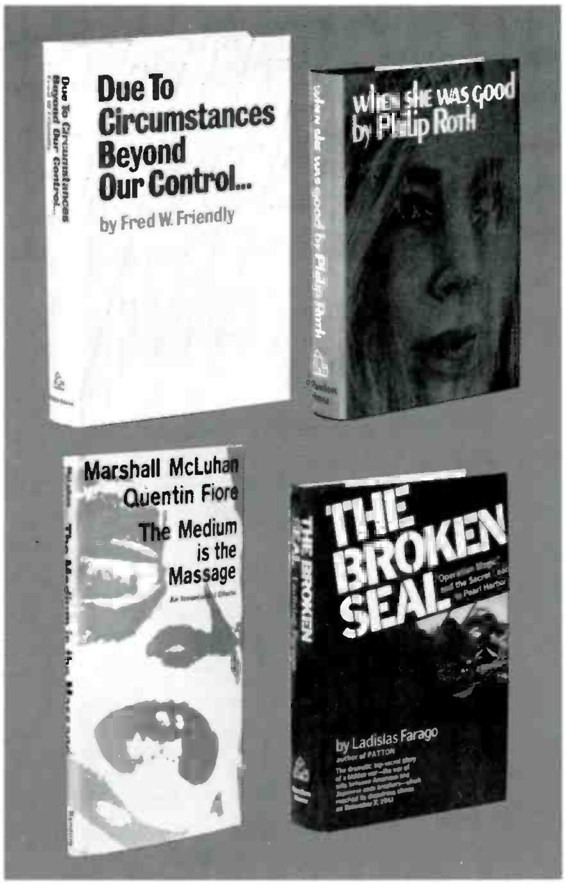
Finally, there is the microscopic tube mentioned earlier. Why make one so small? It will be extraordinarily fast because the electrons have such a short distance to travel. It can be packed into a minute space, possibly forming an element of tiny integrated circuits and thus taking on some of the advantages of solid-state devices. It does not use a hot cathode to produce electrons but simply pulls them out of submicroscopic points on a thin film of aluminum.

And it shows spectacularly, along with the other examples, that the electron tube is still a most vital invention, fruitful far beyond anything our grandfathers could have imagined. ■

Books at Random...

Due To Circumstances Beyond Our Control, by Fred W. Friendly (Random House). Mr. Friendly, former President of CBS News, has written an "occupational memoir" about his experiences in broadcasting. The book covers such memorable events as the "See It Now" programs he produced with Edward R. Murrow and the "CBS Reports" series, which included such outstanding programs as "Harvest of Shame," "The Population Explosion," and the annual interviews with Walter Lippmann. The book also outlines the Ford Foundation proposal of Mr. Friendly and McGeorge Bundy in which satellites will take the place of land lines to the benefit of noncommercial TV.

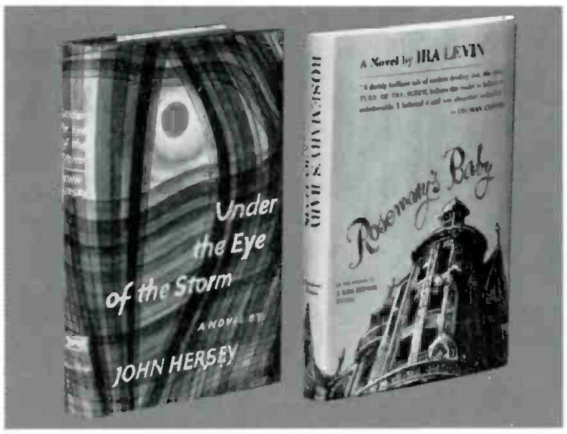
The Medium Is the Massage, by Marshall McLuhan and Quentin Fiore (Random House). A visual interpretation of the new way of looking at our world and its electronic technology first advanced by Marshall McLuhan in *Understanding Media.* McLuhan and Fiore, who is responsible for the visual layout, show how the medium—the forms of communications that we use—is reshaping our times and restructuring patterns of social interdependence, and, indeed, every aspect of our personal lives. The book explores and analyzes our new world with insight and humor. Every page offers a picture or drawing often of the familiar but providing a new way of looking at people and things.



When She Was Good, by Philip Roth (Random House). This powerful and original novel by the author of *Goodbye, Columbus* and *Letting Go* is set in the parochial world of Liberty Center, a thoroughly authentic Midwestern community. The protagonist is an implacable and self-righteous young woman in impassioned pursuit of perfection, a Midwestern girl who believes herself to be the moral superior of her family and friends. The novel tells of how she and those around her are destroyed when she sets out to prove that in matters of right and wrong she is the ultimate authority. Her special mission is to make men do their duty by their wives and children.

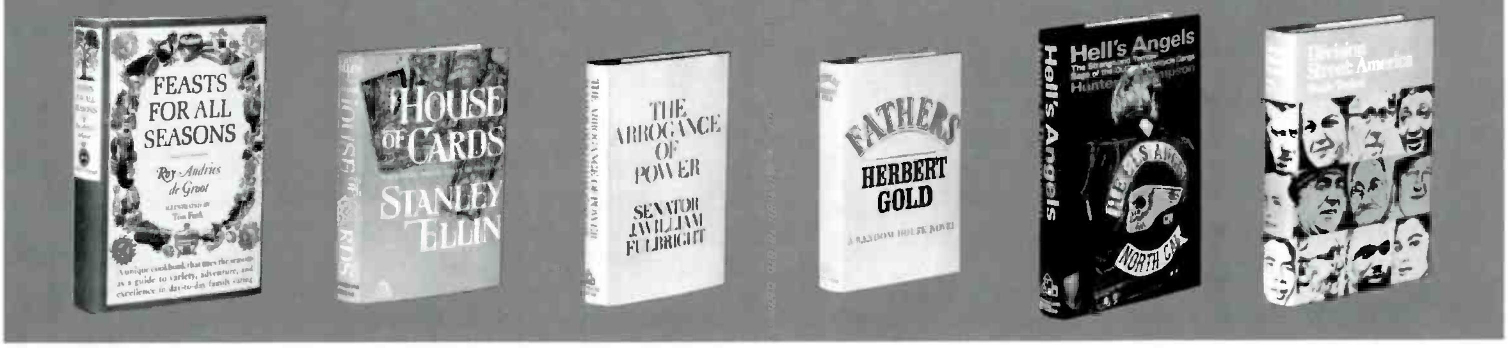
The Broken Seal: *"Operation Magic" and the Secret Road to Pearl Harbor,* by Ladislas Farago (Random House). The top-secret story of a hidden war—the war of wits between American and Japanese code-breakers, which reached its disastrous climax on December 7, 1941. *The Broken Seal* not only presents definitive answers to the questions raised regarding the Pearl Harbor tragedy but abounds in astounding revelations climaxed by an almost hour-by-hour reconstruction of our last days of peace. It is one of those rare books that are as dramatically exciting as they are authoritative. Mr. Farago is the author of the best-selling *Patton: Ordeal and Triumph.*

Under the Eye of the Storm, by John Hersey (Knopf). This dramatic new novel by the author of *A Bell for Adano, The Wall,* and *Hiroshima* is an examination of the illusions that men hold about themselves and others. Dr. Tom Medlar and his wife are joined by another couple for a weekend cruise on their sailboat *Harmony.* As they unwittingly sail into the heart of a great storm—one of the most exciting sea episodes in modern fiction—their attitudes toward themselves, as well as the excuses they employ to preserve those views, slowly change. Their distorted conceptions of their own identities are mirrored by a flaw in the *Harmony* itself.



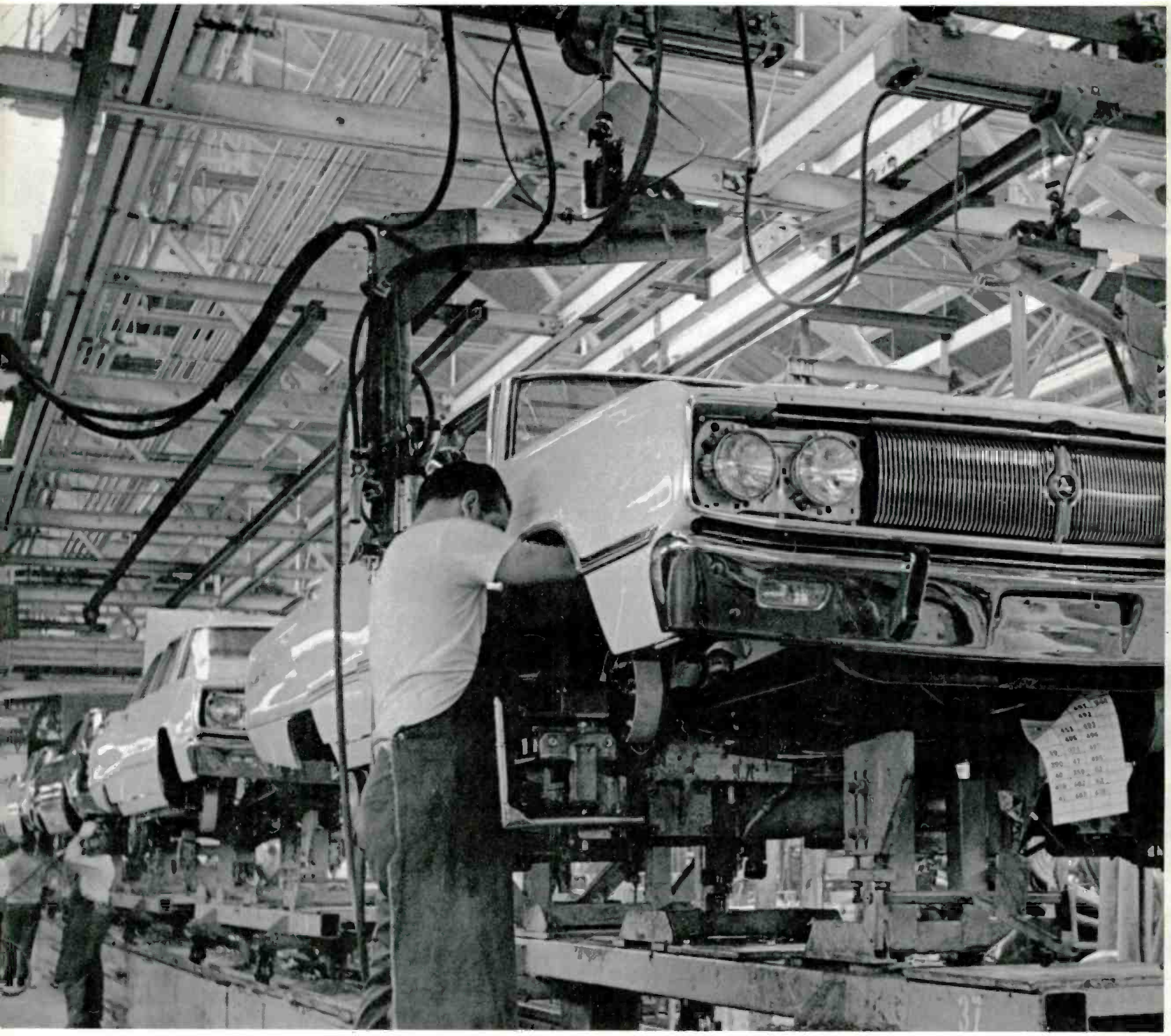
Rosemary's Baby, by Ira Levin (Random House). Evil legends and undefined terror beset one of Manhattan's oldest apartment houses and envelop a newly arrived young couple in this terrifying novel by the author of *A Kiss Before Dying.* Quietly and with compelling matter-of-factness, Ira Levin tells a story of mounting terror and icy climactic shock. Author Truman Capote commends *Rosemary's Baby* as "a darkly brilliant tale of modern deviltry that, like James' *Turn of the Screw,* induces the reader to believe the unbelievable. I believed it and was altogether enthralled." Mr. Levin has also written television plays, short stories, stage plays, and song lyrics.

OTHER RECENT RANDOM HOUSE BOOKS



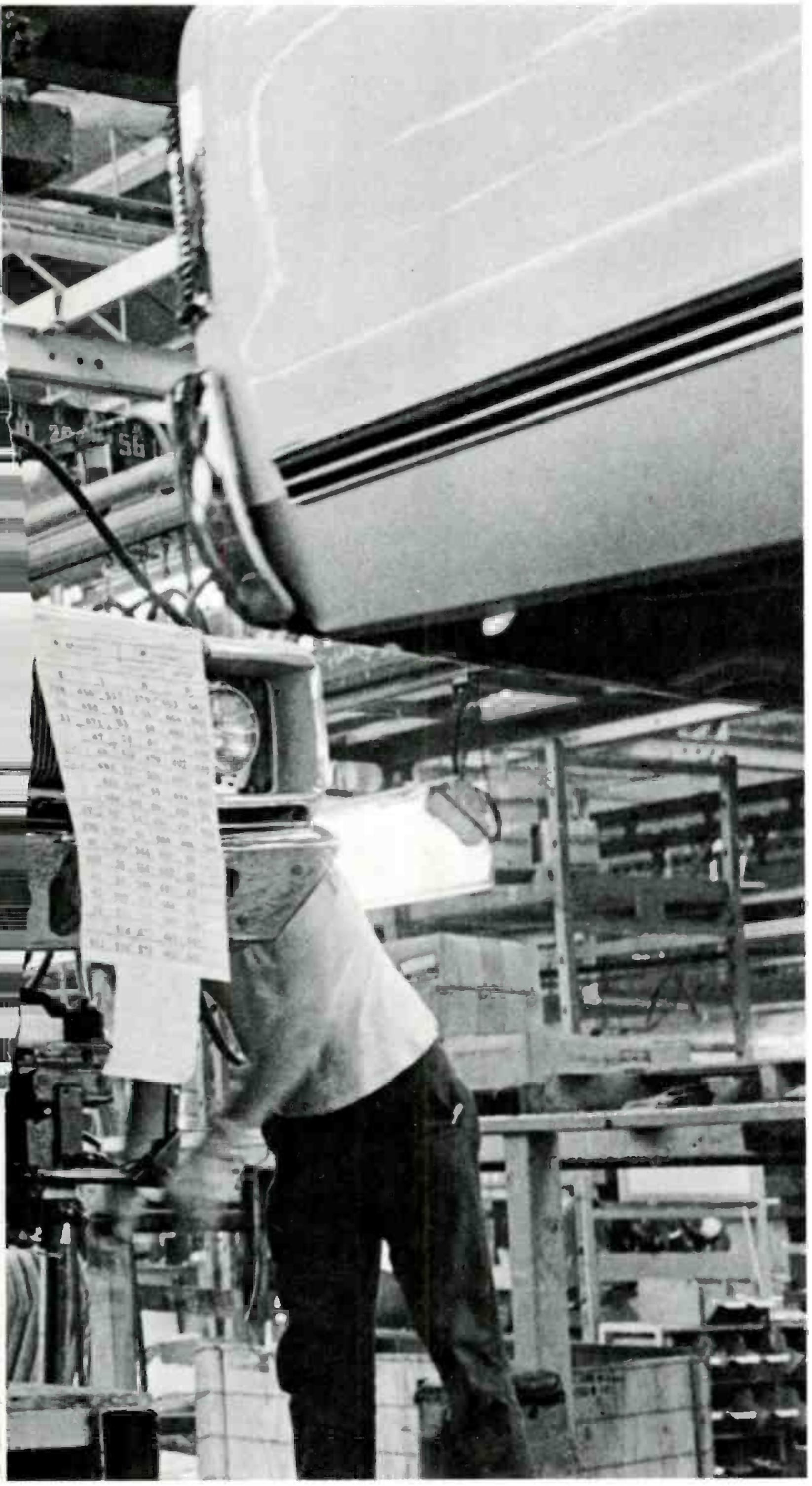
Computers and the

Chrysler Corporation cars are assembled with the aid of a computer-monitoring system that keeps track of defects and coordinates the flow of parts to the assembly line.



Automobile Industry

From preliminary design to final assembly, the computer has become the all-purpose tool in automotive production.



by John F. Sand

The American automobile industry annually produces some 11 million vehicles, sustains on the highways another 90 million, gives work to 12 million people, and adds to the national wealth at the rate of 22 billion dollars annually. It has also become one of the nation's leading users of the electronic computer.

And the computer—born just 20 years ago—arrived at a critical moment for the industry. In order to expand and improve the efficiency of production, the computer has been integrated into virtually every stage of the manufacturing process, from preliminary design to final assembly. It is being used as an analytic laboratory to build quality and reliability into every vehicle, to coordinate the flow of thousands of individual parts, to simulate car performance under a variety of road conditions, and to maintain a comprehensive history of each vehicle from the moment it leaves the assembly line until it is discarded on the junk heap.

The potential of the computer in improving and simplifying automotive design and production has not been exhausted by any means. Automotive engineers say that it is theoretically possible, with the assistance of highly advanced computer systems, to produce more than 1 million cars without building two exactly alike—a far cry, indeed, from the days when Henry Ford offered car buyers any color they wanted "so long as it was black."

Electronics keeps tabs on car manufacture from the first weld to the final adjustment of lights. For instance, at Chrysler Corporation more than 80 computer systems are used throughout the company in nearly every phase of vehicle development, including the simulation of crash conditions. The traditional crash test of a new model design may, in fact, become a thing of the past as the computer obtains greater accuracy in measuring the safety potential of the interior design.

In using computers to simulate crash conditions, Chrysler engineers began by applying computer analysis to the head-on collision—the most frequent and dangerous accident condition. From this computer analysis, a comprehensive design analysis program evolved to predict collision performance of a proposed interior design.

In another format—the animated motion picture—the computer is programmed to print-out sheets representing a single frame of a high-speed motion picture film. All the body positions of the occupants are delineated by the computer for each frame. The computer also plots the exact posi-

JOHN F. SAND is a staff writer at RCA Electronic Data Processing.

Complete history of a motor vehicle is retrieved from a computer and displayed on the face of a video device. The system is part of Chrysler's electronic warranty protection program.

tions of the seat, floorboard, instrument panel, and windshield. The computer data are then transferred to film—frame by frame—in animated form by a motion picture camera mounted on an animation stand. Engineers then study this visualized computer data in assessing the safety potential of particular interior designs.

The computer also furnishes key information on peak forces, energies, pulse durations—specific information from every crash simulation that is significant in predicting occupant injury. Ultimately, computer simulation will establish an accurate and comprehensive "figure of merit"—a numerical safety rating for styling proposal—for each interior design before any commitment is made to manufacture.

As far back as 1956, automotive engineers were taking "electronic" rides over chuck-holed roads and smooth boulevards—all without leaving the confines of their laboratories. By utilizing the problem-solving capabilities of the computer, auto researchers have accelerated development of better suspension systems, engines, and other components for the greater comfort, safety, and economy of motorists.

Today, new computerized automobile-testing techniques spot trouble before it starts. If a design engineer has a problem with a suspension system, he provides the computer with data on road conditions, such as bumps, ridges, loose gravel, brick, concrete, asphalt. Based on these conditions, the computer reveals the right standards and requirements for the system. Engineering time is saved, and engineering accuracy is improved.

Car performance under actual road conditions can be predicted before a prototype is built. And by feeding the computer information on separate parts, these "paper parts" can be tortured and tested in a few hours of analysis as much as real parts could in years of actual use.

"Before we had electronic helpers, we had no accurate knowledge of how designs would work until a full-sized model was built," said one automotive research engineer. "We relied on a process of learning by experimentation, by eliminating or adding certain features, by building and tearing down."

For better car performance, Chrysler is using the computer to calculate a vehicle's acceleration, its speed, the distance it can travel in a given period of time, and the speed with which it can climb a hill. Digesting data on the specific characteristics of a prototype vehicle, the computer quickly gives results as accurate as those obtained from actual proving ground tests.

In order to calculate the maximum number of miles per gallon that can be expected from a vehicle, Chrysler has reproduced in a mathematical model the typical conditions encountered in turnpike driving. Fed into the machine are such factors as engine fuel consumption under specified speeds and at a certain power, the amount of power lost through the drive train, the wind resistance and inertia of the vehicle, and the type of fuel used.

Engineers have also developed a mathematical model of a vibrating system to find solutions to the complex vehicle noise and "shake" problems. Information covering the mass of the engine, its locations, and the stiffness and orientation of the mountings is analyzed by the computer to determine the best possible location for the engine in the vehicle and the most effective mounting system.

In still another test application, a test engine is run, and the computer analyzes and catalogues such information as the engine's power, fuel consumption, and the efficiency of its various components. It also calculates and plots data on the composition of the engine's exhaust gas components to determine the relationship of exhaust gas emissions to engine performance and to assure that exhaust emissions are within desirable tolerances.

Getting the right part to the right place at the right time in an automobile assembly plant is as complicated a logistic problem as supplying an army in the field. In addition, every operation and every part in automobile assembly must be under constant, critical quality control. One computer approach—a reporting and recording system to keep track of defects—has been operating in Chrysler assembly plants since 1965.

It works this way: an inspector spots a defect, say a loose door handle. He marks a three-digit number corresponding to that defect on the inspection card that travels with the car on the assembly line. When car and card reach a check point, the defect report is punched into a data collector, which relays it to a central computer. The defect is repaired, and the computer then locates the source of the error and issues corrective orders via teletypewriter to the foreman of the department at fault. The system has enabled Chrysler to check 600 more items than was formerly possible, including every one of the more than 3,000 welds in each car.

At the Plymouth plant in Detroit, there are seven electronic reporting centers on the five-mile-long assembly line. As each car moves into a quality reporting station, inspectors make certain that each part is in place and performs as intended. So complete is this inspection process that a tiny screw not imbedded deeply enough is detected. Any "demerits" are electronically noted in a corrections system, and adjustments are made before the car moves ahead to another part of the line.

"Gone are the days when a car can reach the end of assembly before its imperfections are detected," says Fred M. Glassford, Chrysler vice president for quality and reliability. "There was a time when we had to tabulate corrections manually in order to establish trends and inform production supervision."

So efficient is the computer system that it not only controls car quality but also signals the storage bank of hardware materials, seats, upholstery, lights, engines, and so on to have them moving to the right car at the right time.

To help Chrysler meet its car-assembly schedule, an instant information computer network was inaugurated last December which supplies up-to-the-minute inventory and shipment data on all parts used in its 1967 passenger cars. The necessity for such a system was dictated by the proliferation of car lines, body styles, accessories, and optional equipment. For example, just five years ago, Chrysler produced 93 body-style combinations, compared to 160 for the current model year. Trim combinations have increased from 301 to 556 in the same period. In 1966, more than 21,000 separate items were required to build the 1967 Chrysler line.

The former system of production control was not only slow and cumbersome; it required many man-hours just to process the paperwork to keep track of daily parts shipments. With more than 250,000 advance shipping notices received each month, it took from two to eight hours to determine the status of a particular part. The manual records system was so massive "it's a wonder we were able to build automobiles at all," admits Joseph F. Kerigan, Chrysler car assembly vice president.

The new system, linked to 77 independent suppliers, 26 Chrysler parts manufacturing plants, and the company's seven-car assembly plants in 18 states and Canada, allows Chrysler to take immediate action to prevent assembly-line shortages.

Computer surveillance in the auto industry does not stop at the end of the assembly line. It follows the car into the dealer's showroom or used car lot, and it stays with the buyer until the five-year, 50,000-mile warranty on the power train components expires.

The electronic warranty protection system works in this way: a customer in the market for a used car spots a recent model (1963 or newer) in a dealer's lot and asks the salesman its price, the true mileage, whether there have been major repairs, how many owners it has had—a complete history, in fact, of the car since it came off the production line. This information is made immediately available to the dealer on query to his regional office. He merely gives the office a 10-digit serial number of the particular vehicle. This number is then typed into a video display device which is tied by telephone lines to an RCA 3301 computer and mass-storage file. Within two seconds, the history of the vehicle lights up the screen, and the information is relayed to the dealer.

Looking to the future, automobile manufacturers foresee an even greater use of computer systems in the design, production, and marketing of their product. For instance, Ford Motor Company mathematicians have been working for more than a year on a mathematical model of the company's distribution system that will enable the corporation and its dealers to maintain optimum levels of new-car inventories.

Automotive planners are engineering vehicles for use on automatic highways; special utility cars are being designed to ease commuting and shipping problems. Research continues on gas-turbine engines. And there are experiments with "wheel-less" automobiles that move on a cushion of air.

In all these applications, the computer is the indispensable tool, refining designs, projecting performance data, assuring that every car—both now and in the future—is a safe and durable product. ■

McCoy: Second Chance for Dropouts

Hopeful youths from city ghettos and impoverished farms are acquiring basic educational and vocational skills at the McCoy Job Corps Center in western Wisconsin.

by William Robersen

The story of the poor boy who leaves home, works hard, studies, and becomes a success is one that has been told countless ways and countless times. But what about the American unsuccess story? What happens to those young people who do not leave home, do not work or study, and never will make the grade?

The truth is they stay behind, they never escape the ghetto or the small farm. They go on drawing relief checks or barely earning enough money to feed their growing families. Or, they finally rebel against their lot. Their protest often involves the use of a gun, or narcotics...the vehicle does not matter, so long as it is something that at least makes them feel successful for a while. Then it's frequently off to prison.

Being poor has been described in many ways. It must be like quicksand for some youngsters, who through television, movies, and automobiles can see what a great world there is on the outside as they slowly suffocate in poverty, squalor, and ignorance.

When a child's parents are poor, when his father is unemployed, or even unknown to him, when success is measured by what can be gained by cheating, and education is more appealing in alleys than classrooms, then he begins to realize what poverty is all about.

There is another terrible aspect to poverty. It is usually handed down from generation to generation like a tattered overcoat. If a youngster never has the opportunity to break the poverty cycle, he is going to beget it.

This is not just a truism. In the past 10 years, the population of the United States has increased 18 per cent. In that same period of time, relief rolls have grown by 46 per cent. Mere percentages do not begin to tell the story of the increase in crime.

WILLIAM ROBERSEN is on the staff of the McCoy Job Corps Center.

Vocational instruction is a major part of the educational program at McCoy. These corpsmen are learning about automotive repair.

Slowly, too slowly, perhaps, Americans have become aware of the problem of chronic poverty and are beginning to do something about it. Our government has declared a "war on poverty" and has created a national agency, the Office of Economic Opportunity, to wage it. There are many fronts, as there are forms of poverty, where the battle is being fought. One of these projects is the Job Corps, a program that owes something of its origins to the old Civilian Conservation Corps (CCC) formed in the 1930s to offer remunerative and healthful employment to jobless youths.

There are basic differences, however, in the two programs. CCC offered temporary employment for a token salary in forests and on conservation projects.

The purpose of the Job Corps is to help young men learn a trade. Conservation work is done but only in those camps termed "conservation centers." But corresponding to the increasing urban character of American society, many of the Job Corps schools are urban training centers.

At present, more than 30,000 young people between the ages of 16 and 21 are enrolled in 113 Job Corps centers, both urban and conservation, around the country. The urban centers are set up as resident training schools. The Office of Economic Opportunity has certain academic qualifications that determine whether a young man should go to a conservation center or an urban center. There are many instances in which a corpsman graduates to an urban center from a conservation center.

One of the newest of these urban centers is located in the woods and marshes of western Wisconsin on about 10 per cent of sprawling Camp McCoy, an Army base used primarily for training National Guard and Reserve units. McCoy Job Corps Center is operated by RCA Service Company in conjunction with the University of Wisconsin. The University is charged with educational responsibility.

McCoy received its first enrollees on October 5, 1966, and expects to reach its capacity of 1,000 in the early spring of 1967. The young men come from all over the country but primarily from the Midwest and the South. A recent survey showed that 55 per cent were Negro, 40 per cent Caucasian, and the remaining 5 per cent other minority groups including Indian and Mexican. The enrollees come from both large city ghettos and small farms.

Many of the young men come from broken homes or have had to leave school to help support the family. Mere willingness to work is not, however, a sufficient qualification to gain a decent living in our modern, technical society. There are jobs, but the better ones are only for those who are trained.

An example of this was supplied by a McCoy placement specialist who learned from one large Milwaukee concern that it would not even consider someone for the position of

"These young men in the Job Corps want the opportunity to tell the American success story—about themselves."

janitor unless he had received a high school diploma.

Despite state laws requiring school attendance to a certain age, the fact is that 40 per cent of youngsters who reach the sixth grade do not graduate from high school. Many of these youngsters leave out of economic necessity, others because of broken homes, or parental indifference.

Moreover, many American school systems, perhaps out of necessity, do not cater to the slow learner. Teachers have much more time for their better students, while those who have problems are left to fend for themselves, or are left behind. Also, poor young boys or girls find that the clothes they wear, or the fact that they do not live in nice homes, makes them outcasts at the ages of six, seven, or eight.

The mission of the Job Corps is to rehabilitate these youthful failures. That is why the McCoy education is different from that offered by the public school system. Still another difference, perhaps the most important one of all, is that the Job Corps student is a volunteer. These young men and women want to change, they want to learn, they do not want to spend their life on relief. Even more simply stated: "I want to get a job and go to work."

This is what the government, private industry, and a great university want as well.

McCoy is 7 by 21 miles in area, and the Job Corps occupies some 160 of the old Army buildings, which were rehabilitated on the inside. Three additional buildings, including an auditorium, are being constructed. Because McCoy is some distance from the nearest town, it has to provide many of its own housekeeping services.

It is the performance of all these services—which operate 24 hours a day, seven days a week—that makes Job Corps an expensive proposition, at least on paper. As the center has progressed, however, more and more enrollees are taking on some of these responsibility-building tasks.

This represents a great deal of the basic philosophy of the McCoy education; namely, that young men must exercise responsibility and experience the satisfaction that comes with a job well done.

An incentive reward situation is created wherever possible. When a boy has known repeated failure, it can be quite important to receive some sort of reward for almost any measure of success.

In the education system, this is started as soon as possible. For example, when an enrollee completes his orientation he is presented a certificate that identifies him as a Job Corpsman. When he begins his vocational training, the least degree of progress is rewarded in some fashion.

Vocational programs offered at McCoy include welding, various engine and automotive training courses, drafting, basic electronics, culinary preparation, operation of office machines, maintenance service, and the repair of large and small appliances.

A student progresses in these fields at his own speed—he does not have to compete with his peers for an "A" or "B" grade. He also is taught basic education in reading, writing, and arithmetic as it applies to his vocation. For example, a young man learns to spell "carburetor," then how to compute miles per gallon, and then he works on the instrument itself.

This program of education is accomplished by teams of teachers. In each classroom building, there are at least two teachers—one for the vocation, the other for basic education.

All of this is calculated to teach a young man how to do a job. What it does not do is teach the young man how to hold a job. As most employers will tell you, attitude is as important as training.

So when not in the classroom, a McCoy corpsman is still learning. The subject is catalogued as "life adjustment," and it simply means learning to live with people in society.

One method used is what McCoy terms "neighborhood living." It works this way: four corpsmen share a cubicle called a family. There are five families on a dormitory floor, two floors in each dormitory, and three dormitories in each neighborhood. The various units have their own governments, responsibilities, and even spirited competition in intramural sports and other activities.

Then there are such details as learning about installment buying, driving a car, health habits, family relationships, and that great American pastime: filling out an income-tax form.

All of this is tied together outside the classroom and even outside the confines of McCoy Job Corps Center. Enrollees will be able to have on-the-job training and an internship program. They also are allowed to go into town for recreation purposes.

McCoy corpsmen's towns include the three nearby communities of Sparta, Tomah, and La Crosse, plus Milwaukee, Chicago, and Minneapolis and St. Paul. There the young men have the opportunity to practice what they have learned.

As corpsmen receive $30 per month spending money (less the tax deductions, of course), there is not too much activity they can afford, and the temptation to return to their former way of life is great. One way this is counteracted is in the formation of Community Relations Councils in the various cities. These councils help in finding worth-while activities and also provide liaison between the communities and the Job Corps centers.

Actually, McCoy has not had many of the problems other centers have had. This is in part because it was able to learn from the mistakes of other centers. There have been a few incidents, but it would be folly to expect that these can be eliminated altogether, any more than on a high school or college campus. It is just that Job Corps is in the public eye more than, for example, a state teachers college.

In fact, it is the corpsmen who actually sell Job Corps. These young men can and do talk with civic groups and other people about McCoy. It is proving to be the center's best public relations program.

But, that is as it should be. These young men want the opportunity to be able to tell the American success story—about themselves. ■

"I DO! I DO!": *Original Broadway Cast Recording starring Mary Martin and Robert Preston (RCA Victor LOC/LSO 1128)** Broadway's most prolific and successful producer, David Merrick, and Gower Champion, who also directed the smash-hit "Hello, Dolly!", have come up with one of the biggest hits of the season, starring two of Broadway's top performers. Tom Jones and Harvey Schmidt, creators of "The Fantasticks" have written a charming and intimate score for this musical version of Jan de Hartog's "The Fourposter"—the story of a marriage.

"MANCINI '67": *Henry Mancini and his Orchestra (RCA Victor LPM/LSP 3694)** In the past five years, the protean talent of Henry Mancini has been clearly manifested in many types of successful albums, but his early experiences with the kings of the swing era have given him a special affinity for the "Big Band Sound." This album illustrates his ability to lend new character to an unusual set of tunes from a wide variety of sources—pop, jazz, and rock—and to assemble a superb ensemble of talented music-makers to achieve the appropriate effects.

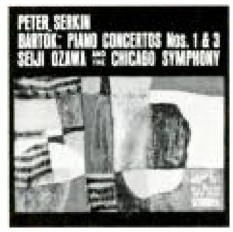
"LONELY AGAIN"—EDDY ARNOLD *(RCA Victor LPM/LSP 3753).* In Eddy Arnold, Nashville has one of its most illustrious ambassadors, both as a musician and a gentleman, and RCA Victor has one of its most popular and beloved balladeers. After 20 years as a top recording artist, his popularity is now at an all-time peak. Recently, he made a successful concert tour of England and a triumphant debut at Carnegie Hall in New York. In his latest RCA Victor album, Arnold displays the warmth in performance that has become his hallmark.

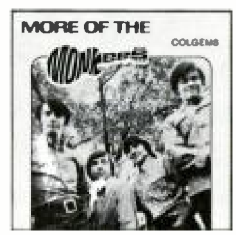
For the Records... NEWS OF RECENT OUTSTANDING RCA VICTOR RECORDINGS

BEETHOVEN: PIANO CONCERTO NO. 3: *Artur Rubinstein, Pianist, and Erich Leinsdorf conducting the Boston Symphony Orchestra (RCA Victor LM/LSC 2947).* The world's foremost pianist, Artur Rubinstein, not only tours the world giving more than 100 concerts a year but also continues as one of the most prolific recording artists of the century. In this new recording, Mr. Rubinstein once again performs the Beethoven Third Piano Concerto, a work long associated with the Rubinstein repertoire. He approaches it here with the same freshness of insight present in his earlier recordings of Beethoven's Fourth and Fifth concerti with the Boston Symphony.

WALTON: SYMPHONY NO. 1: *André Previn conducting the London Symphony Orchestra (RCA Victor LM/LSC 2927).* This album continues the remarkable collaboration between André Previn, one of America's most gifted conductors, and the London Symphony, one of Europe's most esteemed musical ensembles, that began several years ago with a recording of the Shostakovich "Symphony No. 1." Sir William Walton never has been a prolific composer, tending rather to labor over each work with great care, taking from the classics as much as needed, and adding a contemporary zeal for experimentation. The result is a work of considerable musical consequence.

DONIZETTI: LUCREZIA BORGIA: *Montserrat Caballé, Soprano, with Jonel Perlea conducting the RCA Italiana Opera Orchestra and Chorus (RCA Victor LM/LSC 6176).* Just two years ago, the Spanish soprano Montserrat Caballé made her debut in America with the American Opera Society in the title role of Donizetti's famous opera. Since then, she has made musical history of the most exciting order, being acclaimed a star on the Callas-Sutherland-Price level. For her first appearance in a complete opera on records, RCA Victor engaged Miss Caballé to re-create the role that won her instant fame. She performs with warmth, pathos, and excitement.

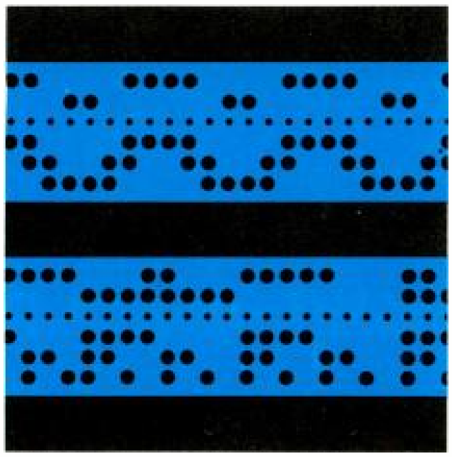




OTHER CURRENT RELEASES

*Also available in 8-track stereo tape

Electronically



Speaking...

TYPESETTING BY COMPUTER

A continuous flow of technical documents is being produced by a computerized typesetting system that not only eliminates the often misplaced and overworked hyphen but also effects a substantial reduction in time and money.

Developed jointly by the Western Electric Company and RCA to produce technical documents, the system combines an RCA Spectra 70/25 computer with a phototypesetter to justify lines on two-column pages. Edited copy is punched on eight-channel coded paper tape, read into the computer, stored on magnetic tape, and printed out on the computer printer as proof copy. Changes are processed, also on paper tape, and keyed to a paragraph and line number assigned by the computer and printed on the proof copy. The tape is read back into the computer, and the changes or deletions are made on the magnetic tape and on the printout.

When copy is ready for final production, the computer composes the material on a second paper tape that is used to drive the phototypesetter. A firm positive of the page is produced and is then converted to negative form by contact printing. Illustrations are spliced into place in space assigned by the computer, and the negative is then sent out for final printing.

LASER WARNING DEVICE

Fatigued turnpike drivers may soon have the assistance of a laser device that will warn of a too-rapid approach to the car ahead or even stop the car automatically if the driver fails to respond to its signal.

Called a solid-state injection laser, the device will give designers a new tool for electronic development in many areas of safety, security, communications, and computers. It is being marketed in pre-production quantities by RCA Electronic Components and Devices.

In an automobile collision warning system, the device could help eliminate accidents caused by unexpected stops and turnpike fatigue. Mounted on the front of a car, the laser transmitter unit would send out invisible infrared signals that would be reflected from the car ahead and indicate the relative speeds and closing rates of the two cars. If the laser system determines that the closing rate is too rapid for safety, it would activate an audible signal or flashing lights on the dashboard to alert the driver. If the driver fails to respond to the signals, the car's brakes could be applied automatically.

The injection laser could also be utilized for short- and long-range "secure" communications systems for ships, aircraft, and spacecraft. In such a system, an extremely narrow beam of invisible, infrared light is aimed at a receiver. Messages carried by this beam would be extremely difficult to intercept unless the precise path of the beam is known and suitable infrared detection equipment is available.

INTERCONTINENTAL WEATHER LINK

More reliable and rapid interchange of weather information between the continents of North America and Europe is now possible through a new high-speed communications circuit linking the U.S. Weather Bureau's National Meteorological Center in Suitland, Md., and the National Weather Service Center at Offenbach (Frankfurt), Germany.

Capable of voice, data, or pictorial transmission, the circuit replaces a link that carried only teletypewriter messages. Meteorological data are being transmitted at a speed of 1,050 words per minute, more than 10 times the 100-word-per-minute capability of the earlier circuit. Weather maps can also be transmitted in both directions, and voice communications are utilized for cue and control, maintenance, and other functions.

The circuit, provided by RCA Communications, Inc., is routed via the newest transatlantic cable connecting the United States and continental Europe. It is expected that the circuit will later become part of the World Weather Watch telecommunications system for total exchange of weather information on a global basis.

COMPUTER MEMORY CIRCUIT

A tiny, integrated electronic circuit about the size of a housefly's eye has been developed for use in a new type of high-speed computer memory that bridges the widening gap in speed between the latest computer circuitry and the main computer memory.

Such memories are known as "scratch-pad" or auxiliary memories because they do for computers what a scratch-pad does for a person working with figures, providing a means for jotting down subtotals until they are needed. A recent advance in computer technology, the memory acts as an extremely fast temporary storage system between the high-speed logic circuits and main memory systems of a computer.

An experimental memory employing the new circuits and capable of storing nine bits of computer information has been built at RCA Laboratories, Princeton, N.J. It is expected to lead to similar memories that can store up to 256 words, each 16 bits long, and process the information at the rate of 20 million words a second.

The circuits were achieved by using a novel "silicon-on-sapphire" fabrication technique that enables the circuits to be joined together in large arrays to form extremely high-speed memories. Such circuits are inherently faster and consume considerably less power than those so far produced by any other approach.

MICROSCOPE FOR MEDICAL RESEARCH

An electron microscope fitted with a television image intensifier that boosts the microscope's magnification potential to 2 million times has gone into operation at New York's Lenox Hill Hospital. It marks the first use of the powerful instrument system in medical research and teaching.

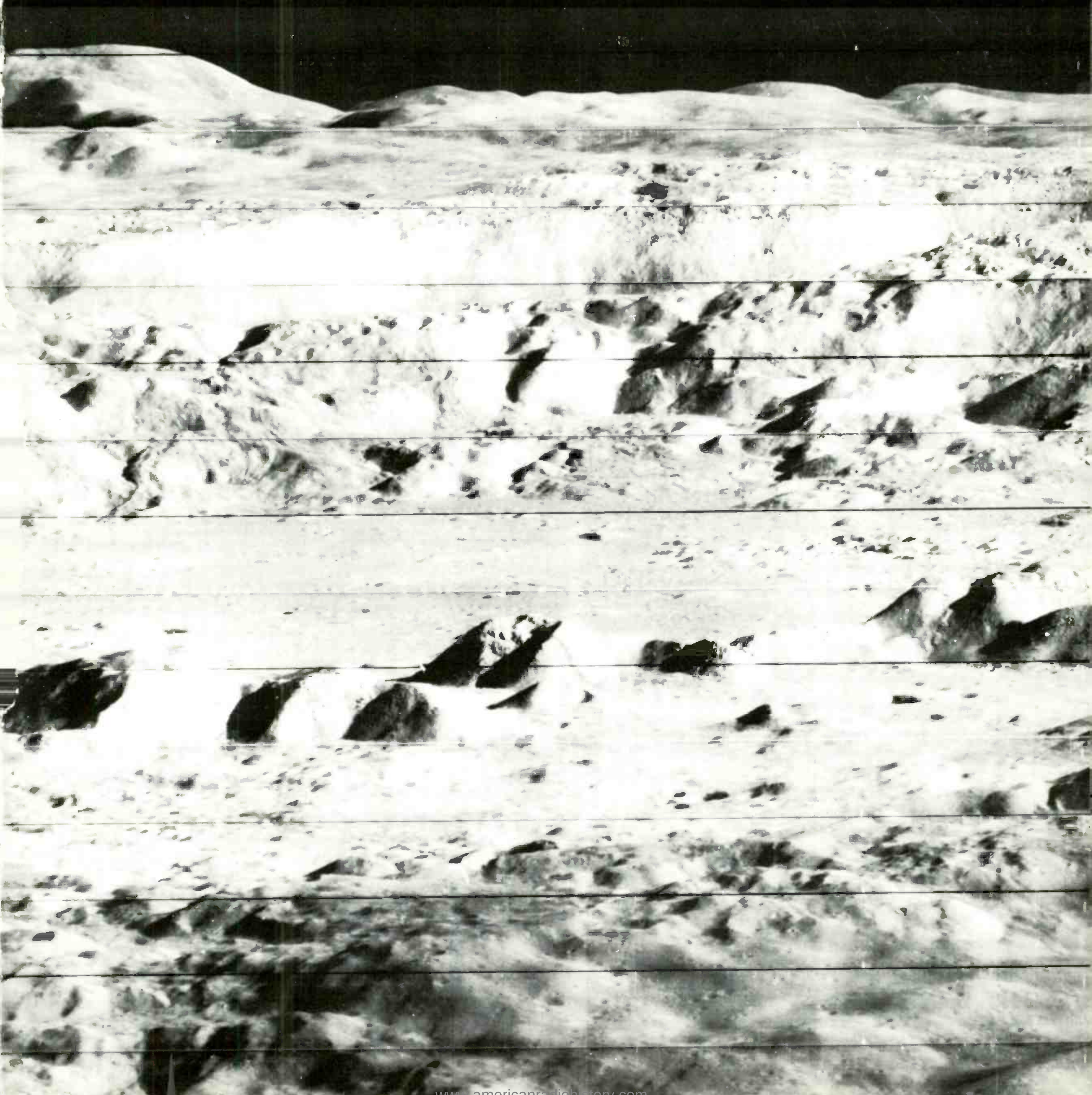
The system, which has been installed in the hospital's Department of Pathology, includes an RCA Electron Microscope, TV image intensification equipment, and a TV tape recorder. The two-stage image intensifier combined with a highly sensitive TV camera reveals to the microscopist specimen images formerly too faint to be seen at high magnification.

Because the images produced can be displayed on TV screens for group viewing, hospital officials expect the system will become an important new tool in the training of pathologists and other specialists. The TV tape equipment is of the type used in broadcasting so that recorded material can be broadcast if desired or reproduced and viewed through any standard closed-circuit TV system.

An early research use to be made of the system will be in the Department's current project to investigate viral causes of leukemia and other forms of cancer. Later, hospital researchers hope the system may be employed to examine biological material from patients suffering from cancer and related diseases to determine whether viral particles are present.

The conventional electron microscope is capable of direct electron magnification of up to 200,000 times. With the addition of TV image intensification, this can be boosted tenfold.

Lunar Orbiter II, the moon-circling spacecraft built for the National Aeronautics and Space Administration, took this first close-up photograph of the crater Copernicus, one of the most prominent features on the surface of the moon. The picture was taken with a telephoto lens from 28.4 miles above the crater. Mountains rising from the crater floor are 1,000 feet high with slopes up to 30 degrees. The photo was transmitted via the RCA-built communications system aboard the spacecraft to the Deep Space Network station at Goldstone, Calif.



ELECTRONIC AGE

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Spring 1967

Searching the Atomic Labyrinths