ELECTRONIC AGE

RCA Winter 1965/1966

Gemini 6 is launched from Cape Kennedy.

We stand on the threshold of a new era in communications, in which the physical barriers of space and time will be abolished and in which a global system of instant sight and sound will link people everywhere. It will provide communications media with the ability for the first time to reach the entire population of the earth simultaneously.

The rapidity and sweep of technological advance in the 20th century have already conditioned us to change, but let us hope that they have not made us callous toward it. For what will soon occur in communications represents change of a far different character from any that mankind has as yet experienced....

We can expect the coming revolution in communications to extend the power of our brains. Its ultimate effect will be the transformation and unification of all techniques for the exchange of ideas and information, of culture and learning. It will not only generate new knowledge but will supply the means for its worldwide dissemination and absorption....

None of the great technological revolutions of the past has waited upon the convenience of mankind, and communications will be no exception.

In preparing for it, however, we must learn from the past. Thus far, the history of international mass communications has been a succession of missed or neglected opportunities for achieving greater harmony among men and nations....

The impending communications revolution provides humanity with a fresh opportunity to remedy the mistakes of the past. Prompt action is imperative if the new technology is to be harnessed in the cause of greater understanding and well-being among people everywhere. This, it seems to me, is the most promising path to follow in the search for an enduring world peace.

—DAVID SARNOFF

(Excerpts from an address, "New Dimensions in Mass Communications," delivered at the Advertising Council Annual Dinner, New York City, December 13, 1965.)

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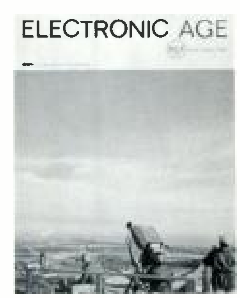

Cover: An RCA color TV came covers the lift-off of NASA's Gemini 6 from Cape Kennedy, Fla., on December 15, 1965. The camera was hoisted atop huge gantry by helicopter to provide on-the-spot TV coverag from the launch pad. In this picture, taken within 10 second of ignition of the modified Air Force Titan 2 launch vehi. the booster and the Gemini 6 spacecraft are still joined and appear as a white speck in the upper left corner.

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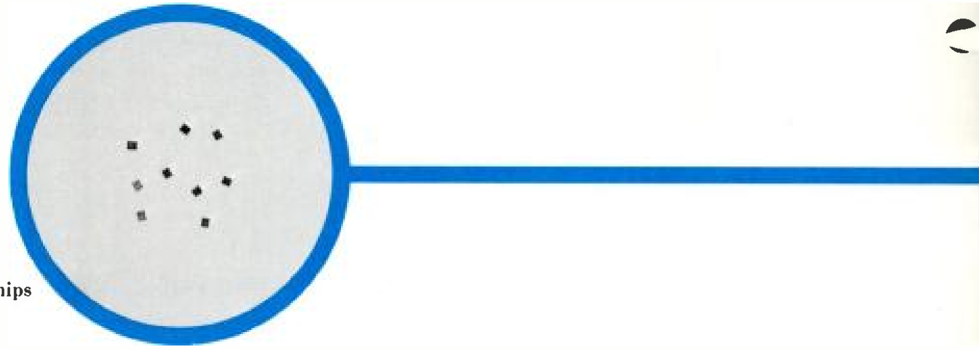
RCA Vol. 25/No. 1 Winter 1965/1966



Nine integrated circuit chips
shown in actual size.

Microelectronics–
The Quiet Revolution

by John Ott

A tiny chip, smaller than the head of a pin, has triggered the quietest and perhaps the least noticed technological revolution of this century.

Fashioned basically from one of the most abundant elements — silicon — the chip carries within its microscopic dimensions an entire electronic circuit, performing the same functions as earlier arrays of tubes, transistors, resistors, and other circuit elements together with their interconnections.

The electronics industry is beginning to produce these chips in millions by means of swift and ingenious mass-manufacturing processes. Their introduction into electronic devices is leading to entirely new concepts of speed, reliability, compactness, and even function — for they are removing previous limitations upon the number of circuits that can be joined practically and economically to achieve almost any desired objective.

The chips are known as monolithic integrated circuits, and the technology from which they have emerged is the new art of microelectronics. Their application promises to transform most aspects of computing and communications.

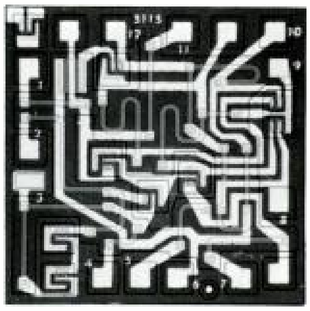
By compressing many times more functions within any given limits of space and power supply, they can extend the capabilities of computers to physical, social, and economic problems too complex for solution by today's most advanced systems. They can reduce the size and cost of sophisticated data processing and control systems to levels practical for use in the smallest enterprises and even in homes. They can bring about a new era in communications based upon extremely compact and reliable personal equipment accommodating both sight and sound, and upon increasingly flexible terminal and switching apparatus operating at far higher levels of speed and capacity for all types of point-to-point communications.

Despite the promise held out by these devices, their introduction in commercial quantities was greeted by the general public with about as little excitement as an announcement from Detroit of a new model change. Perhaps one reason for this lack of general response is the fact that integrated circuits do not, strictly speaking, perform a new function. Essentially, microelectronic techniques have led to circuits that do the same jobs as the familiar vacuum tube or transistorized circuitry. That they do it at a considerably lower cost with greater dependability and very often with appreciably higher performance seems to have been of limited interest to the general public. That these circuits are unbelievably tiny is to many the most intriguing aspect of this new technology.

Actually, though, size — except for specialized applications by the military and in space — was not the governing factor in the development of microelectronics. Size was a result of attempts to improve the performance of an electronic circuit, not because it was desirable in itself. However, the advantages of size quickly became apparent.

In any circuit, the basic function of a transistor is to regulate the flow of current in response to a signal. In applications such as computers and microwave communications systems, the speed of response is critical and depends inversely upon the size of the transistor. The smaller the circuit, the greater the speed of operation.

Design concepts for the newer computer and communications systems required circuits that could respond to signals in a few billionths of a second. Since it takes electricity one billionth of a second to travel about a foot,



Close-up shows integrated circuit enlarged 625 times.

Minuscule silicon chips that carry complete electrical circuits provide dramatic improvements in computers and radical advances in communications.

designers came to the conclusion that components had to be placed within a hairbreadth of each other for circuits to function at the required speed.

Most of the significant developments in this area have taken place over the past 10 years and following the invention of the transistor in 1947. The transistor itself represented a dramatic step forward in circuitry and readily captured the public's imagination with its promise of such electronic marvels as the invisible hearing aid, the wristwatch radio, and truly portable, personal radios.

As with so many key scientific discoveries, the transistor was one of those devices that simply had to be invented. Vacuum tubes, despite their versatility, could no longer perform the complex tasks demanded by the fast-moving technology of electronics.

For example, the first electronic digital computer, a huge, room-sized machine called ENIAC, employed something like 19,000 tubes throughout its miles of circuitry. This posed formidable problems of reliability, to say nothing of the immense power needed to operate such a monster. Clearly, if any advance were to be made in computer art, some new device had to replace the vacuum tube. It made no sense simply to add to the already unwieldy number of tubes and miles of wiring.

The answer, of course, was found in transistors, which have supplanted the majority of vacuum tube functions in electronic circuitry. The virtues of transistors are many. They operate at lower power on the average as compared to tubes. They consist of a simple chip of silicon and are less susceptible than tubes to breakage or wear.

An added bonus, especially from the point of view of the military, is the fact that they are incredibly small compared to tubes. This is a matter of paramount interest to the Armed Forces because of their need for compact, reliable field communications equipment. As a result, a number of programs were undertaken to open the way to further miniaturization of complex electronic systems.

These programs led directly to the reduction of basic circuitry to small blocks, or micromodules, of uniform size and shape. A micromodule consists of a stack of thin ceramic wafers, each carrying a packaged circuit. The aim was to crowd as many electronic devices into as small a space as possible.

However, there was one problem that still plagued designers. Even though dramatically reduced in size, the number of devices and interconnections required to perform any given function was exactly the same as in the equivalent conventional electronic circuit. The probabilities of malfunction had thus not been reduced.

The solution to this problem came in the creation of the microelectronic techniques that led to the development of a circuit in which all the elements are inseparably associated — today's monolithic integrated circuit.

The manufacture of an integrated circuit begins with a paper-thin wafer of silicon, a little larger than a quarter. Silicon is a favored transistor material because its electrical properties can be precisely altered by adding carefully placed layers of impurities, known as dopants. After having been sliced, the silicon wafers travel to precision processing areas where photographic masks, accurate to millionths of an inch, are used to expose and etch circuit patterns on the surface of the wafer.

Preparation of these patterns demands extreme precision. They are drawn first on a large scale and then

Integrated circuits are packaged into a "flat-pack," which becomes part of a plug-in module used in an RCA Spectra 70 computer.

photographically reduced to microscopic size before being transferred to the silicon by a controlled diffusion process.

The wafers are then fed into a diffusion furnace where semiconductor elements or dopants are deposited on them in layers whose thickness approaches the wave length of light. Layer by layer, and pattern by pattern, the various electronic components are diffused into the surface of the silicon wafer until an entire circuit has been created. Actually, several hundred circuits are processed simultaneously on the single 25-cent-piece-sized wafer. After processing and testing — for example, the Radio Corporation of America performs more than 200 of these tests on each circuit during the production process at its Somerville, N.J., plant — the wafer is separated into individual chips, each about 50-thousandths of an inch on a side.

These tiny elements carry as many as 40 discrete electronic components, and a thimble can comfortably hold enough to provide circuitry for thousands of radios. But just as important as their minute size is their reliability. In a complex system such as a computer, thousands of interconnections have been eliminated. They require very little power so that the problem of heat removal is lessened.

Size, of course, is of vital importance to the nation's space effort, and, in fact, the rapid development of rockets and space vehicles during the past few years gave an urgent incentive to the perfection of microelectronic techniques. These tiny chips are saving enormous amounts of money in the space program. One estimate of savings is approximately $20,000 for every pound of reduced payload.

Beyond military and space applications, the integrated circuit will profoundly affect present-day electronic systems and hasten others that now exist only in the laboratory or within the imagination of scientists and engineers.

To name but one example, the tiny chips carrying integrated circuits will dramatically improve and radically alter computer forms and functions. Gone is the arbitrary ceiling placed on the development of the computer by bulky vacuum tubes and even transistors that seemed such marvels of compactness only a few years ago. Computers employing monolithic integrated circuitry are already available, the

Technician uses microscope to inspect oversized pattern of an integrated circuit.

first circuit having been introduced by RCA in the Spectra 70 series of advanced computers.

What makes the chip so important to the computer is simply a matter of numbers. Because of their size, speed of response, long life, and reliability, there is now little practical limitation upon the number of circuits that can be put together in proper sequences. Basically, a computer is made up of a large number of these simple circuits, with the capability of the total system increasing in direct ratio to the number of circuits in the system.

Going in the other direction, extraordinarily efficient computers can now be made in smaller sizes for modest cost. This will inevitably expand the market for computers, until one day they will become consumer items, as indispensable to the smooth running of a house as a vacuum cleaner or a refrigerator.

Integrated circuitry, applied to communications, could bring a new era in personalized communications. Such a system could lead to a combination of personal voice and video communications, point to point, anywhere in the world. It is even possible to foresee the time when everyone will possess a personal number code to make or receive local or global television calls. This may seem like futuristic gadgetry, but, in fact, it represents only one aspect of life that could be radically affected by the tiny chip.

In another area, RCA Board Chairman David Sarnoff has predicted that "computers will touch off an explosion in the social sciences comparable to that which we witnessed during the past half century in the physical sciences." He added that "the use of the computer provides a vast opportunity for finding answers to many of our most complex social problems — in education, conservation of natural resources, air and water pollution, urban planning and renewal, the retraining of persons displaced by automation, the reduction of poverty."

If today's computer systems can contribute even partially to the solution of these problems, then some credit must go to a tiny chip, not much larger than a mote of dust, that has quietly but significantly extended the art and technology of electronics and its usefulness to man. ■

The Need to Know

What motivates the scientist to seek new knowledge? How does he approach his work? An interview with three young RCA scientists suggests some answers.

by Desmond Smith

The spectacular growth of what economist Fritz Machlup has called the "knowledge industry" — that is, the production of knowledge or information — has focused public attention on its prime motivating force, the boundless world of scientific research. It is a well-known fact — and a significant one — that 90 per cent of all the scientists who ever lived are alive today. What is less well known, according to Sir Charles P. Snow, is that eight out of 10 of them are working in the United States. But although science is regarded as a national asset, scientists themselves seem to be the national puzzle. People have the most curious ideas about scientists. For years, they have been regarded as strange birds, likely to wear orange socks and green bow ties.

More recently, another myth has taken precedence. The prodigious American effort to land a man on the moon has had its impact on the U.S. public. Now, it appears, scientists are miracle workers. Much is spoken today about the man-made wonders around us, and rightly so. But the point is, they are man-made. By any standard, the most important research tool is still the mind of man. Unfortunately, although we know a good deal about the results of scientific research, we know very little about how scientists go about getting them. Some weeks ago, in an inquiring frame of mind, I took a train to Princeton, N.J. There, at the David Sarnoff Research Center, I talked with three young scientists: Drs. Robert H. Parmenter, Frederic P. Heiman, and Donald S. McCoy.

How *does* new knowledge come about? This is the question I had been asking myself. What distinguishes a scientific investigator from you or me? That is what I tried to find out from these men in the following roundtable discussion.

SMITH: At a scientific meeting in Paris, Pasteur described the pleasure of scientific discovery as "certainly the liveliest that the mind of man can ever feel." Near the end of his life, recalling all his frustrations, he declared, "I have wasted my life." The pleasure-pain phenomenon appears to be an intrinsic part of scientific investigation. What is the most frustrating element in research?

HEIMAN: I think you would have to say it is the fear that all your work will be for nothing. The goals seem clear enough, yet you may pick an approach that turns out to fail, or someone else may pick an approach that leads to these goals. In the end, you have worked so hard in the wrong direction. I think it is the fear of not being in front.

MCCOY: I would go along with that. Above all, it is the uncertainty as to whether you have optimized your choice of alternatives.

PARMENTER: I would agree with both of you, but I'm not sure that is necessarily a bad thing. I think it enhances the excitement. It gives a keener edge to this process; it enables you to keep really on top over these very long periods of time.

SMITH: Scientists have been compared to the great detectives of popular fiction who seem to fall into two schools: the James Bond *inductive* type and the Sherlock Holmes *deductive* genre. How valid is the analogy?

MCCOY: Well, it seems to me that most of the research I have seen has started off on an inductive basis, and then it is put in the more traditional detective-story form — as an after-the-fact kind of thing.

PARMENTER: I would say that the actual process of doing scientific research combines both elements, almost simultaneously, and it may be misleading to try to separate them. The one thing we can certainly say is that the process of doing scientific research is not a science — it's an art.

HEIMAN: You're not only looking for clues either. Selling comes into research. It's not enough to come up with an idea; you have to convince other people that your idea is right. There is also a little confusion as to what is meant by research. Very little of the output from our industrial labs or universities is really brand-new. A lot of it is development of ideas already around.

SMITH: Some writers have likened scientific investigation to warfare against the unknown. Do you agree?

MCCOY: I don't think I have any great hostility toward the unknown at the moment. This is not what motivates me. I think there are other reasons, more tangible goals, than that one which is rather vague.

HEIMAN: I think a good deal of research is hard work. You are making it a little too glamorous with people sitting around inventing things, strokes of genius, things like that. A lot of it is just detailed and very hard work.

MCCOY: The need to know, which is really this warfare against the unknown, is important. There is a satisfaction that comes from understanding, and this may be present in scientists much more than in the general public. We get a satisfaction from understanding. To that extent, you do work on many things that won't lead you immediately to a tangible goal.

HEIMAN: I think the real questions are: Why does a scientist want to do this type of work? What makes him different, if he is, from other people? Why is scientific research different from other vocations? I think the important point is that he wants to know what he doesn't know; essentially, this is what drives him. He's not just doing a job. No one here has such things as fixed hours; it does not go along with scientific research.

MCCOY: On the other hand, we should not overemphasize a total difference between the scientist and other people. I had one rather disconcerting interview with a young man who was coming for a job, and he was worried about going into research. He was afraid that he would not be able to carry on normal family life. I don't believe that scientists differ that much from the general public with regard to their family lives.

SMITH: Nevertheless, we have already made a number of distinctions that appear more clearly in your profession than in other fields. First, a scientific investigator must have the capacity for "hard work." Perseverance, then, is a characteristic. Second, what you have called the need to know gives us another clue. Pasteur thought tenacity was the key attribute in a good investigator. I wonder if we could enlarge on this.

MCCOY: Tenacity may have to be broken down a bit. You must be tenacious in pursuit of your goal, but you cannot be tenacious in pursuit of your original concept of how to get there. You must be flexible enough to recognize this. When you realize your present approach is not going to work, you look for another one.

HEIMAN: Flexibility is a real good point. There is no better project than one you have invented yourself, but you have to be careful that there isn't a better approach.

PARMENTER: Here again, it is a matter of judgment. One has to know when to continue trying and when to give up. That's part of the art of the game. I would say, number one: it's no good doing trivial problems. Number two: it's no good beating your head against a wall on a problem so difficult that the time isn't ripe for even attempting it.

SMITH: What part does intuition play in scientific investigation? Einstein always thought it was the chief asset in a scientist's balance sheet.

MCCOY: Intuition may be the wrong word. The other word we coin for this kind of thing is serendipity — the fortunate accident. The most inventive person I have ever seen had an unusual approach. He would begin with a hypothesis, usually wrong, and then he would make all permutations and combinations of the original information in order to try to prove his original hypothesis. In the process of doing these many different things, he usually found something interesting and was able to recognize it.

SMITH: This ability to recognize the unexpected seems to be a very marked quality in the great scientific investigators.

MCCOY: I think this is very true, and the classic example is, of course, penicillin. What was happening was that the

The author (second from left) interviews RCA scientists Heiman (left), Parmenter (third from left), and McCoy (right).

mold was growing in a culture of other organisms. Fleming noticed that the other organisms were dying in a small ring surrounding the mold. Then his question to himself was: What the devil is causing them to die? So, this is the fortunate accident followed by the observation. But then, from that point on he had to pursue a more coherent approach to find an answer. This is what we were talking about earlier. It takes both the inductive and the deductive processes.

SMITH: Penicillin is an outstanding example of how many scientific breakthroughs occur. Though Fleming observed the phenomenon in 1929, it was not until World War II that Florey — using Fleming's basic research — turned penicillin into a commercial product. Transfer of knowledge is another way by which science evolves.

PARMENTER: What comes to my mind in this regard is the laser. Since the end of World War II, there has been a tremendous amount of new scientific knowledge concerning quantum mechanics, energy levels, and transfers of energy levels. Out of all this knowledge came the maser and its successor, the laser. The general public might think that back in 1960, when it came to national attention, somebody just sat down and invented the laser. Unfortunately, these are really gradual processes that take shape only over many years. You see, it's not only the prepared mind but also the state of the art of science at a given historical moment. When times are ripe, it may well happen that a number of people, more or less simultaneously — yet independently — will come across very much the same idea.

HEIMAN: Publication is a major factor in all of this. Nowadays, you can find out what people are doing all over the world by reading, say, the top 15 journals in your field. Today, there isn't just one company working on lasers — there may be 15 or 20 — and by publication, each one is closely aware of what the other is doing. So it is not just a scientist sitting alone not talking to anyone else — like a hermit in his cave. It is not *eureka!* he invents something. Many scientists are always working toward similar goals.

SMITH: George Bernard Shaw in a lighthearted moment once suggested that "reading rots the mind." Is there any danger of this in science? I read that there are more than 50,000 scientific journals published in this country alone.

MCCOY: Well, I think you have to be selective. You pick those journals that seem to you to convey the most information in your field. Very often, you know people who run across an article that may be of interest to you and they call your attention to it.

HEIMAN: There is too much junk published. I think this is the thing. There may be 50,000 journals, but most of the articles in those journals are probably not worth publishing. I think that this is a pet peeve of mine and maybe of lots of others in research.

SMITH: I think this raises an interesting question. If I may split it into two parts — first, if you are working in an original area, is there not bound to be a shortage of information? and second, is not there a chance that what you read may be false information?

HEIMAN: A lot of it is false information, but I don't think you can work in an original area; I don't think there is such a thing.

PARMENTER: Even when the information in an article is false, this may produce or trigger some useful discovery. If it seems to you that the information is false, you may work twice as hard to prove that it is wrong as you would have worked originally to get the same result. And, of course, it's not only reading; it is listening to lectures as well as just informal discussions among various individuals. It all plays a part in the scene of communication.

HEIMAN: I think a scientist has to be a little careful of being too narrowminded, getting too involved in the particulars of the project. Every once in a while it is good to sit back and think — blue-sky think. You have to sit back and try wild way-out approaches. It is often the only way to get something new.

PARMENTER: Oh, I think it's essential, which is perhaps another way of saying a great deal of research is not a particularly logical process. Hopefully, the end results have some logic, but the means of going about it may not necessarily be logical.

MCCOY: You cannot legislate productivity by daydreaming though. I remember at the Industrial Research Institute many of the directors of research who attended mentioned that they had attempted to set aside 10 per cent of the time of the research staff for blue-sky thinking — daydreaming. But somehow it didn't work. The men who took the time to spend their 10 per cent daydreaming were not productive, whereas the people who didn't have the time were the guys who were coming up with the ideas. So I don't think you can sit down and say: "All right, I'm going to take half an hour and I'm going to be very ingenious and inventive." It isn't going to work.

HEIMAN: The question of daydreaming and timing actually comes together. Jules Verne dreamt of a submarine. He doesn't get credit for discovering the submarine. He shouldn't. You have to sort of daydream along with the times. Using the knowledge you have from some of the latest developments, you can try to piece things together.

SMITH: I suppose it's broadly true to say that a great many of today's scientific breakthroughs are coming — not from the scientist working alone in his lab — but from great research centers like the one we are in.

MCCOY: One of the reasons for this is there is an interaction when you are in a group, and it may be a beneficial one. For instance, you can daydream in a group — this is what you call the bull session or the brainstorming session. Something that someone says may trigger an idea in another man. But then, in order to implement that idea, he will go and do his thinking by himself.

HEIMAN: Archimedes, for example, knew all there was to know about science. But, nowadays, it is just impossible for one person to come up with a rather large piece of invention. You need a chemist, a physicist, an electrical engineer. It encompasses many different fields.

PARMENTER: Whether it's a group effort or an individual one in part depends upon what the area of research and development is. Most of mine is individual research. I'm working with paper and pencil or a computer of some sort. But when you get into an area that cuts across many disciplines, or where it is essential to use a piece of massive apparatus — say in high-energy physics — you need a small army of technicians just to keep the thing running. This is another reason why group effort is essential in many areas today.

SMITH: Earlier, we were discussing the pleasure–pain phenomenon that seems so integral a part of the daily lot of a scientific investigator. We noted some of the frustrations. What about the rewards — can anyone remember a specific example?

Dr. Robert H. Parmenter

Dr. Donald S. McCoy

Dr. Frederic P. Heiman

PARMENTER: One instance that comes to mind was the time when I was living in Switzerland. I was working with another fellow, trying to see what could be done about developing a theory for limited current flow. One night I was home in my Zurich apartment and, suddenly, it hit me! The technique where mathematically one could sit down and solve the equations analytically.

SMITH: What did you do after that?

PARMENTER: Sat down and checked it on paper.

MCCOY: Some years ago, I was involved in stereophonic AM radio transmission. We were designing and building a system to transmit this highly modulated signal. I well remember the first time we got stereo to come out of the loud-speaker systems. It was an exhilarating moment.

HEIMAN: In my case, I remember the time quite specifically — 4:30 in the afternoon. It was the first time, anywhere, the silicon field effect transistor had ever worked. We called in our supervisor and had a party.

SMITH: Of course, all these things that you have mentioned are extremely technical in nature. Can you think of a single thing that you have seen in a drugstore or in your home about which you have been able to say, "I had a part in the making of that?"

HEIMAN: We're really too young. I mean, the time scale involved between research and the product is generally five, 10, 15 years from the inception of a good piece of research to the time you can buy it. There are people at the laboratories here who were involved in the beginning of both black-and-white and color television. Of course, they see it in their homes every day. They have helped design the circuits; they have discovered the phosphors and materials. Personally, I just haven't seen that yet.

SMITH: A final question: What is the single most satisfying thing that you get out of your work?

HEIMAN: To me, publication. Let's put it another way, being referenced. If I read an article and find someone has referenced my publication, I think that's the most satisfying thing.

MCCOY: I would have to place understanding, the satisfaction that comes from the final grasp of the problem, the final understanding ahead. I'd have to place that slightly ahead of the gratification you get from public recognition for your work.

PARMENTER: I'd say mine would be a sort of combination of the two: namely, when you finally understand something that hasn't been understood before and the thing is finally settled and published. Here again, you have created something. You have made an addition to knowledge, to understanding. There is a kind of proprietary pride in this, and it's sort of like giving birth.

As the train clattered back to New York, I kept thinking of the endless production of new products in this country and of our scientists' inventiveness. Ever since the industrial revolution, the growth rate of this nation has been the result not of a single development but of a series of developments. During the 60-minute train ride, a dozen examples of new technology flashed by — superhighways, jet planes, TV aerials, oil cracking plants, and many more — none of which existed only a few years ago. I also wondered if I had succeeded during the discussion in getting an answer to the question, how does new knowledge come about? Hardly! Did I discover, however, a single common denominator shared by the three research workers? Yes, I thought — the need to know. ■

New Eye on the World of Color

Outstanding design feature of RCA's TK-42 color TV camera is the addition of a fourth tube to produce monochrome signals.

The TK-42 color TV camera, first to employ the four-tube concept, produces richer hues and greater sharpness in color pictures and also provides improved black-and-white pictures.

by Edward J. Dudley

For television viewers, 1965 was the year of the Big Rainbow, when everybody, it seems, was switching to color. The switchers were served up big helpings of color, a diet that watchers of black-and-white found increasingly hard to resist. With more and more sponsors insisting on color for their commercials, the rainbow had arched over much of the TV industry, and was glowing brighter all the time.

All this had a resounding impact on that part of television the viewer seldom sees: the control room and associated broadcasting plant. As signs of the color boom multiplied, broadcasters scrambled for the color cameras, film systems, TV tape recorders, and other equipment needed to put color shows on the air.

The equipment rush turned the spotlight on the color TV camera, the hub of the broadcasting process and a $75,000 marvel of electronic intricacy and performance. Color king of all it surveys, the camera looks at the scene with sharp and sensitive eyes, sorts out the colors, and converts them to electrical pulses. Thus begins the complex chain of unseen events that ends with a color picture on the home receiver.

In the first years of color TV — when hue was new — broadcasts were put together under rather hectic conditions. A two-man crew operated each studio camera. One man composed the picture in the viewfinder; the other, a few feet away, manned the camera control position, in effect "painting" the colors of the picture. It was a time when every camera controller fancied himself an artist, and the picture that went out on the air tended to vary in quality with the color taste of the man at the controls.

Some early color TV amounted to witchcraft, with performers on occasion obliged to wear weirdly colored make-up to satisfy the individual color preferences of technicians. And when program pickup was switched from Camera No. 1 to Camera No. 2 or 3, the variations in color were all too apparent to the viewer at home.

Camera manufacturers were well aware of the need for consistent performance and were developing designs that would replace artistry with sound and unvarying technology. On one occasion, a prototype camera was being tested in RCA's Camden, N.J., laboratories by training it on objects with familiar colors. When it came time to test-shoot a bunch of bananas, an RCA engineer — in a bit of inspired horseplay — plunged the bananas into a bucket of purple paint that happened to be nearby and set them before the camera. The resulting pictures caused a frantic twiddling of dials and a gnashing of teeth among the engineers that seldom has been equaled.

On another occasion, a front-office network vice president wandered into a studio where an early color show was being rehearsed. The program featured animals, and the picture appearing on studio monitors as the VP entered showed a monkey with rich green fur.

"Change it!" howled the executive despite a technician's protest that it was merely a color test. So the controls were adjused to produce pictures of the monkey with natural brownish fur. But when the camera was switched to the animal trainer, he appeared with a green face!

Other problems, like the super-bright studio lighting needed to compensate for the low sensitivity of the first color camera pickup tubes, plagued the pioneer broadcasters of color. Indeed, it was a wonder that color programs ever got off the ground and on the air.

These troubles largely have been engineered into oblivion since 1954 when RCA delivered the first practical color television camera. Now, the operating experience of those 12 years is built into a radically new color camera, RCA's type TK-42, which promises to make color pictures even better than they are now. No slapdash product trotted out to ride the color stampede, the new camera had been developed, tested, and refined over a period of nearly five years — probably the longest and most thorough shakedown ever for an item of TV equipment.

Perhaps the most striking design change represented by the TK-42 is its introduction of a fourth pickup tube, a concept pioneered by RCA. Up to now, all color TV cameras have used three pickup tubes, for the red, green, and blue signals that are combined in the home receiver and appear as color pictures on the screen.

The job of the fourth tube is to produce monochrome signals that are independent of those generated by the three color tubes. Viewers who have seen the new four-tube camera in action find the effect is twofold: color pictures seen on color receivers are crisper and more detailed than ever before; the same pictures viewed in monochrome are the equal of those from the finest black-and-white cameras.

Although the TK-42 is engineered to produce the best-quality color pictures for the growing audience watching programs in color, its design recognizes the fact that most viewers will continue to see color broadcasts in black-and-white during the transition years to universal color.

The TK-42 had its design roots in the original RCA color cameras, developed more than 13 years ago, which met the needs of both color and black-and-white program viewers. To produce monochrome pictures, the TV signal needs to carry but one kind of information — brightness. It paints a continually changing picture of variations in brightness, ranging from black to white as the scene shifts and the reflected light varies.

Color imposes a heavier burden on the system, making it carry, in addition, information on hue and saturation. Hue is another word for color, or more exactly for the characteristics that make it possible to distinguish one color from another. Saturation describes the intensity of color. A deep purple is heavily saturated, a pastel shade lightly so. All of this essential detail must be loaded electrically into the television system — to fashion the finished color picture.

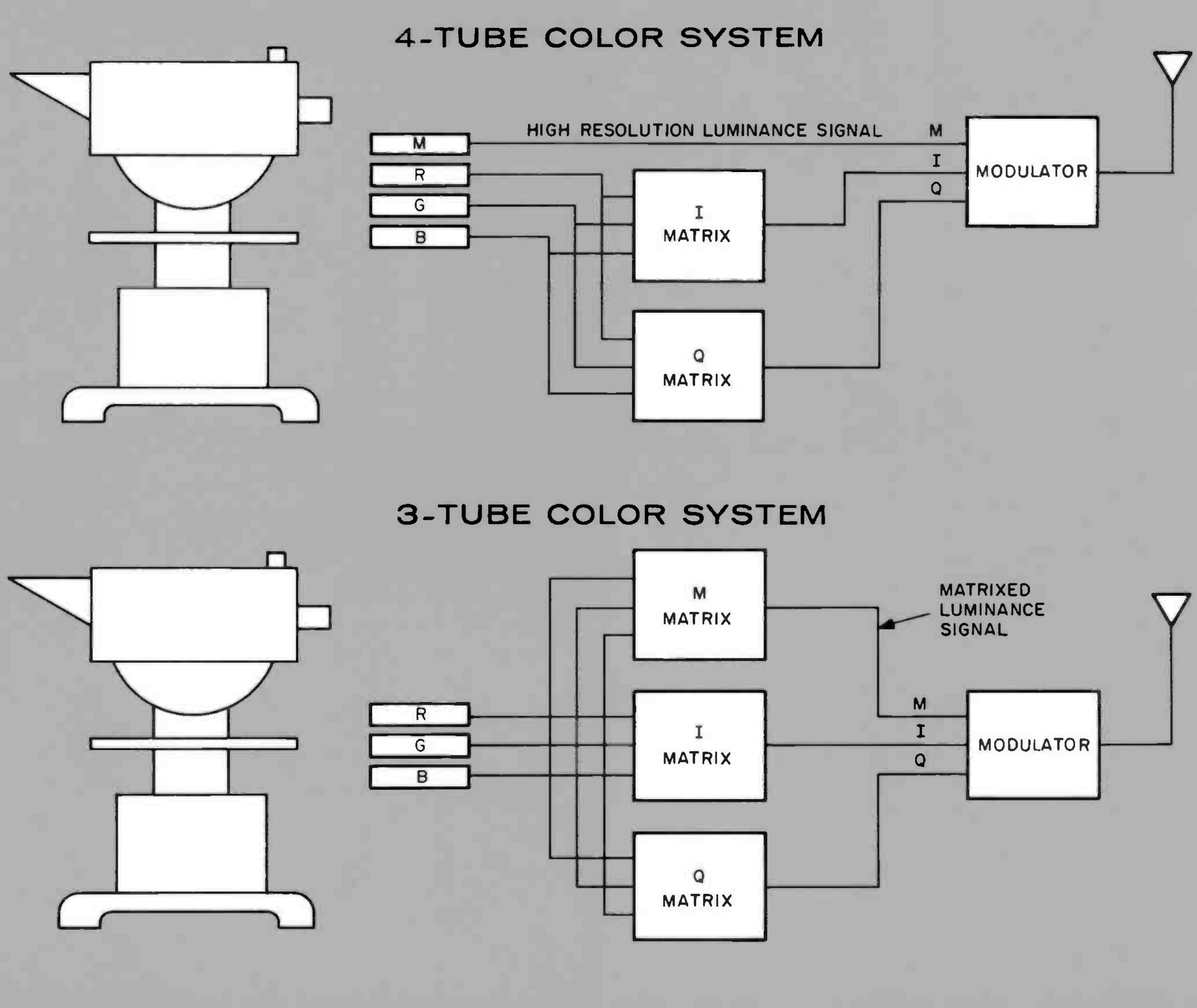
With the four-tube camera, the brightness part of the signal — producing in essence the picture received by black-and-white sets — comes directly from a 4½-inch image orthicon. This is the same kind of pickup tube used in top-rated black-and-white cameras.

On the color side, the function of the fourth tube can be likened to that of the black plate in four-color printing. Seen without black, proofs from color printing plates are pale and washed out. When black is added, the picture takes on a richness that is appealing and true to life.

The separate monochrome tube performs in much the same way, adding detail to the color picture and affording a degree of sharpness beyond that attainable with three-tube cameras. And, since most of the picture detail is carried in the fourth channel, the registration of the three colors becomes less critical.

Like its predecessors, the TK-42 uses an optical light splitting system to break down the picture into its components. The process begins with the camera lens collecting

Diagram illustrates essential difference between three-tube color TV camera and RCA's new four-tube model.



TK-42 color TV camera shoots studio scene on set of "Today in Georgia" show at station WSB-TV, Atlanta.

light rays in full color from the scene being televised. Twenty per cent of the light is sent along to the monochrome tube, while the remainder is divided among the three color tubes.

Light for the color tubes strikes dichroic mirrors that have the property of reflecting one color while passing another. The first mirror reflects the red light to one of the pickup tubes, while allowing the blue and green light to pass through. The second reflects blue similarly, leaving only green rays for the third tube. Thus, the system, using filters to assure color purity, creates three images in the primary colors.

The images are focused on the tube faces where the electron beam works its magic, scanning the images and converting them to electrical signals. The signals are processed, amplified, and radiated into the air and, upon reaching the home receiver, are changed back again into pictures visible on the screen. All of this occurs instantaneously with the synchronous precision that has made television, and especially color TV, a marvel of our age.

The passage of little more than 12 years since color TV broadcasting was authorized already has blurred that marvel and the technological achievement that color TV represents. For example, an early hurdle facing development engineers was to design a color camera that would be compatible with the existing black-and-white TV system.

Compatibility meant that broadcasts in color could be received in black-and-white, without adjustment or addition to black-and-white receivers. It meant, too, that color transmissions, carrying much more information than black-and-white, had to be squeezed into a six-megacycle channel, the same width being used for black-and-white broadcasts.

Camera designers met the first requirement by devising a way to add the three color signals together, producing a monochrome signal that the black-and-white receiver would accept while ignoring the color signals.

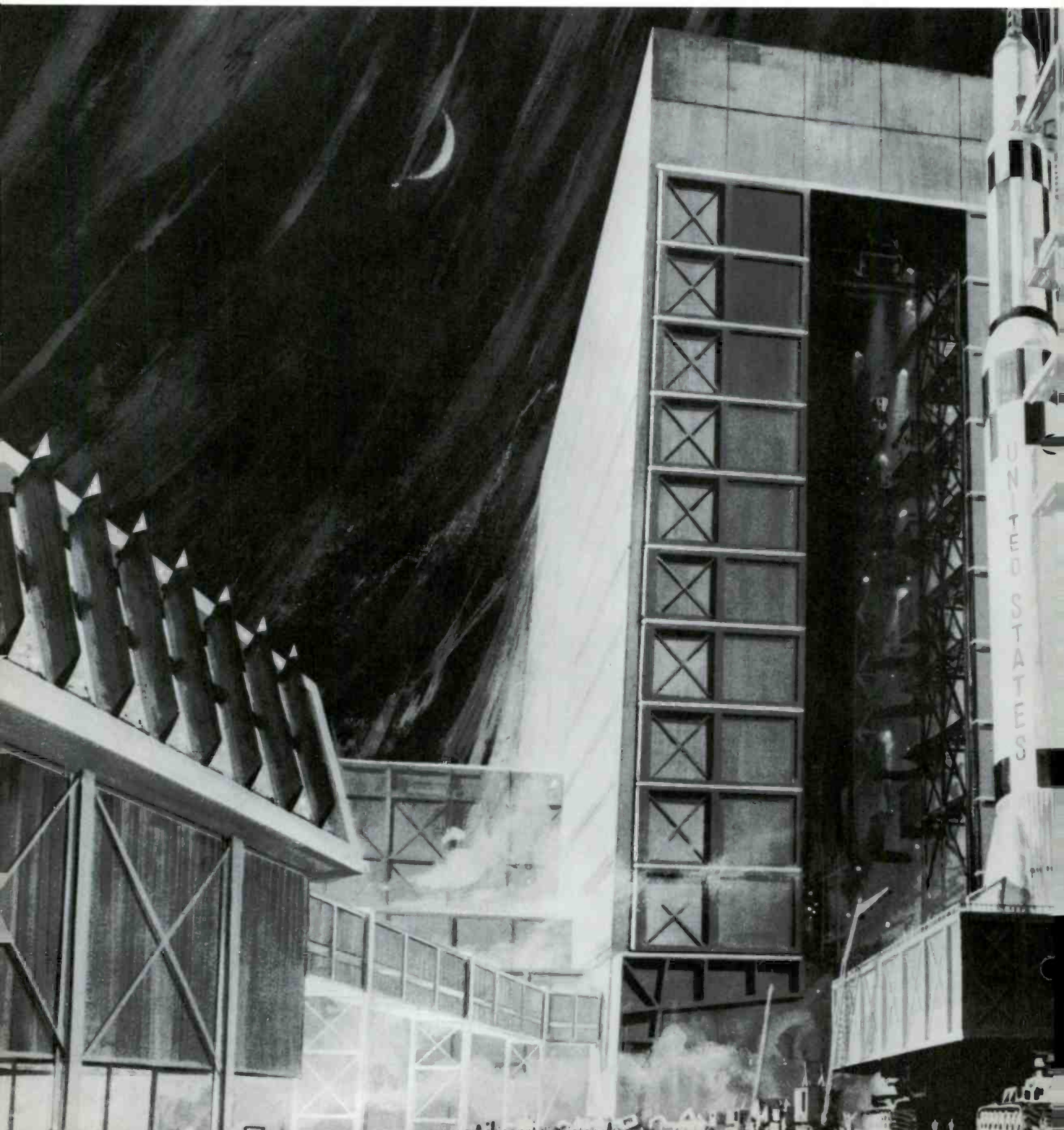
The matter of keeping color broadcasts within the six-megacycle slice of the spectrum called for all of the electronic sleight-of-hand the engineers could muster. Even though the TV band of 6 million cycles is huge by comparison with the standard AM radio channel of 10,000 cycles, the "squeeze" would be a tight one.

A few statistics of the TV system describe the problem: TV pictures are presented 30 times each second, giving the viewer an illusion of motion. Each picture consists of 200,000 electrical "bits." Ergo, the TV system must handle information at the astonishing rate of 6 million bits per second.

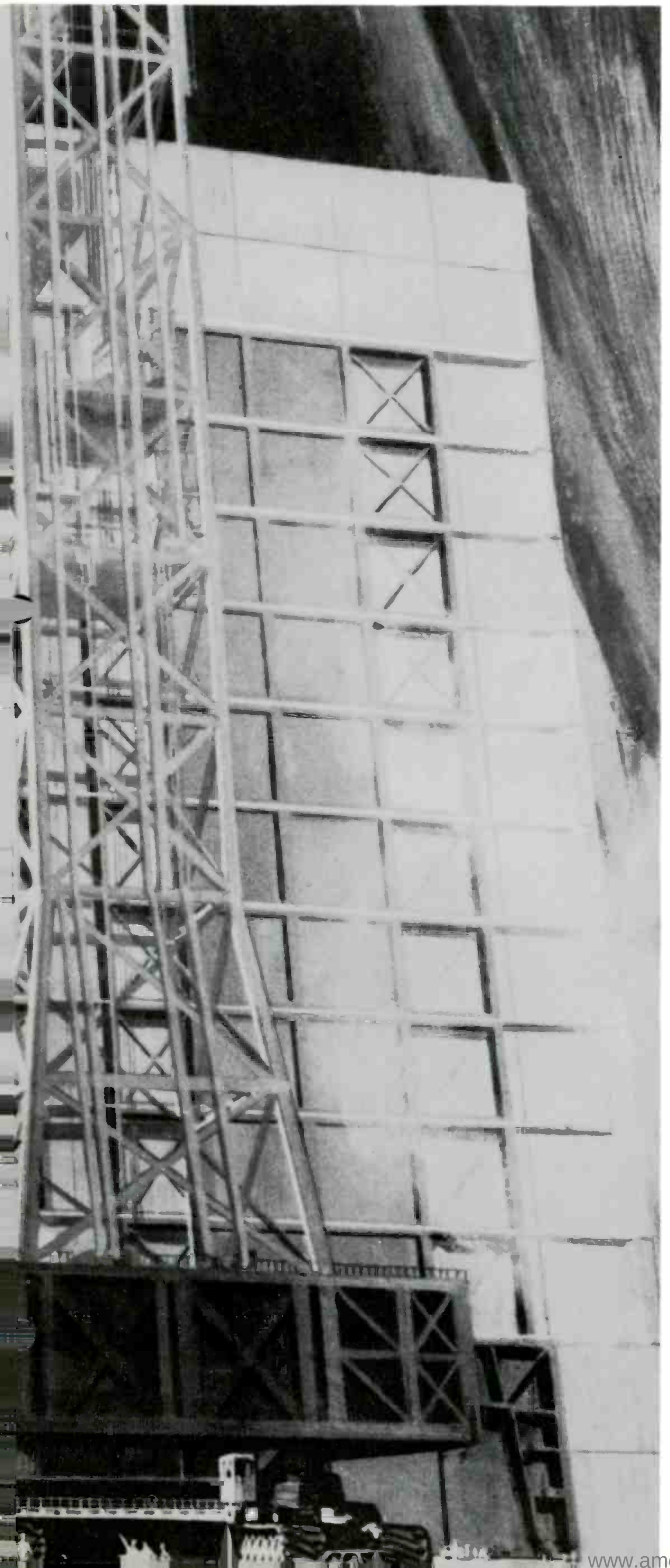
To impose color data on this mass of information, the engineers saved part of the bandwidth by taking advantage of the limitation of the human eye in distinguishing colors only in relatively large areas. Picture detail was made a function of the system's "brightness" signal, while the color signal carried information on hue and saturation for large areas of the picture. Thus, "compatible" color broadcasting became practical, and a sound technical basis was laid for the industry's growth.

Today, as the color boom reverberates on all sides, new and advanced broadcast equipment as symbolized by the TK-42 camera is pushing the color television industry ahead on the technological front. Within a few months, when the new cameras are in general use, viewers themselves will be able to see, in pictures on their home screens, the new level of technical excellence they provide. For viewer and broadcaster alike, the new cameras will help fulfill the promise of television's color age — a kaleidoscope of color in the world outside, faithfully reproduced in the living room. ■

Some Call It the "Countdown Computer"



But the RCA 110A is assigned to do more than just handle the countdown in the moon mission: it is helping to manage production of the Saturn boosters themselves.



by Robert L. Moora

Twenty years ago if some sage scientist had predicted that man would be walking on the moon before the end of the 20th century, the public might have accepted his statement with some degree of reserved credence. The era of rocketry had been ushered in by the German V-bomb successes in World War II and, while rocketing to the moon was still a dream, it was now a more credible one.

If that same scientist, however, had gone on to say that the first vehicle to take men to the moon would be launched not by human beings but by a machine, the public would have laughed in derision. Yet, in a sense, that is precisely what the National Aeronautics and Space Administration is planning to do in its Apollo program to land men on the moon by 1970. For, during the last four and a half hours of countdown at the John F. Kennedy Space Center — and during the two and a half hours when launch toward the moon will be feasible — a computer sitting an uncomfortable 50 feet from the blast-off pad, unattended by men, will be in command of many functions of the giant Saturn 5 vehicle that will carry the Apollo spacecraft skyward with its three astronaut passengers.

A human crew, safely ensconced in another building seven miles away and equipped with a similar computer that is "talking" constantly to its partner on the pad, will be on hand to step in and take action if anything should seem amiss. But, essentially, it will be the computer, ticking away in solitary confinement, unseen and unattended by mankind, that will execute the launch.

This is one of the dramatic developments in a new chapter being written in the story of the computer age — a chapter unalterably linked with the one being written concurrently on the Apollo moon mission.

Without computers, the program would be extremely difficult. For, in addition to their countdown role, computers will play, and already are playing, an almost incredible part in the mission — in the design, development, production, and checkout of the Saturn 5.

The machine that will be used in the lift-off is a refined version of an industrial controls computer known as the

Artist's conception of Vehicle Assembly Building at John F. Kennedy Space Center, where Saturn 5/Apollo will be assembled.

RCA 110. It has already demonstrated its ability to do the job. In the 10 Saturn 1 launches since October, 1961, all of them successful, the data processing equipment played important roles — before, during, and after launch.

The same computer, which is designated the 110A because of the sweeping changes it has undergone for the Apollo program, is now in service on the next important step in the moon mission. This will consist of 12 scheduled launches of Saturn 1-B, intended to practice maneuvers necessary in the ultimate voyage to the moon.

Data processing systems, those electronic "brains" that mystify all but the people who work with them, are performing remarkable services for man today. They tabulate phone calls and process bills; control traffic in busy railroad freight yards; make reservations for airline passengers; set type in newspaper print shops; record bank accounts, payrolls, insurance premiums and claims — and act upon them when necessary. And, by liquidating mountains of paperwork, they help corporation executives make decisions easier, quicker, and with sounder judgment. On the lighter side, computers have been used to match couples for marriage, write poetry, and compose music.

But nowhere is there a data processing program that compares in scope with that of Saturn, in which computers are helping man to manage the project, from design through development and production to the launch itself.

At the very start of the Saturn program, the rocket experts at NASA's George C. Marshall Space Flight Center, Huntsville, Ala., realized that the ground support equipment needed for the job would be so complex that it could not be operated manually.

NASA estimated that approximately 5,000 individual tests or measurements would be taken on a Saturn 5 vehicle at the launch site, thousands more at other facilities where various stages of the rocket were to be developed.

The MSFC staff then cast about for a computer that would meet the following requirements, among others:

- It must be a powerful tool, capable of handling a large volume of data simultaneously on multiple channels.
- It should operate more slowly than most commercial and scientific computers to cut noise and interference.
- It must be able to transfer data to display consoles, tape, and punch cards, and at the same time store the data for later study.
- It must be capable of detecting trouble areas, pinpointing the causes, and taking immediate corrective action.
- It must be flexible enough to be applicable to all major phases of the program.
- It must be durable enough to survive the rigors of the blast-off only a few feet away from its blockhouse.

The computer that seemed to come closest was the RCA 110, originally developed by the Radio Corporation of America in the early 1960s for industrial controls — checking the thicknesses and tolerances of metal plating, for example, or counting and assigning distribution of such products as soda pop bottles coming off the production line. One such computer was used in the launch of the first Saturn 1 in October, 1961, thus beginning the exploration of the problems of ground support equipment, telemetry, tracking, and other factors that eventually would apply to the Saturn 5 that will take the Apollo moon vehicle into space. In that first Saturn mission, the computer assisted in the checkout and monitoring in the control room, but the launch was controlled manually.

As the Saturn program progressed, the computer underwent extensive refinement, expansion, militarization, and custom-tailoring. As of today, RCA has produced 29 of the 110A computers, some just nearing completion, for NASA's Saturn/Apollo program. They are deployed around the country wherever important stages of the Saturn vehicle are under construction.

The most glamorous of the computer operations, of course, are at the Kennedy Space Center, where the Saturns will be assembled in the new Vehicle Assembly Building. This is the world's largest building, with a cubic volume almost equivalent to the combined volume of Washington's Pentagon and Chicago's Merchandise Mart. Inside, protected from the elements, the Saturn 5 — 360 feet tall — will be assembled alongside a launch umbilical tower (LUT) that itself is 445 feet tall, about the equivalent of a 45-story building.

The computer assigned to countdown duty is installed in the base of the tower. It is connected to the Saturn vehicle by a myriad of wires and electronic devices. It is also connected with an identical computer installed in the launch control center adjacent to the assembly building. Together, they check out the vehicle as it is assembled stage by stage. The two computers "talk" to each other, much as two people talk on the telephone, over a communications system known as the computer data link that sends and receives "words" or data in computer language. When the booster finally is taken to its launch, the two computers will still be linked for coordinated action.

On launch day, the Saturn system will have already been checked out by the computer. The astronauts will enter the Apollo spacecraft atop the huge rocket. All other personnel will vacate the launch pad. For the next four and a half hours, the RCA 110A has a lonely vigil to keep as it makes final checks on the readiness of the rocket and final countdown adjustments and instrument settings, guided when required by its twin computer in the control center.

During this final checkout, the computer commands the rocket to exercise valves, engines, and relays, and it measures their performance in response to these signals. If the responses are judged by the computer system to be satisfactory, the system then proceeds toward launch. Should problems arise, these will be reported by data link to the control center computer that will decide corrective action. At any time, the test operators may decide to direct the action, and break into the computer command chain.

The computer tending the launch is protected by thick concrete and steel walls, but it will still be subjected to tremendous forces of vibration and noise as the booster is blasted off. Its designers and builders are confident it will "stand the gaff," for the machine has been subjected to formidable endurance tests at a laboratory in Huntsville, Ala. It has been shaken on a vibration table at a rate that equaled the estimated punishment it will take when the Saturn is pushed skyward with 7.5 million pounds of thrust. It has been placed in a horn-shaped building at

Saturn rockets will travel on launch umbilical towers (left) from Vehicle Assembly Building to launch pad over roadway at right.

Technicians check one of the 29 RCA 110A computers scheduled for service in NASA's Saturn/Apollo program, including checkout of launch itself.

one end of which a massive siren screeched at it in the fierce sound level of 140 decibels to prove it could continue performing amid the noise of the blast-off.

Not only do the computers participate in the launch itself but they eliminate a monumental task of paperwork in the postlaunch analysis. What the computers provide in 24 hours would take men many months of study of papers laid out on literally miles of 50-yard-long boards.

At Huntsville, 12 of the 110As are now in service for the Saturn 1-B program and Saturn 5 for various tasks such as experiments, developmental work, tests, and the creating of programs for other computers. Others are serving the Douglas Aircraft Company and NASA in the building of the Saturn 5 vehicle's third-stage rocket. Still other computers are in use at government facilities in Louisiana and Mississippi to assist the Chrysler Corporation in the building of the Saturn 1-B first-stage rocket and The Boeing Company in building and testing the Saturn 5 booster.

"In every one of these tasks, the computer must have absolutely top reliability," says Arvid E. Fogelberg, the 110A program manager at RCA's West Coast Division, Van Nuys, Calif. "A good example of the reason why is in the stiff time requirements for the launch. The computer on the pad must be counted on to operate flawlessly, unattended by men, for seven hours straight — the last four and a half hours of countdown and the two and a half hour 'window' for launch.

"The people at Huntsville have set a goal of 99 per cent assurance of seven hours' dependable operation — as, I assume, they have done with other contractors on their systems. But we've got to aim for that kind of reliability far beyond seven hours — in fact, stretch it back months through the development phases. And we're doing it." ■

"Bonanza"

One of the most popular TV shows of all time, this NBC drama, now in its seventh season, is seen in more than 60 countries each week.

by Al Husted

Since its debut in 1959 as the first network hour-long film series in color, "Bonanza" has consistently remained one of the highest rated television shows in the United States.

To satisfy the desire of a vast American audience, it is estimated that the NBC Television Network has rolled more than 2 million feet of "Bonanza" color film through the projectors to feed more than 250 episodes and their repeats to 203 affiliated and 22 associated television stations.

Now in its seventh season, "Bonanza" tells the story of Ben Cartwright (Lorne Greene) who, with his sons Hoss (Dan Blocker) and Little Joe (Michael Landon), owns the Ponderosa, a thousand square miles of timberland on the shores of Lake Tahoe. The Cartwrights' protection of the Ponderosa from the invasion of miners and get-rich-quick transients drawn to Virginia City in the 1860s by the discovery of silver was the original plot. Now the story line is sometimes expanded to include other frontier problems and historical events. Early this year, the first two-hour, two-part episode featured the establishment of the Pony Express. And, once, far removed from the Ponderosa, one of the Cartwrights was shanghaied in a sea tale.

Executive producer David Dortort insists that the plots be historically credible. Although the interior scenes and some exterior shots are taken on Paramount Studios' sound stages in Hollywood, members of the "Bonanza" crew constantly search for authentic and colorful location sites.

Each year the "Bonanza" stars and technicians spend more and more time on location. The areas used have included the Lake Tahoe–Virginia City region of southern Nevada, the Kern River country of California, and the wooded mountain area near Flagstaff, Ariz., site of the world's largest stand of ponderosa pine.

When the Cartwrights move out of Hollywood for on-location work, difficult logistic problems arise. More than 150 tons of equipment must be transported, plus 135 persons and dozens of horses and cattle. Moving vans and two airliners carry the largest production aggregation since Ringling Brothers' Barnum and Bailey circus trains. On the production call sheet appear such items as a generator truck, a camera truck with boom, trailers housing five dressing rooms and sanitary units, water wagons, horse trucks, and a five-ton truck filled with set dressing material (which may include trees, rocks, grass, and other items that nature may not have arranged conveniently). When a scene was filmed in a desert, a dump truck loaded with tons of sand was brought along to make certain the desert looked real.

During daily meetings, a list is made of people and gear required for the following day's shooting. All outside arrangements such as location rent, horse rentals, and catering service may be canceled as late as 8 P.M. the night before shooting if the crew is rained out. Nevertheless, everything must be paid for, regardless of the weather.

The company has been rained out only once since "Bonanza" has been in production. One hot day in July the crew set up in Bartlett Dry Lake near Big Bear in southern California. Suddenly, there was a thunderstorm that turned the dry lake into a sea. "Out of the canyon came a wall of water that forced our cast and crew to make a run for it," producer Dortort recalls. The next day, the crew was digging out pieces of heavy equipment from the mud, and the actors were soaking their feet in buckets of hot water.

"Fortunately there were no injuries in that incident," Dortort said. But occasionally the action called for in the script does lead to injury. In a chase scene at Iverson's Ranch in the San Fernando Valley, both Dan Blocker and Pernell Roberts were hurt when their horses fell. Roberts'

Guest star Gilbert Roland leans forward in chair during a rehearsal.

Technicians surround Lorne Greene, on horse, as they prepare to shoot close-ups.

horse, leading the chase, stumbled in the soft ground and fell. Blocker's horse, following closely, could not avoid the pile-up and also fell. Blocker fractured his left clavicle and suffered a shoulder separation. Roberts received neck injuries. Blocker was in a cast for several weeks, but Roberts returned to work in a few days. The writers on the show reworked the scripts to allow for Blocker's absence and even wrote scenes for his appearance in a plaster cast if it would be necessary.

A doctor always accompanies the crew when it goes on location. Other persons needed for shooting are extras, hair stylists, stand-ins, stunt men, a nursery man, grips, crafts servicemen, camera assistants, sound technicians, a sound boom man, men to handle the cables, a painter, property men, special-effects men, wranglers for the horses and cattle, wardrobe people, electricians, and make-up men.

An on-location assignment gives the stars a chance for a little fresh air, but a typical shooting day in Hollywood is easier for the crew. Lorne Greene recently described a day's work:

"Our day starts shortly after five o'clock in the morning. Dan Blocker and Michael Landon meet me at a quiet spot at the back of the big stage about 6 A.M. We all get our hearts beating and our lungs pumping with a few cups of gosh-awful coffee, and then we start reading the pages of the script that we'll be shooting that day.

"While we are rehearsing, about 50 others are getting the stage prepared for filming. The electricians are setting the lights to make sure that the color on the film will look good, or to eliminate the microphone shadow on the saloon's swinging doors.

"The wranglers are feeding and preparing the horses for the day's work. The wardrobe men are checking to be sure that the right clothes are ready for the proper scenes and actors. Soundmen are checking out microphones and recorders, and hairdressers are primping any women who may be scheduled during the day's shots.

"In the meantime, make-up men are doing their best to work on us while we rehearse.

"Just about the time that normal people's alarm clocks are going off all over the city, we hear the director yell 'First team!' That means that the 'second team' — our stand-ins — have run through the scene to make sure that the lighting is right and that all we're supposed to do can be done.

"Then we step in and the filming begins. We wrap up about 6 or 7 P.M."

Shooting seldom stops on the "Bonanza" set. However, there are special occasions when all production stops, such as the day the stars of the show helped to swear in 50 new members of the U.S. Air Force. The new servicemen, all recent high school graduates from the Los Angeles area, enlisted in the "Buddy Flight" program. This Air Force program enabled any group of 50 young men to form a unit, choose a name for it, and enlist in the Air Force with assurance that members of the group would remain together during their enlistment period. This particular group chose the name "The Bonanza Flight," so the Air Force brought the men and their families onto a Hollywood sound stage where "Bonanza" is filmed to allow the stars of the series to be present as the enlistees were sworn in.

At other times, one or two of the stars may be absent from the set to make personal appearances. Lorne Greene, Michael Landon, and Dan Blocker have traveled extensively in the United States and often in other countries to promote the show. They have appeared at city and state festivals, fairs, and centennials. Greene seems to love a

Lee Marvin, a guest star, points gun during filming in Hollywood.

Crane supports artificial balloon carrying Little Joe.

parade. He co-hosts the annual Macy's Thanksgiving Day Parade in New York. Last year, he did the Rose Bowl Parade, and this year he will do the Orange Bowl Parade, too. Blocker, a native-born Texan, was invited to the White House by President Johnson to meet British Prime Minister Harold Wilson.

"Bonanza" is acclaimed by critics and poll-takers so often that the stars of the program are kept busy accepting trophies, plaques, and certificates for the show as well as for themselves. All three have won the "Silver Spurs," given by the Reno, Nev., Chamber of Commerce to outstanding Western stars. Blocker is the only actor to receive the Spurs twice. Other actors awarded the Spurs are John Wayne, Gary Cooper, James Arness, and Richard Boone. The program has won, among other awards, "The Golden Mike" from the American Legion Auxiliary, "The Best Show on TV" award from the *TV Radio Mirror* poll, and the "Look-Listen Opinion Poll Award" from the American Council for Better Broadcasts.

Oscars and Emmys have been given to behind-the-scenes workers on the program. Edward Ancona won an Emmy as color consultant on "Bonanza." Jay Livingston and Ray Evans who scored the "Bonanza" theme have won Academy Awards for "Mona Lisa," "Buttons and Bows," and "Que Serra."

Producer Dortort thinks "Bonanza" may continue to win awards for at least another two years. That is the current projection by cast and crew for the life of the program. But, because of the increased popularity in each of its seven years, no one is taking bets on the date production stops. When "Bonanza" does get to Boot Hill, syndicated distribution is expected to keep its memory green for many years in domestic markets. NBC Films has already lassoed domestic distribution rights.

In the United States, the Cartwrights are seen not only on television but also on the newsstands and in book stores. A paperback book, magazines, and comic books featuring the "Bonanza" characters and stories are now available. A comic strip will appear in 1966 for publication Monday through Saturday in 12-week episodes. NBC Enterprises licensed Lorne Greene's Los Angeles company, Creative Illustrators, to turn out the strips. Writers from the television program will originate the material.

In addition to film and print, "Bonanza" and the Cartwrights appear in plastic, wood, metal, paint, and cloth. Some of the products licensed by NBC for merchandising are slacks and skirts, Ponderosa Ranch bread flour, lunch boxes, paint-by-number sets, jigsaw puzzles, bedspreads, games, phonograph records, maps of the Ponderosa Ranch, and men's sport shirts. Toys licensed include rifles and guns, costumes, target ranges, molded plastic hobby kits, and coloring books. A new line of doll-sized replicas of the stars of the show is expected to be the main attraction of the toy fair to be held in New York during March. Working models of Ponderosa Ranch machines, tools, and wagons are also to be unveiled at the spring fair.

Outside the United States, in such exotic-sounding places as Aden, Hong Kong, Trinidad, and Pago Pago, "Bonanza" corrals what is believed to be the largest world-wide audience for any regularly scheduled television program. It is estimated that more than 350 million people in 62 different countries see "Bonanza" each week by arrangement with NBC International Enterprises.

This year, for the first time, overseas fan mail sur-

Nigerians watch "Bonanza" on the first television set produced in that country.

"Bonanza" is seen on communal TV in many Latin American countries.

passed the count of domestic letters to the Cartwrights. The largest amount of international fan mail comes from viewers in African countries, New Zealand, Brazil, West Germany, and Canada.

It is presumed that "Bonanza" has a large viewing audience in the USSR. The program is reportedly bootlegged into the Soviet Union by a Helsinki station. Lorne Greene said, "We found out about it from a man with a name similar to Cartwright. He was at the United Nations for official business when a Russian diplomat asked him if he were related to the TV Cartwrights. The diplomat said that 'Bonanza' is seen by a good many Russians."

Although there is no official count of the number of Russians who tune in to "Bonanza," an accurate poll in Holland shows that more than 3.6 million Dutch viewers tune in on Saturday nights to watch the Cartwrights protect the Ponderosa. Recently, in Belgium, *Humo* magazine announced that "Bonanza" was selected by the viewing public as the top television program. In Spain, Television Espanola's official publication reports that Spanish viewers voted the program the most popular show on TV.

David Dortort attributes the universal popularity of the program to its theme of family togetherness and the dominant father image projected by the head of the Cartwright clan, Lorne Greene. Dortort believes paternal dominance is something people in other countries can understand and respect.

In addition to providing the international audience with entertainment and adventure in a socially acceptable format, "Bonanza" is easily understood — literally — in seven other languages. The program is in its sixth year of Spanish dubbing, and the newest language for the Cartwright family is Arabic. The other dubbed languages are German, Portuguese, French, Italian, and Japanese. It is reported that at one time "Bonanza" was first telecast in English in Thailand, and then repeated immediately with a Thai translator ad-libbing narration in the local language from notes.

NBC International Enterprises dubs "Bonanza" in the language of the country in which it will be seen to assure authentic speech and to prevent an American accent. In many cases, expensive audio techniques are employed to enhance the dramatic intensity of the program for the international audience.

Theatrical techniques used in dubbing "Bonanza" vary from country to country according to custom. In Japan, the sound track is dubbed in the classical Kabuki style. The actor whose voice is used for the Lorne Greene role was trained in the Kabuki tradition for more than 60 years. The services of Kabuki actors are often reported to cost as much as the purchase price of the program. However, this Western form of Kabuki drama has proved worth while. When the program switched from conventional actors to Kabuki voices, the size of the Japanese audience increased dramatically, according to NBC International representatives there.

Overseas, some countries are telecasting almost current episodes of "Bonanza." Others are only now showing the first episodes of the 1959 series. With seven seasons of the program available for distribution, and with the number of local television stations rapidly increasing in almost every country in the world, it is expected that "Bonanza" will remain one of the most popular programs in television history. ■

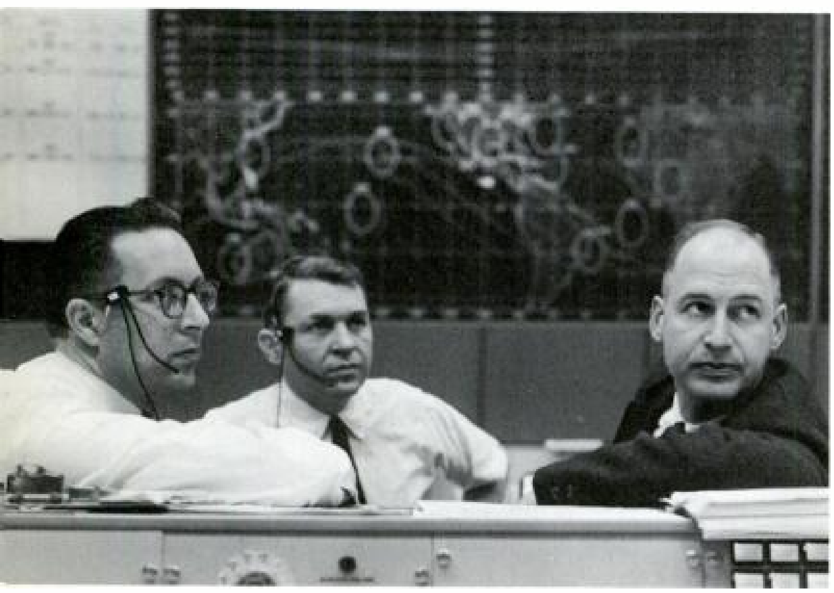
Space Age Lifeline

How the Manned Space Flight Tracking Network maintains constant electronic contact with orbiting space vehicles and their crews.

by Edward W. Atkinson

Two telemetry antennas are silhouetted against the Florida sky in the Cape Kennedy launch area.

At Manned Spacecraft Center, Dr. Charles A. Berry, Chief of Center Medical Programs, astronaut Elliot M. See, and George M. Low, Deputy Director of MSC, listen to communications between Gemini 7 spacecraft and the Mission Control Center.



As a Gemini spacecraft rises over the flat Florida landscape at Cape Kennedy, invisible electronic umbilicals begin at once to send an unending stream of information to the earthbound flight controllers. Electronic eyes and ears now will be in constant contact with the Gemini capsule and its two occupants. Their vigilance is as unremitting and as thoroughgoing as it is essential to the conduct of the mission. For the National Aeronautics and Space Administration's Manned Space Flight Tracking Network is in a very real sense the lifeline of manned space exploration.

The network is worldwide in scope and comprises tracking radars, telemetry receivers, and communications and data processing systems. It permits the mission director to exercise command control by giving him the facilities with which he can assume direct control of spacecraft functions if that becomes necessary. It collects millions of bits of information and digests them in milliseconds. (A bit is the unit of information used in computers; a millisecond is one one-thousandth of a second.) It provides the mission director with the facts he must have to make decisions, and it gives him the communications capabilities required to effect these decisions. The data gathered by the network are studied for months, even years, after each mission and are a valuable source of scientific information.

NASA's Manned Space Flight Tracking Network is the most comprehensive global web of electronic systems ever organized for specific single scientific projects. It spans three continents and three oceans; involves thousands of men; and performs communications, tracking, and data processing tasks of staggering magnitude with startling speed and accuracy.

The heart of the network is the Mission Control Center at NASA's Manned Spacecraft Center in Houston, Texas. Here the information pours in from various points throughout the world and, indeed, from out of this world. The Mission Control Center is, of course, also the heart, the headquarters of the mission. The Control Center has complete charge of the mission; it is the place where decisions are made. It directs the flight of the spacecraft, keeps close tabs on aeromedical and spacecraft systems, disseminates information about the mission status to the astronauts and the telemetry and tracking stations (and, for that matter, to a curious and waiting worldwide audience of millions), furnishes the recovery teams the information they must have to recover the astronauts and their vehicle.

To perform its functions, the Mission Control Center must have information — current, up-to-the-second accurate information. The source of this vital commodity is the Tracking Network, and the backbone of that network is the tracking radars and the complex telemetry system.

The radar workhorse of the Tracking Network is the RCA FPS-16, the first precision tracker made specifically for missile and space vehicle work. RCA has made and emplaced more than 60 of these remarkable instruments. These are supplemented by other sophisticated RCA radars, most notably the FPQ-6, developed especially for the Gemini and Apollo missions and those to follow.

The radars used in NASA's Tracking Network are manufactured at RCA's Missile and Surface Radar Division at Moorestown, N.J., and they have already established an outstanding space tracking record. Their most noteworthy performance to date was perhaps the job they did in connection with the Gemini-Titan 4 mission of astronauts McDivitt and White. The RCA radars were the only radars used to plot the moment-by-moment position of the spacecraft throughout the 62-orbit flight. Their high performance was cited by James Donegan, head of NASA's Data Operations Branch at Goddard Space Flight Center, Greenbelt, Md., in these words:

"The quantity of the data we obtained was completely satisfactory at every point. Every radar in the chain found the target each time we expected it to do so, and gave us information which had beautiful quality and consistency. This is a high tribute to the reliability and flexibility of these instruments."

The radars furnished a steady stream of information at lift-off, at insertion into orbit, during Major White's historic walk in space, throughout the other experiments conducted by the two astronauts, during the attitude correction maneuvers that preceded re-entry, at the critical instant when the retrorockets were ignited, through the spacecraft's re-entry into the earth's atmosphere, and while the capsule was drifting to its precise touchdown point.

Orbital changes necessitated by the rendezvous experiment conducted by the Gemini 4 astronauts made particularly severe demands on the radars in NASA's Tracking Network, causing a number of impromptu variations in the tracking program. "In spite of this," Donegan noted, "the radars were able to accept frequent changes in designation instructions on short notice and yet acquire the target without difficulty."

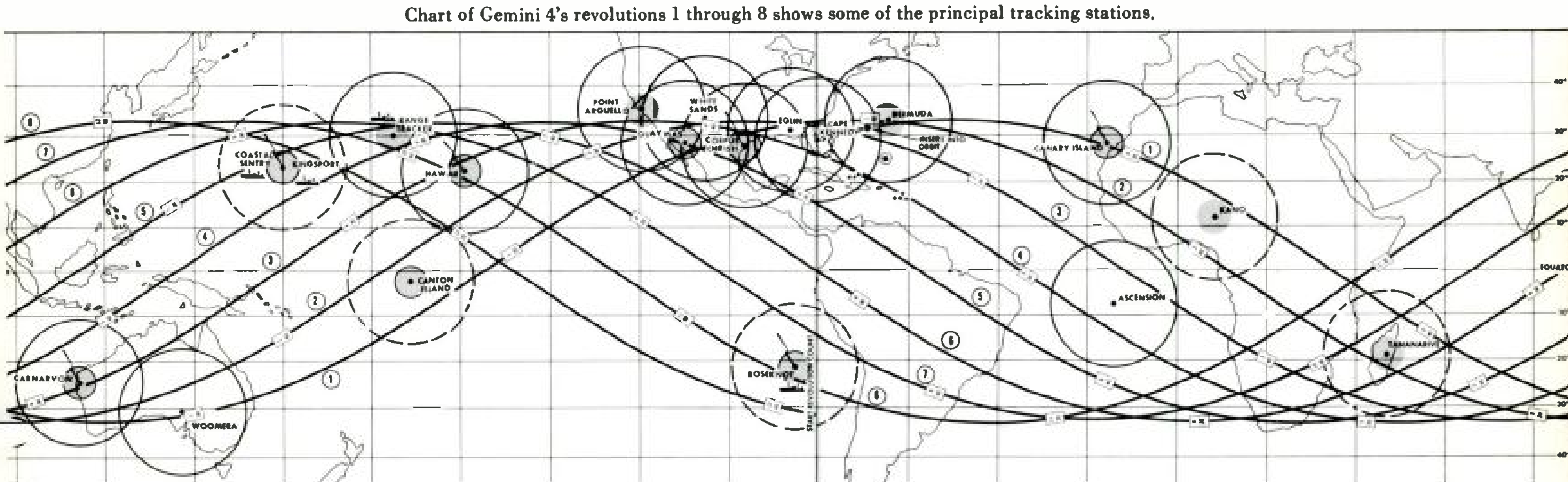
In addition, the radars scored two tracking "firsts" during the Gemini 4 mission: they "skin-tracked" the spacecraft consistently; and they made detailed radar observations of the re-entry and breakup of the booster. Skin-tracking is accomplished by directing energy from the radar transmitter in successive bursts that echo from the body of the object being tracked back into the radar receiver. It differs from beacon tracking, the other commonly used method, in that it is performed by the radar on the earth's surface with no electronic assist from the object being tracked; in beacon tracking, an electronic device (a small transmitter) aboard the tracked object fires a strong pulse of energy back to the radar upon being tripped by a beam from the radar transmitter.

Prior to the Gemini 4 mission, scientists and engineers speculated as to whether any radar could consistently yield precise and reliable data from space through skin-tracking. The results achieved by NASA's Tracking Network on that mission have settled the question positively. "Not only were our skin-track data consistent," says Donegan, "but the data quality was so good that it appears to be just as precise as the beacon track data we obtained on this mission. This is important because, on long missions, the battery power required to drive beacons is an important consideration. On Gemini 4, the beacons had to be turned off a great deal of the time in order to conserve power. With the wonderful radar performance we got, we were able to maintain track whether the beacons were on or not."

The accomplishments of the radars on the Gemini 4 mission represent only one aspect of the complex Manned Space Flight Tracking Network. Another is telemetry, which provides flight controllers with the masses of information they must have at their fingertips so that they can make the minute-by-minute decisions necessary for the successful completion of any manned space mission.

As soon as a rocket engine blasts a spacecraft and its

Chart of Gemini 4's revolutions 1 through 8 shows some of the principal tracking stations.



crew of astronauts toward orbit, a torrent of information rushes from its telemetry transmitters to be received and processed by far-flung ground control stations. A spacecraft transmits information to ground stations over as many as 300 channels. But since a space vehicle travels at hypersonic speeds (17,500 m.p.h.), it is within range of a telemetry receiving station only a very short time. When it is within range of a ground station, the spacecraft transmits many separate items of information simultaneously. These data — which typically include intelligence about the astronauts' physical condition, cabin pressure and temperature, engine performance — can be collected selectively for flight controllers on the ground.

Even the complex electronic system that makes possible simultaneous transmission of many data over crowded communications links is inadequate to cope with the oceans of information being steadily generated aboard the spacecraft and eagerly sought by the controllers at the Mission Control Center and the other ground stations of the worldwide Tracking Network. To bring together the "seller" of information from space and the "buyer" of information is the function of the telemetry system; in effect, it serves as an electronic "broker." To do so, it employs a powerful miniature tape recorder and a telemetry transmitter aboard the spacecraft. Manufactured by RCA's Communications Systems Division at Camden, N.J., the tape recorder stores data continuously for four hours and plays back its storehouse of facts in 11 minutes. When the spacecraft is again within view of a ground telemetry station, the information thus stored can be "dumped" in great volume and at high speed to the waiting ground station.

The spacecraft "dump" transmitters can be activated manually by the astronauts or triggered by a command signal from the ground. Once released, the information is received by what might be called the central station — NASA's Communications Network (NASCOM), headquartered at Goddard Space Flight Center — or one of the remote telemetry receiving stations throughout the world. In the basic Manned Space Flight Network, there are 14 ground stations and four located on ships at sea; the number of stations used varies to meet the requirements of each particular manned space mission.

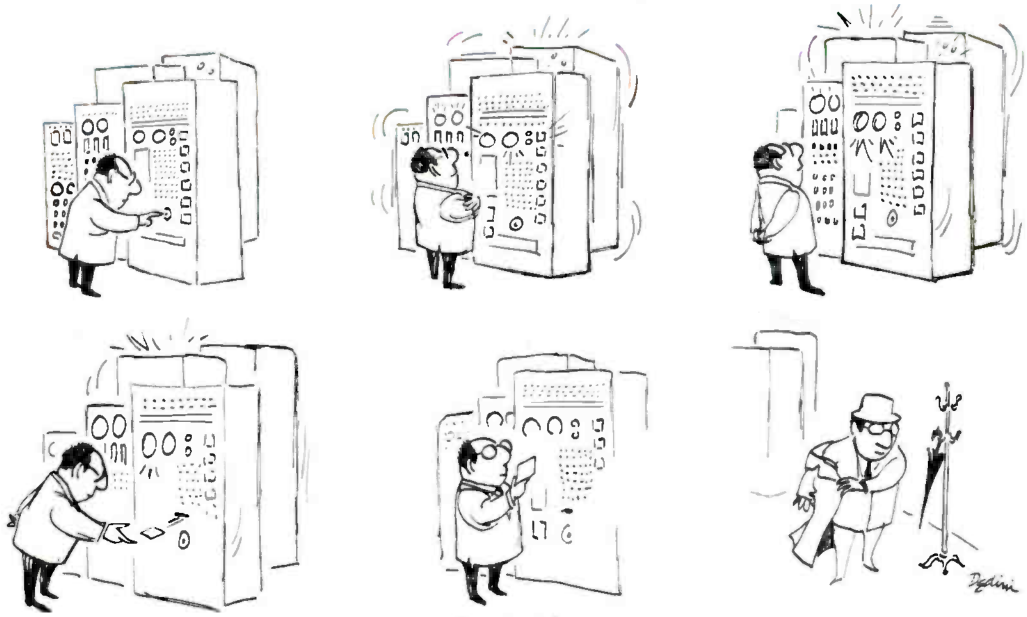
Information received from the spacecraft by any of these remote stations is flashed to the NASCOM at Goddard, where it is processed and relayed to the Mission Control Center at Houston — an operation that takes only 1.6 seconds to complete. A Gemini spacecraft transmits information at a rate of more than 51,000 bits per second. As that figure indicates, a tremendous volume of information, coded in various ways, comes from the space vehicle to the ground stations. It must be received, recorded, analyzed, and transmitted to the Mission Control Center. Most of these operations must take place in "real time"; that is, almost instantaneously, so that the information transmitted can be used in immediate mission operations.

Reduced to its simplest terms, the basic purpose of the entire Manned Space Flight Tracking Network, the reason for its being, is communication and command control. The radar, the telemetry, the instrumentation, the planning, the effort — all exist to gather and relay information, to communicate. Although space communications form perhaps the most glamorous segment of the over-all communications complex necessary to the conduct of a manned space mission, they do not by any means constitute the entire communications picture. Equally important, albeit more prosaic, is the high-speed ground communications support required for every space mission. Responsibility for this function rests with the NASA Communications Network, whose circuits and terminals span 100,000 route miles and half a billion circuit miles. The NASCOM, termed the switchboard for U.S. space exploration, links 89 stations, including 34 overseas points, with message, voice, and data communications. For its activities in connection with the Manned Space Flight Tracking Network, the NASCOM includes some 173,000 circuit miles consisting of 102,000 miles of teletype facilities, 51,000 miles of telephone circuits, and more than 8,000 miles of high-speed data circuits. Many of the international links in the NASCOM are operated by RCA Communications, Inc.

All the radar, telemetry, and communications devices and instruments employed in NASA's globe-girdling Tracking Network are, in the last analysis, only inanimate tools used by men. The oceans of data they collect, the instantaneous computations they make, the prodigious tracking feats they perform — all must be initiated, governed, and interpreted by men. Among the thousands of men who make the tracking system work and who give it meaning are the scientists, engineers, and technicians of the RCA Service Company's Missile Test Project. These specialists operate and maintain the data acquisition, data processing, communications, and associated systems at Cape Kennedy and on the Air Force Eastern Test Range, the instrumentation and communications "laboratory" stretching 10,000 miles from Cape Kennedy into the Atlantic and Indian oceans. More than 3,500 of these men regularly provide support for the missile and space programs conducted there. During a manned space mission, RCA operates and maintains communications and instrumentation on the Eastern Test Range, on land and marine stations from the Cape to the Pacific Ocean.

Despite its obvious importance, NASA's Manned Space Flight Tracking Network is but a part of any manned space mission. As one observer put it: "The Tracking Network may not make the spacecraft go, but it surely tells you how it's going and where it has gone." Perhaps the most cogent summary of the worth of the Tracking Network was made by another observer, one eminently qualified and a satisfied "customer" of the Network, astronaut L. Gordon Cooper. Said Cooper:

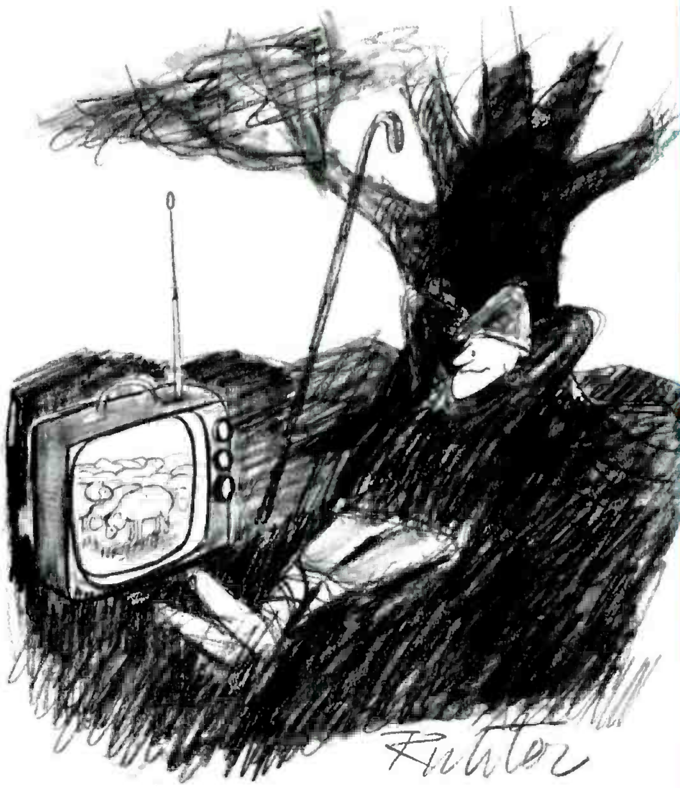
"It would be difficult to single out any one group or organization for special praise because they were all a wonderful team and a smooth blending of extraordinarily competent technical skills. However, I do think that if one could be mentioned organizationally, certainly I would have mentioned the world-wide network. It is certainly comforting to know when you are out there, that the world's finest communications network and the finest electronic facilities that man can devise are functioning with a fantastic computer complex that will allow the on-board systems specialists to break out their diagrams and tell you immediately what your situation is in the event of trouble. . . ." ■

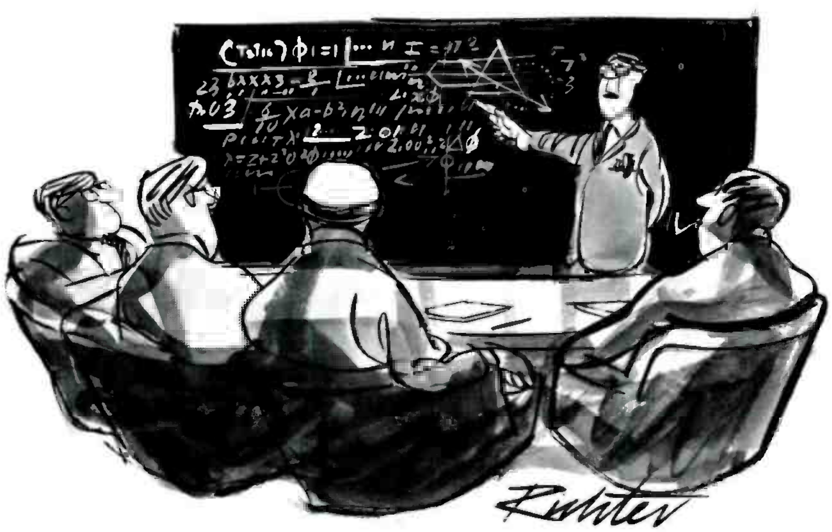


"6:15 P.M."

THIS ELECTRONIC AGE...

"For the last time, put that satellite in orbit some place else."





"Of course, I'm just thinking off the top of my head."

Electronics and Medicine

The combination of electronics and medicine has produced a new discipline: biomedical engineering.

by Dr. Alfred N. Goldsmith

A blending of modern electronics and medical science has launched a promising new technology that is now producing a mounting flow of devices for the more effective detection and treatment of human ills.

A symbol of this new art is the "radio pill," a triumph of electronic miniaturization that is designed to explore man's digestive process. The pill is a complete transistorized FM broadcasting transmitter encased in a plastic capsule that measures only one and one-eighth inches long by two-fifths of an inch in diameter. It is swallowed by the patient, and it transmits messages from within the body much as a satellite sends information from space.

The new technology embraces a widening range of electronic applications to the special needs of medical science. Historically, the trend is a recent evolution that began in 1895 with Wilhelm Roentgen's demonstration of the fact that a stream of impacting electrons could be used to produce ultrahigh-frequency light capable of taking pictures of bone through flesh. Soon afterward, a Dutch physiologist, Willem Einthoven, began experiments that led to the development of the electrocardiograph, a device for recording the characteristics of heartbeats.

Physicians acknowledged the usefulness of these instruments but still considered them essentially as tools created by one discipline and adapted for use by another. There was little thought given to a more immediate relationship between the science of electronics and the science of medicine. However, when it was established that the brain, nerves, and muscles of the human body are activated by minute electrical currents, the two fields began moving closer together. This process of convergence has continued throughout this century until, today, medicine and electronics have joined to produce a new discipline — that of biomedical engineering.

As its name implies, biomedical engineering is the study of man through biology, medicine, and engineering. It takes the view that man is an organism sensitive to his surroundings and reacting to them, that he enjoys the mobility and the feedbacks necessary for effective reaction, that he possesses an information storage and retrieval system, and that he is capable of communicating comprehensive information to his fellow man.

To some, such a definition of man might seem bloodless and machine-like, but it has opened the way to new techniques that promise relief from suffering, crippling disease, and even premature death.

The arsenal of electronic devices presently in use by physicians covers virtually every aspect of medicine. Available, for example, are control sensors, networks, feedback, circuit simulation of biological processes, telemetry, information sensors, and miniaturization.

The familiar electrocardiogram and its depicted heart pulses can now be simulated by electronic networks, subject to close mathematical analysis to assist in the diagnosis of heart conditions.

Blood flow can be measured electromagnetically by various methods. Velocity can be determined by applying an alternating voltage to two coils on opposite sides of a probe in one of the blood vessels of the heart. The probe carries two electrodes that contact the aorta walls, and a voltage is generated in the electrically conducted blood that flows through the magnetic field of the coils. From this voltage, blood velocity can be calculated.

Extremely sophisticated information about the human bloodstream is now available. Instruments known as sanguinometers electronically count the number and size of particles in the bloodstream and give information on the blood corpuscles. Location of internal intestinal bleeding can be found by Geiger counters placed at intervals along a "swallow tube" ingested into the intestinal tract after labeling the red cells with a harmless radioisotope.

Voltages derived from body activities can be recorded and analyzed. Encephalograms provide brain-wave records; electromyelograms graphically present muscle-activity waves. Pressures in body cavities or on the body surface are measured by a quartz crystal. Internal body structure can be visualized by ultrasonic means, providing a useful adjunct to X-ray analysis. Respiration rates and the carbon-dioxide cycle in breathing can be measured and electronically studied by using analog computers. The technique of electrogastrography has allowed physicians to investigate the process of digestion. Various types of eye movement can be recorded by electro-oculography, and the examination of the retina can be carried out for several simultaneous observers by using television techniques.

These are but a few of the instruments that have been developed to aid physicians in the measurement of bodily functions. In each case, these instruments employ the techniques and apparatus of modern engineering, modified to meet the special uses to which they are put. All depend upon the fact that the human body operates largely on electrical signals controlling muscles, organs, and glands.

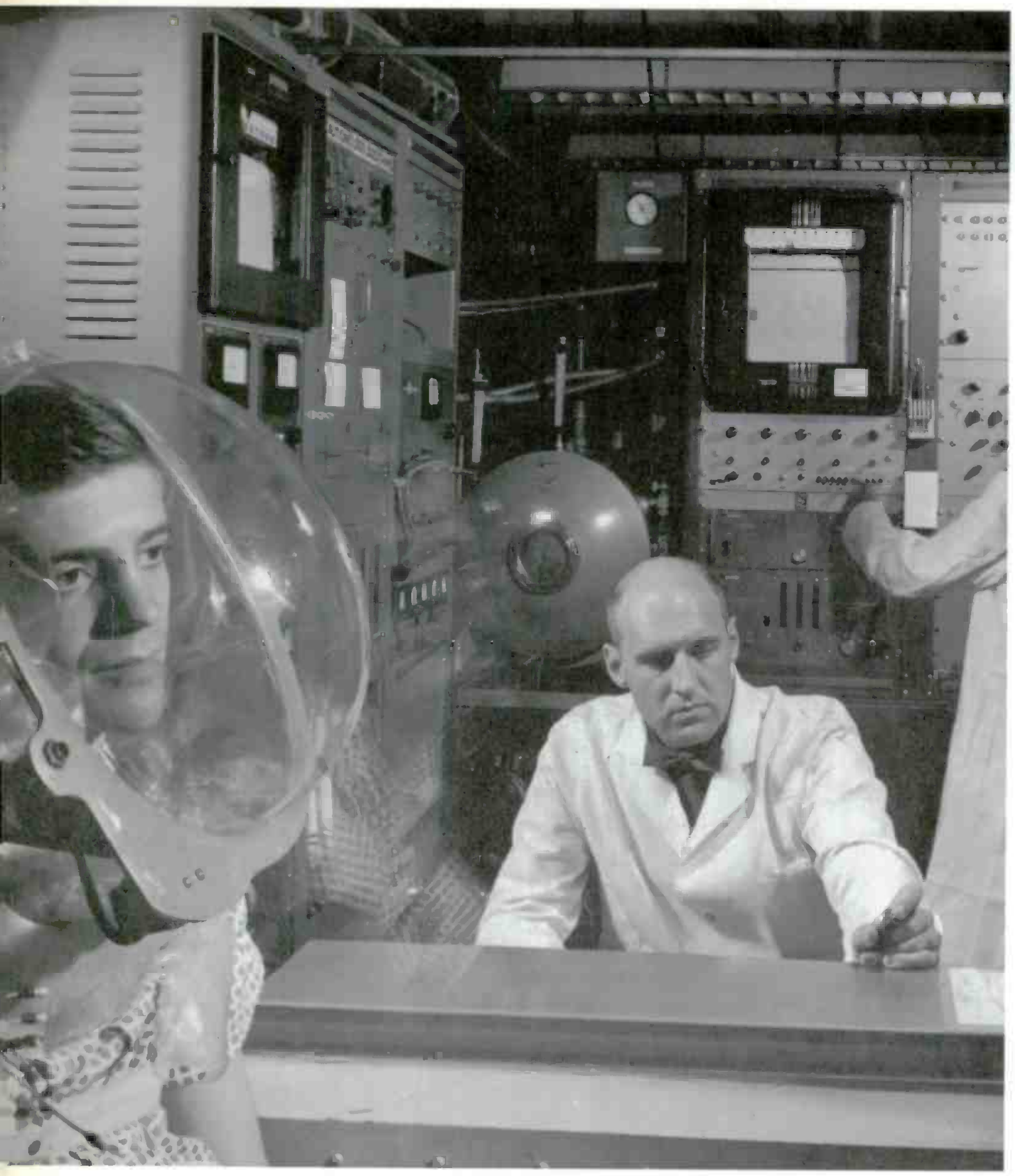
Precise control, however, is one of the chief engineering functions of modern electronics, and so it was natural for researchers to ponder medical applications that would go considerably beyond the design of electronic instruments used merely as measuring devices. Their work, especially in recent years, has resulted in the development of an impressive inventory of "spare parts" for the human body. These are electronic devices that stimulate and control the function of organs in the event of disease or surgery.

One of the best known of these devices is the "cardiac pacemaker," which applies timed electrical impulses to the heart when action falters or stops altogether. An even more dramatic innovation is an external artificial heart, which is used to bypass the patient's own heart during lengthy surgery on that organ.

Intensive efforts are now being made to develop a surgically implanted artificial electromechanical heart to replace the natural one entirely. The implications of this are immense when one considers that coronary heart disease kills more than half a million Americans each year, and that approximately one-fourth of the adult population of this country lives under the threat of heart disease.

Also under development and used occasionally at the present time are artificial lungs and kidneys, and important

"Surprise! You're going to be televised."



Closed-circuit TV system enables physician to observe moving X-ray images. Pictures are also recorded on TV tape for later study.

Continuous-stream gas analyzers collect air expired under mask in studies of life processes conducted by National Institute of Arthritis and Metabolic Diseases.

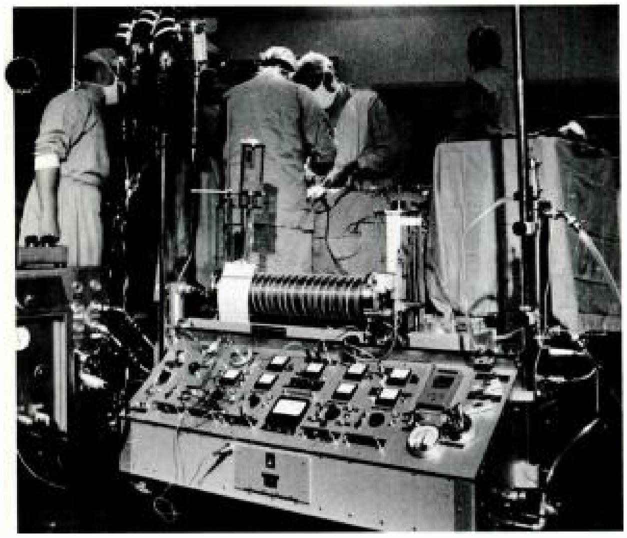
TV image guides surgeon as he threads the catheter in "transseptal left heart catheterization," which is helpful in diagnosis of heart defects.

accomplishments can be anticipated in these areas. Already available are unusually flexible and sensitive artificial limbs and hands. An electronically controlled artificial arm, using external power, can be pre-programmed for a number of different motions selected by the patient. Clenching of the hand and adjustable grasping with fingertips are movements that can be programmed. Highly sophisticated pressure-sensitive controls and feedbacks avoid excessive pressures. Even almost completely incapacitated patients can be provided with a breath-operated pulsing switch that is coded to control a radio or television receiver, operate a typewriter, answer a telephone, or perform any one of a number of functions.

Various electronic aids for the blind are in an early stage of practical development. One guidance device features an ultrasonic airwave generator that produces a highly directional narrow beam, which is reflected by any obstacle in the path of forward motion and picked up by a receiver and earphone.

Electronic aids for the deaf and dumb also show promise. An artificial ear now under development calls for the design and construction of assemblies of suitable electronic components closely simulating the normal ear and its associated processing structures and nerves.

Theoretically, it should be possible to replace any malfunctioning part of the human body with its electronic counterpart, and there are researchers in this field of medicine who see the future as limited only by their imagination. Still, much of the work is in the developmental stage, and even the most optimistic individuals admit that a uni-



The pump-oxygenator heart-lung machine makes possible complex open-heart surgery by permitting a patient's heart and lungs to be bypassed for six hours.

The combination of television and the electron microscope gives scientists more power and flexibility in their exploration of the molecular structure of matter.

versal availability of "spare parts" will not be a reality until some years in the future.

More realistically in the near future is the widespread use of electronic computers in diagnosis, research, hospital administration, and continued professional education. The need to keep up with the voluminous amount of current medical literature cuts deeply into the time of all physicians. Central repositories of information, statistics, and abstracts are being discussed, and even the concept of a World Biomedical Information Center has been suggested.

Local information centers would work like this. A physician, hospital, clinic, or biological investigator would call the center by telephone or data circuit, requesting specific information. A central computer would supply a speedy answer. Questions could cover a wide variety of subjects ranging from information relative to a particular disease to a request for a diagnosis based on a list of symptoms and test results fed into the computer.

Such a system calls for elaborate facilities with large-scale memory and retrieval methods as well as a competent staff. However, despite the substantial investment, there is general agreement that these information centers would prove useful, dependable adjuncts to the experience and trained judgment of medical practitioners.

Already in widespread use are computer installations designed to aid in hospital administration. In 7,000 hospitals throughout America, 1.4 million patients receive care each day, and about 24 million are hospitalized each year. The annual operating cost has been put at $8 billion and is increasing each year. Labor costs, for example, are growing at a rate of $500 million annually. Obviously, devices for reducing the number of routine tasks are urgently required, and in this area computers can and do play an important role. It will soon be usual to find statisticians, mathematicians, and electronic computer programmers on the staffs of hospitals, along with the more traditional medical specialists.

Still another specialist who has found increasing employment in modern hospitals and teaching centers is the television technician. Television has proved itself useful in general administration, patient monitoring, radiology, teaching of surgery, inventory control, and even in diagnosis and treatment. An interesting use of television is for the storage and reproduction of X-ray pictures and other medical views on video tape for later study and comparison.

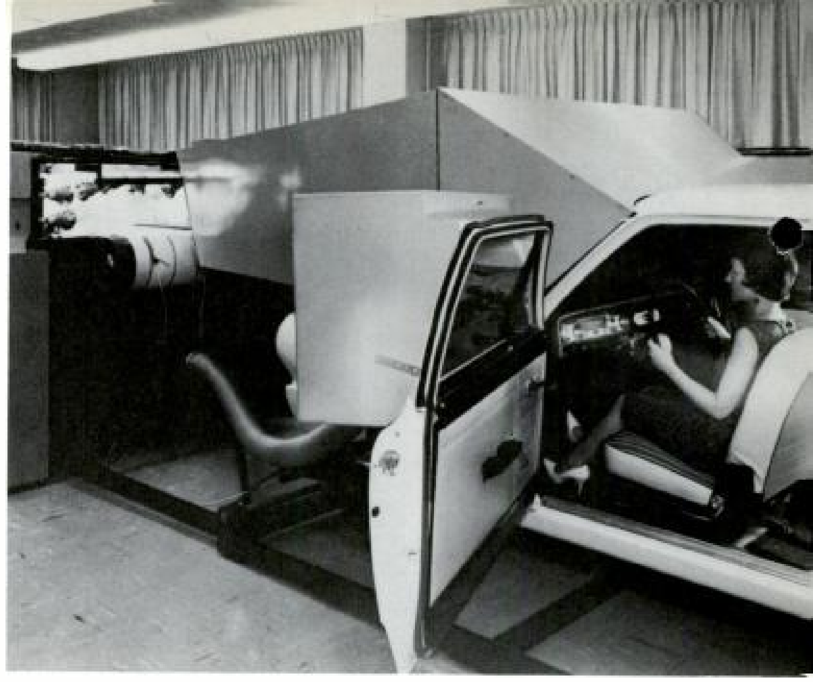
Color television offers significant advantages over black-and-white, particularly in group diagnosis. Surgical instruction becomes more definitive in color. Microscopic views can be shown effectively on large screens with added information made possible by color.

In general, medical authorities agree that television has already proved itself the best method in existence for the teaching of surgery to large groups of students as well as for many other phases of medical training. Within a matter of years, the color camera may replace the familiar operating theater to become standard equipment in every medical and dental college in the country.

The enthusiastic acceptance of television and electronic data processing by medical men has fostered a stimulating exchange of ideas between electronics and medicine and a willingness to explore other areas of mutual development. Equipment such as the electron microscope has become a basic tool in research laboratories. Diagnosticians have come to depend on the sensitive measuring instruments provided by electronics. The remarkable range of prosthetic devices and the promise they offer for the future have excited the imagination of both professions.

Today, medical men do not wait for the electronics engineer to bring them new inventions. Gradually, the barrier caused by different scientific training and differences in terminology is being broken down. Doctors are beginning to go to the engineers in search of solutions to special problems, and, when they do so, the results of their collaboration move mankind closer to the ultimate conquest of disease and crippling debilitation. ■


View of the "highway" from RCA-built driving simulator.


Side view shows how driving simulator is constructed around motorless automobile.

Can Science Make Highways Safer?

A highly sophisticated driving simulator allows detailed study of driver reactions without on-the-road hazards.

by Patty Cavin

When an American motorist slips behind the wheel of the family automobile and turns the key in the ignition, he automatically begins to play a game of motorized "Russian roulette."

Regardless of his reflexes, state of health, or driving proficiency, he has a one-out-of-five chance within the year of becoming a reportable accident statistic. In 1965, some 49,000 people were killed in auto accidents in the United States, and in 1966 the total is expected to exceed 50,000. The problem is rapidly growing worse, admits the Automotive Safety Foundation, which forecasts a traffic accident mortality toll of more than 60,000 persons by the year 1975 if automobile crashes continue at the current rate.

"The average American motorist is nothing less than a fugitive from the law of averages," says Senator Abraham Ribicoff, chief congressional crusader for highway and automotive safety. "All our wars combined haven't been as costly in terms of lost lives."

American drivers must face up to the fact that, as the National Safety Council points out, approximately 87 million vehicles are currently being driven by more than 96 million licensed drivers. In 1965 alone, they traveled approximately 870 billion miles over 3.6 million miles of U.S. roads, streets, and superhighways. Approximately 12.5 million accidents involving about 22 million drivers were reported in 1965.

What can a driver do to protect himself against automobile "accidentitis" — the growing, maiming, often fatal, current American epidemic?

Can America's burgeoning electronics industry lend its research and scientific know-how to probe the problem and supply a solution? Can safety be ensured by constructive legislation?

The answer to these questions is a qualified "yes," according to the nation's safety experts, and electronics may well play a major role.

The Division of Accident Prevention, a small but active safety pioneer in the U.S. Department of Health, Education, and Welfare's Public Health Service, has settled on driving simulators as one of the newer and more effective ways to study the big human X-factor in traffic accidents — the role played by the man behind the wheel.

In 1963, a $180,000 accident research contract was awarded to the Radio Corporation of America's Defense Electronic Products group for the development and construction of the most advanced driving simulation device of its kind in the world today.

Unlike the simple early simulators used widely for driver training classes, the RCA Driving Simulator is a highly sophisticated electronic device designed to allow detailed study of driver reactions under high-speed turnpike conditions without subjecting a person to actual on-the-road hazards. Building time was 16 months plus an additional six months for such essential modifications as the addition of wind and engine sounds.

Actual laboratory tests in RCA's compact Driving Simulator facility in Bethesda, Md., got under way in August, 1965. RCA scientists and U.S. Public Health Service officials are hopeful that these tests will turn up new and useful evidence as to what causes rear-end turnpike collisions at 70 miles per hour, and in what ways a driver's efficiency decreases after hours of high-speed driving.

Sparkplug of the project is RCA research psychologist Dr. Richard Krumm. His previous research for the state of Pennsylvania on the behavior of automobile passengers when an auto is passing other vehicles disclosed the fact that a substantial number of rear-end collisions took place at high speeds on turnpikes. This, in turn, interested Dr. Bernard Fox, acting chief of the Experimental Research Branch of the Division of Accident Prevention, and, as a result, his division decided on further investigation.

Physically, the RCA Driving Simulator looks much like a car attached to a long, wooden wind tunnel. The car is actually only a shell of a Rambler automobile with its engine removed. The dashboard and controls, however, are exactly what one would find in a regular model. Outside light is completely blocked by wooden window boxes containing inside illuminated scenes that appear to be a continuation of the forward view that forms part of the experimental picture.

Directly ahead through the windshield lies an enclosed 20-foot-long roadway cabinet containing five endless belts. Two of the belts simulate the two lanes of a normal highway roadbed, two the shoulders of the road, and one the center strip. Moving in unison, they produce the illusion of travel along the road. This scene, in turn, is viewed by the person taking the test through an optical system that makes the one-half-inch to one-foot scale of the device seem real both in size and speed.

In tests now going on, a subject sits behind the steering wheel, turns the key in the ignition, steps on the gas, and hears a realistic but simulated engine hum. As he steps on the gas pedal, simulated wind flows through the windows from hidden side tunnels, and the belts carrying road shoulders — complete with fences, signs, trees, center lines, pavement, and traffic — begin to move toward him.

Action of other cars on the roadway is controlled by an unseen simulator operator seated at a computer console outside the wooden tunnel casing. By the flick of a thumb, this operator can place other vehicles or objects on the roadbeds, thus simulating sudden and unexpected causes of accidents.

The stark realism of the highway scene facing the test driver and the varying console-controlled day, dusk, or night lighting conditions available for tests are primary features that distinguish the RCA Driving Simulator.

"We can reproduce many emergency situations involving one, two, or three cars on a high-speed highway," explains Dr. Krumm, who preceded the laboratory tests with a three-month survey of actual on-the-highway driver performance. He and a team of RCA psychologists photographed 800 cars overtaking their specially instrumented camera car, which included six different and changeable tail-light configurations. The lights were attached in both horizontal and vertical positions to an iron bracket on the rear bumper of the test car. In night tests, RCA researchers selectively illuminated various tail-light patterns to approximate the actual configuration found in recent models of various makes of cars. "The brightness and configuration of these tail lights," explains Dr. Krumm, "may be a major factor in influencing a driver's overtake speed and his judgment of when to pull out and pass."

Driver reactions were logged at varying sets of closing speeds. While these road statistics are now being checked against driver-simulated behavior in the laboratory, preliminary results indicate a marked correlation.

Dr. Paul V. Joliet, chief of the Division of Accident Prevention for the Public Health Service, Dr. Fox, and Dr. Krumm hope to have in the near future a full set of test-based data on accident causes. Final evaluation of these initial tests may lead, they hope, to further probes with the RCA Driving Simulator into the highway effects of driver fatigue, use of drugs, consumption of alcohol, and possibly the effects of defective vision.

But the problem is far from solved. Not nearly enough is being done about safety and mounting accidents, says William Randolph Hearst, Jr., chairman of the President's Committee for Traffic Safety. Although his group of prominent citizens and public officials plus four ex-officio officers (Secretaries McNamara of Defense, Wirtz of Labor, Gardner of Health, Education, and Welfare, and Connor of Commerce) are responsible for the much-lauded Highway Safety Action Program, they have neither the authority nor the desire to force action in the states.

The program itself is considered by both President Johnson and his hand-picked committee as the national master plan for traffic accident prevention. It recommends *what* should be done, and features equal emphasis on all phases of traffic safety: laws and ordinances, traffic accident records, education, research, engineering, motor vehicle administration, police traffic supervision, traffic courts, public information, and organized citizen support. Final action on *how* to apply this program is up to the individual states which, according to Chairman Hearst, can seek technical assistance, if needed, from the committee's Advisory Council.

On the legislative front, Senator Ribicoff hopes to win congressional authorization to establish a special office in the Commerce Department that would centralize federal responsibility in solving traffic safety problems. He also has long-range hopes of Administration-financed support to the states to establish standardized auto inspection and driver training programs.

With activity under way on many fronts, one general observation is made by most persons interested in auto safety: If the American driver is to survive in the deadly game of motorized "Russian roulette," it will take strong teamwork between the law makers and the auto makers. And their decisions will be based to a great extent on what occurs in the electronics laboratories. ■

Computers and the War on Crime

by Ken Kizer

A uniformed policeman stops his patrol car at the curb, asks a few simple questions of a loiterer, holds a brief conversation on his radio-telephone, then asks the suspect to accompany him to the station for investigation of receiving stolen property.

A highway patrolman, noting an automobile license plate that rings a bell somewhere in his memory, holds an equally brief radio-telephone conversation, stops the car, and takes the operator into custody for driving a stolen vehicle.

Plain-clothes detectives knock on a rooming-house door and handcuff a man almost before he has a chance to count the money burglarized from a local pet shop.

Obviously, the everyday pattern of crime isn't changing much; the above paragraphs read like capsuled items from any daily newspaper. However, there has been a noticeable change in the speed of identification, investigation, and apprehension: electronic systems are shortening the time advantage the criminal has enjoyed following a felonious action.

For instance, California criminals are going to have to contend with an electronic hawkshaw that can recall millions of facts about them in a fraction of a second. In addition, the device will make immediately available for law enforcement officers a basketful of statistics designed to make it tougher for felons to remain free of the law.

A data processing system now being installed in California's Department of Justice for the Bureau of Criminal Identification and Investigation (CI&I) and the Bureau of Criminal Statistics is playing a vital role in the continuing technological development of police work in the Golden State.

The system, an RCA 301 general-purpose computer with a duplexed mass random access memory unit, has been installed in the Justice Department's Sacramento headquarters as an integral component of the California program to build a statewide criminal data-gathering network.

Under the direction of Attorney General Thomas C. Lynch, the system will be used initially to maintain records of criminal activities; to store information on all registered firearms; to keep track of miscellaneous lost, stolen, or pawned property; to maintain assorted statistics on illegal narcotics traffic and other criminal activities; and to store information concerning *modus operandi* of criminals.

CI&I is the largest state bureau of its kind in the nation, its files being second in size only to the Federal Bureau of Investigation in Washington, D.C.

The amount of data handled by CI&I is staggering. For example:

CI&I has the over-all responsibility for coordinating police information in California. In the state's master name file are nearly 8 million cards containing real names and aliases. More than 130,000 inquiries are made into this file each month.

Processing of fingerprints involves the monthly receipt of more than 95,000 cards, adding to the existing 6 million cards on file from police agencies throughout the state. Each must be checked and a report must be made to the originating police department.

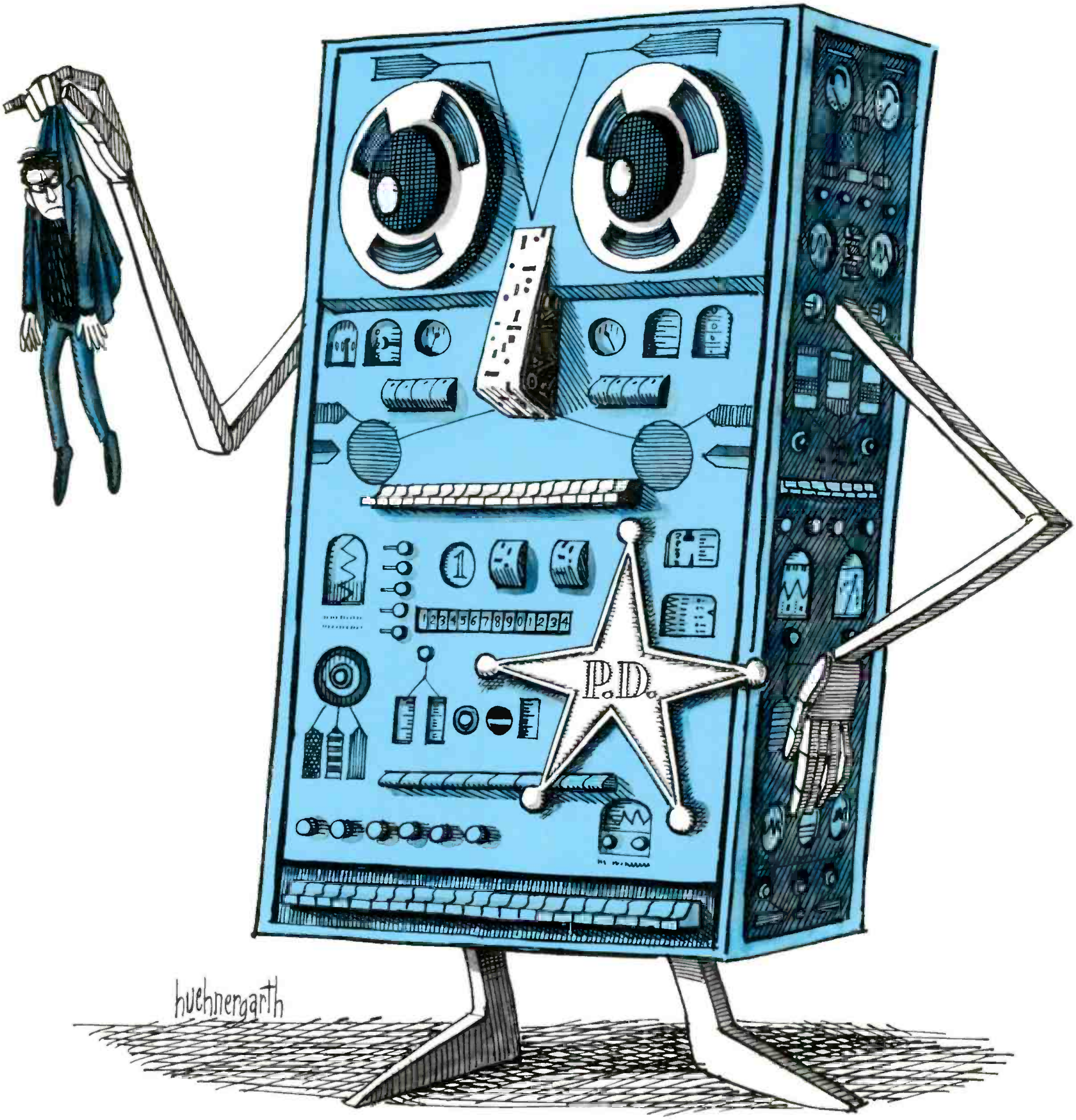
More than 2.5 million identification folders are filed, located, studied, and refiled.

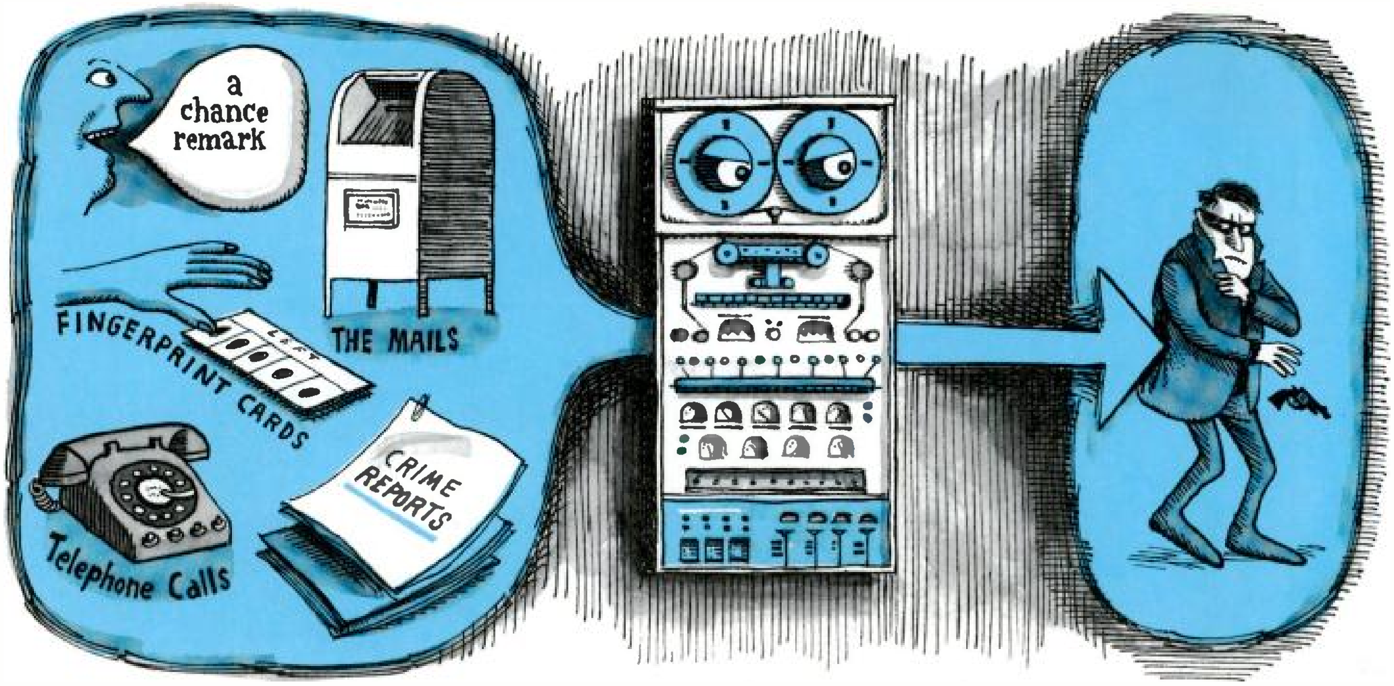
In one unit of CI&I, 144,000 crime reports a month are received.

Pertinent *modus operandi* factors are coded and entered on punched cards and analyzed. More than 3,000 such searches are made into the file each month to help identify the person responsible for a particular crime.

Information involving all the functions described above is being reduced to digital code and stored in a mass storage and retrieval memory system that stores more than

The capability of electronic systems to store and to recall instantly millions of statistics about criminals and their methods gives law enforcement agencies a new tool in fighting crime.





"Information is the lifeblood of police work."

681 million characters of information and operates on a direct line to the computer.

When the system is placed into full operation, a law enforcement officer will be able to radio-telephone the headquarters within his area where a remote communications keyboard send-receive unit will speed his query on to Sacramento. The needed information will be retrieved by the computer from its random memory and all pertinent facts will be returned over communication lines to the original sending location or to any other desired send-receive unit. The reply will be automatically typed out and then radio-telephoned to the originating officer—virtually a hold-the-phone response to an inquiry that involves searching out the correct facts and figures in the twinkling of an eye from the computer's randomly stored memory system.

A typical inquiry as to whether a suspected criminal has a previous record will be answered in seconds rather than minutes. Normal communication and interchange of information will be similarly reduced from hours or even days to minutes.

Each new crime adds inordinately to non-police clerical detail. A Department of Justice crime expert says: "We are striving to make it possible for police agencies to concentrate on their primary job of protecting our citizens. California is a big state geographically and the biggest in the United States in population. Time plays a vital factor in criminal investigation, often measured in seconds.

"Here we are dealing with the exchange of information among more than 500 police agencies, with a population in excess of 20 million persons in a land area of more than 156,000 square miles. Communication links stretch sometimes for more than 900 miles, from Eureka to San Diego."

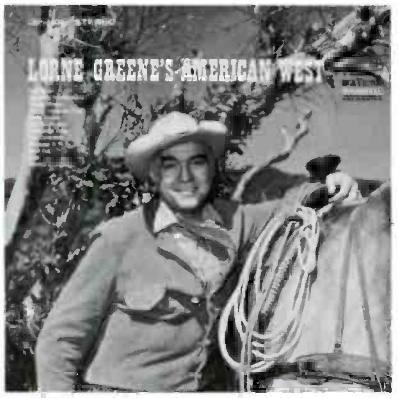
Information is the lifeblood of police work. It comes from a variety of sources, including crime reports, fingerprint cards, telephone calls, the mails, even a chance remark made on a street corner. All of these sources generate some 2 million messages each year; indeed, CI&I receives about a million reports of pawned property in just one year's time.

Meanwhile, as these plans for a statewide information interchange are going forward, California Department of Justice officials are exploring additional avenues, including the establishment of a network of remote inquiry stations throughout the state, and are studying the possibility of utilizing video displays.

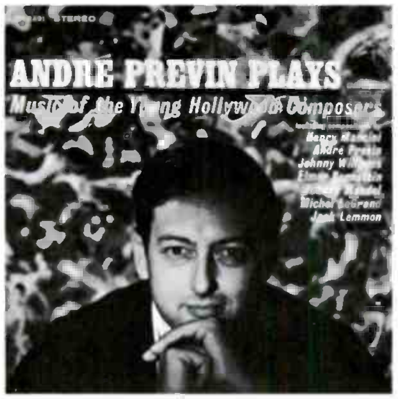
The ultimate goal? To do a more effective job of protecting the life, liberty, and personal property of California's citizenry and to make a life of crime an even more precarious one than it is now. ■

"THE DEBUSSY PRELUDES": *Leonard Pennario, Pianist (RCA Victor LM/LSC 7036).* Leonard Pennario has had great success in playing these masterpieces of musical impressionism, first in concert and now for RCA Victor. The complete Book I and II Preludes date from 1910 and 1913, in which Debussy succeeded, in perhaps greater degree than elsewhere in his piano music, in creating those impressionistic effects of tone color that were his ideal of composition. Leonard Pennario's performance catches every nuance of these works.

"LORNE GREENE'S AMERICAN WEST": *(RCA Victor LPM/LSP 3409).* Ben Cartwright of the top-rated TV show "Bonanza" has, with just four RCA Victor albums, established himself as a singing star. In his latest recording, he sings several songs in the vein of his best-selling "Ringo" as well as such old Western favorites as "Cool Water," "The Ol' Chisholm Trail," and "Wagon Wheels." Lorne's deep, resonant baritone and story-telling ability are evident in the new material—"Five Card Stud," "The Devil's Grin," and others.



"ANDRE PREVIN PLAYS MUSIC OF THE YOUNG HOLLYWOOD COMPOSERS": *(RCA Victor LPM/LSP 3491).* André Previn showcases some aspects of his versatile talents in this collection of themes and songs from such top films as "Checkmate," "The Pink Panther," and the ones for which he wrote scores, "Inside Daisy Clover" and "The Moving Target." Previn's jazz-inspired pianism reveals the high level of recent movie scores by composers Henry Mancini, Elmer Bernstein, Michel LeGrand, and others.



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

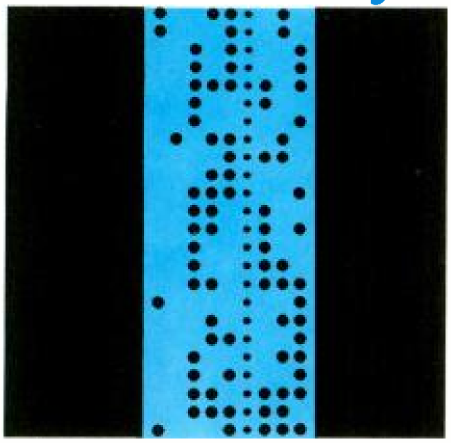
"PRESENTING MONTSERRAT CABALLE": *Montserrat Caballé, Soprano, with orchestra conducted by Carlo Felice Cillario. (RCA Victor LM/LSC 2862).* When the Spanish soprano Montserrat Caballé appeared in New York in December, 1965, in a performance of Donizetti's "Roberto Devereaux" for the American Opera Society and made her Metropolitan Opera debut a week later as Marguerite in Gounod's "Faust," the audiences and critics alike were ecstatic. In her RCA Victor debut, Madame Caballé sings arias by Donizetti and Bellini and displays the kind of *bel canto* artistry that, in the space of a few months, has made her the most talked-about diva of the day.

KODALY: SUITE FROM "HARY JANOS"; VARIATIONS ON "THE PEACOCK": *Boston Symphony Orchestra, Erich Leinsdorf, Music Director (RCA Victor LM/LSC 2859).* During the veteran Hungarian composer Zoltán Kodály's visit to this country in the summer of 1965, Erich Leinsdorf programmed and recorded two of his most characteristic works, the ever-popular "Háry János" and the less-familiar but equally lush variations on "The Peacock." "Háry János," an orchestral suite, is based on Kodály's stage work that tells the story of a Hungarian Tom Jones. "The Peacock" variations, written in 1938–39, are based on a Magyar folk melody at least 1,500 years old.

"THE DUKE AT TANGLEWOOD": *Duke Ellington, Pianist; Boston Pops Orchestra, Arthur Fiedler, Conductor (RCA Victor LM/LSC 2857).* The "Duke" of American popular music makes his debut recording with the Boston Pops Orchestra and his Red Seal label in an album of performances recorded "live" last summer at Tanglewood. Included in this collection are 12 of the Duke's greatest standards, among them such enduring classics as "Caravan," "Mood Indigo," "I Let a Song Go Out of My Heart," "Sophisticated Lady," "Solitude," "I Got It Bad and That Ain't Good." The Duke has contributed lighthearted, tongue-in-cheek liner notes on the background of each song in this outstanding album.

OTHER CURRENT RELEASES

Electronically



Speaking...

VOICELESS BILINGUAL COMMUNICATIONS DEVICE

A self-powered device that permits voiceless communications between allied jungle fighting groups speaking different languages has been developed for the U.S. Army by the Radio Corporation of America. Called the Jungle Message Encoder-Decoder (JMED), the new device transmits coded messages that overcome the language barrier that exists where friendly troops speak different languages or dialects. It also provides a means of communicating silently in dense jungle where the enemy may be only a few yards away.

The device is used in conjunction with standard Army pack radios to send and receive 32 special five-digit messages. It is approximately the size of a pocket transistor radio and employs digital techniques similar to those used in sophisticated communications equipment and computers. Its operation, however. has been kept simple.

A soldier can send a selected message by operating five switches on JMED, each capable of transmitting an "X" or an "O." When the fifth switch is activated, the message is automatically sent and the unit is cleared for the next transmission.

To read a message, a soldier checks the five-digit code received on his JMED unit against a printed message card. Pictures, the user's own language, or symbols on the cards eliminate the need for translators and help avoid misinterpretation.

JMED weighs approximately three pounds and draws power only during transmission or reception. Rechargeable self-contained batteries supply enough power to send or receive as many as 200 messages. A number of the new communications devices have been delivered to the Army Electronics Command for evaluation.

ELECTRON TUBE FOR SPACE APPLICATIONS

A new type of electron tube will enable space scientists to detect and measure the nature and extent of any harmful radiation on the moon, Mars, or more distant planets. Such information is necessary to assure the safety of America's astronauts on their pioneer trips destined for landings in outer space. The tube is sufficiently rugged to withstand the rigors of rocket blast-offs and space vehicle landings in interplanetary operations.

The new device is a photomultiplier, the first of its kind to be built entirely of metal and ceramic material. Previous photomultiplier tubes have been constructed within a glass or metal-glass enclosure.

Typical applications of the new tube include neutron-activation analysis of the moon or planets and radiological surveys of the earth's environment by satellite explorations. Other types of photomultiplier tubes are already widely used in the scientific and medical worlds and by industry. They are used, for example, in surveying for the location of oil well drilling sites; by sensing the radiation produced by a neutron source, these tubes can accurately log the composition of the earth's strata. Photomultiplier tubes are also employed to ascertain the ratio of fat-to-lean content in the human body, for stellar-navigation control of aircraft and missiles, and in medical diagnostics.

NEW "TWO-IN-ONE" LASER

A compact "two-in-one" solid-state laser that produces high-power continuous light beams with the greatest efficiency yet achieved with a solid has been developed by RCA scientists. The new unit is three times as efficient as conventional solid-state lasers and may hold the key to the realization of truly practical laser systems for use in industry and defense.

In its present laboratory form, the new laser has produced a 10-watt beam of continuous infrared radiation — close to the highest power ever reported and far short of the maximum expected from the system eventually.

This combination of high power and high efficiency could make such a laser extremely attractive to industrial users for such tasks as micromachining, welding, drilling, and working refractory materials. In addition, its high power suggests useful military applications as the basis for short-range radar and secure, line-of-sight communications systems.

The new device is a garnet crystal composed of yttrium, aluminum, and oxygen and containing trace amounts of chromium and the rare earth neodymium.

ALOUETTE 2 PROBES IONOSPHERE

In the acronymous lexicon of the spacemen, "ISIS" stands not for an ancient Egyptian goddess but for a joint U.S.–Canadian research program called International Satellites for Ionospheric Studies. The first such satellite, the Canadian Alouette 2, was launched into orbit at the Western Test Range, Vandenberg Air Force Base, California, on November 23, 1965. Accompanying it on a Thor-Agena rocket was the National Aeronautics and Space Administration's Direct Measurement Explorer-A spacecraft. The two satellites comprise ISIS-X.

The Alouette 2, for which the RCA Victor Company, Ltd., of Montreal, was the prime contractor, will probe the top side of the ionosphere, measure galactic and solar radio noise, investigate upper atmospheric radio "signals" initiated by lightning strokes and other radio sources, and will detect energetic particles. The Canadian satellite will also measure electron densities and temperatures near both spacecraft.

Known as a topside sounder satellite, the 320-pound Alouette 2 is distinguished by an unusually long — 240 feet — antenna.

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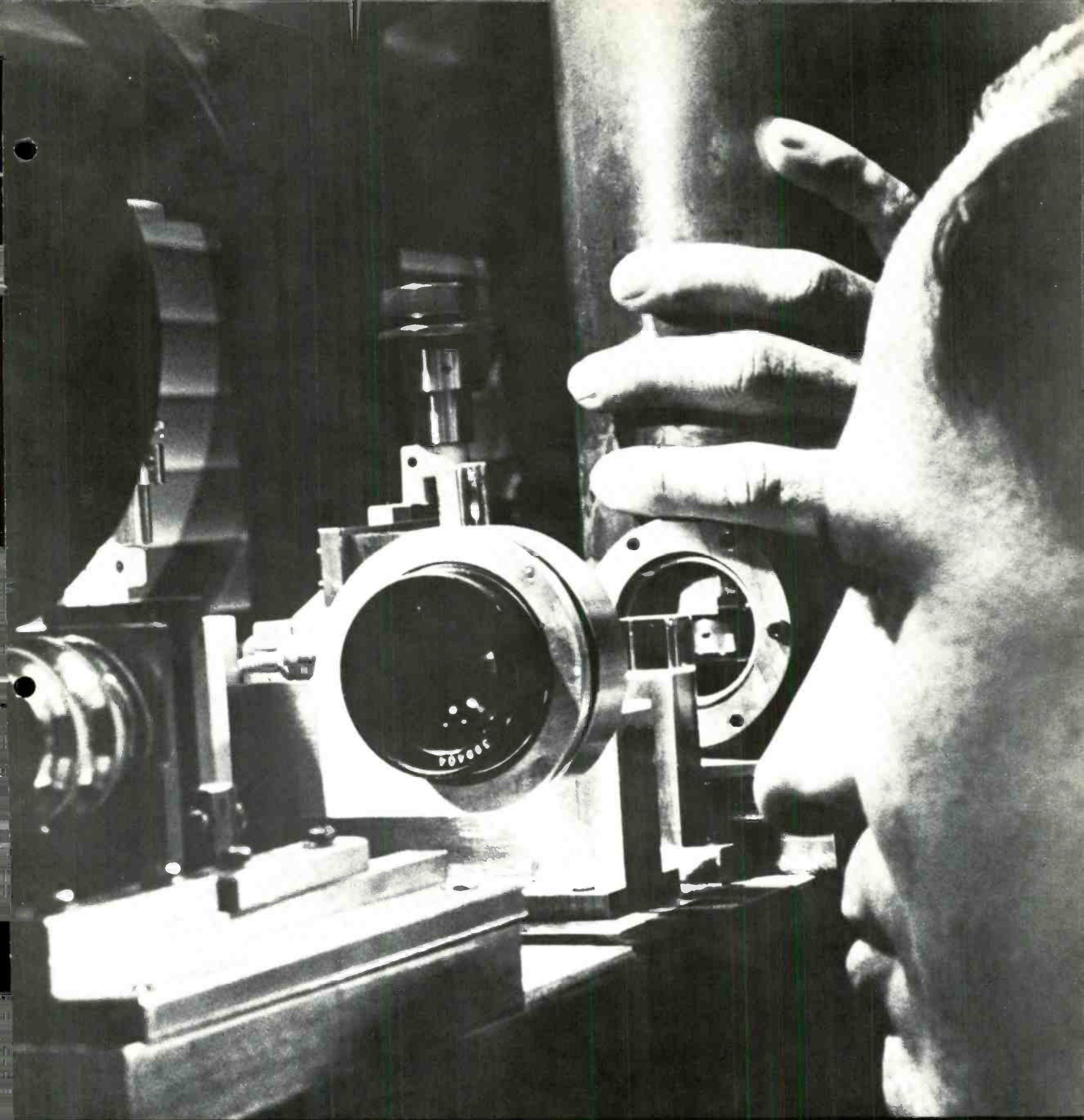

RCA's new high-frequency laser detector is tested by a research technician at RCA Laboratories in Princeton, N. J. The new detector, which is shown in the vertical cylinder behind the glass porthole in a bath of liquid nitrogen, can sense intensity variations in an infrared light beam entering from below at rates up to 100 million times per second. Such high-frequency variations could be used by the laser to carry 25 TV programs simultaneously.

ELECTRONIC AGE

RCA Winter 1965 / 1966

Gemini 6 is launched from Cape Kennedy.