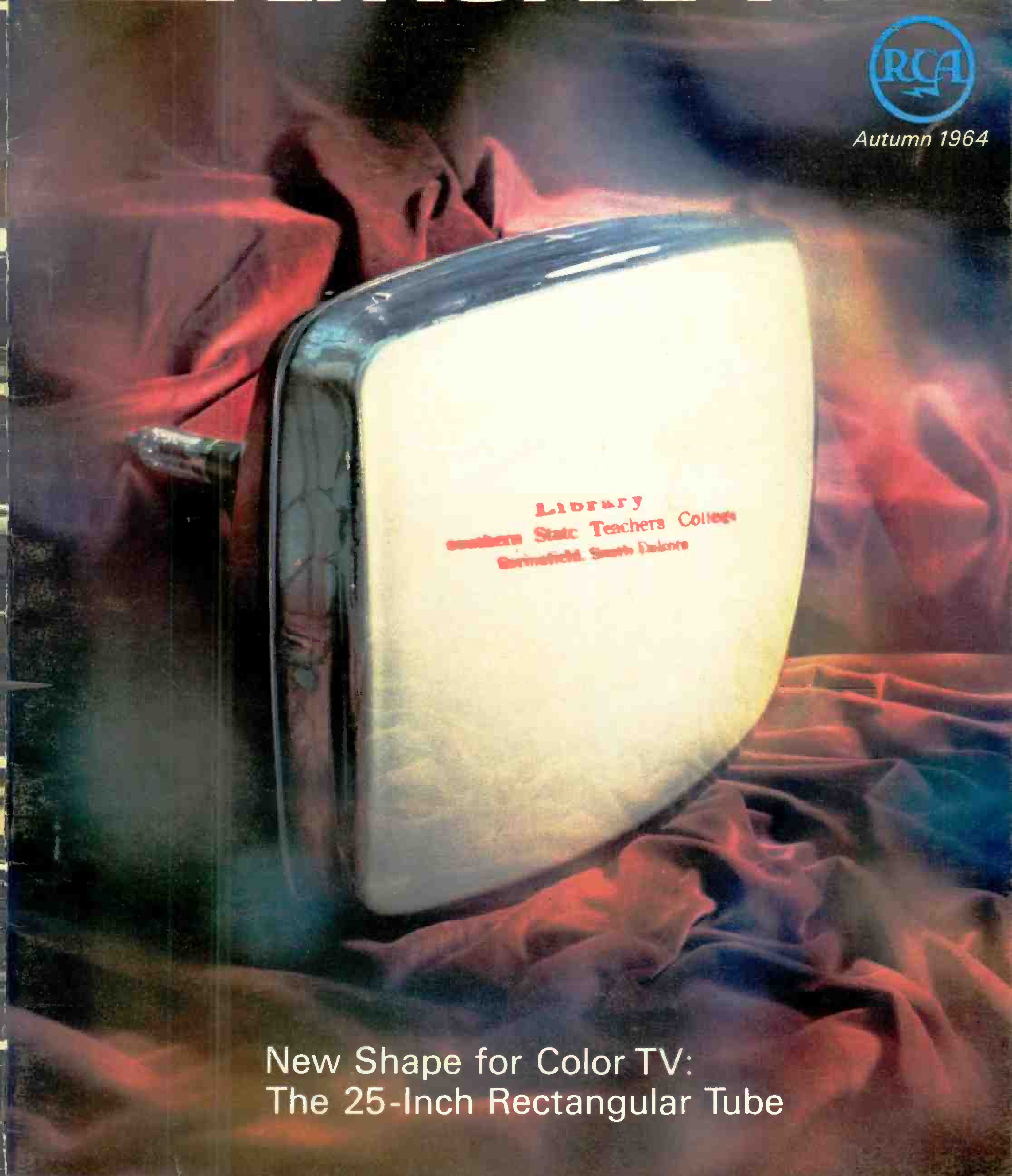
ELECTRONIC AGE

RCA

Autumn 1964



New Shape for Color TV:
The 25-Inch Rectangular Tube

ELECTRONIC AGE

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Editor
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← On July 31, 1964, when the lunar phase was a few degrees less than third-quarter, RCA television cameras aboard Ranger VII spacecraft transmitted man's first close-up photographs of the moon back to earth. Of these historic photos, the eminent astronomer Dr. Gerard P. Kuiper said: "What has been achieved is truly remarkable. . . . I have never in my experience as a scientist seen a series of scientific documents where there was not just a good selection of good quality pictures among a whole lot of different pictures, but where every picture—literally every picture of the A and B series—is of high quality."

COVER: RCA's new 25-inch, 90-degree rectangular color television tube. A report on this significant development begins on page 2.

New Shape for Color TV

by David Lachenbruch

The 25-inch rectangular tube ushers in a new generation of color picture tubes.

At a time of booming sales, the color television set is taking an important leap forward — which will bring it a new look and even greater appeal.

The first completely new generation of color picture tubes in more than 10 years is now arriving, to bring the consumer a far wider choice in color TV. The RCA 25-inch rectangular short color tube, now in limited production, is the first in this new range of sizes.

The history of color television has been a continuing evolution of improvements and refinements, as opposed to revolutionary product changes. Many of these improvements have involved the color tube, but the physical dimensions of the one standard tube have remained unchanged from the time RCA introduced the 21-inch round 70-degree picture tube late in 1954.

The introduction of rectangular color tubes, therefore, becomes an occasion of great significance in broadening the market for color television. The new 25-inch tubes are now being shipped, in limited quantities, from RCA's Lancaster, Pa., color-tube plant.

The 25-inch rectangular 90-degree color tube offers three important advantages over the standard 21-inch round 70-degree type:

First, it makes possible better proportioned television cabinets. More than four inches have been slimmed from the tube's depth, and color consoles can now be built which protrude only about 22 inches from the wall. It also permits the use of lower cabinets.

Second, it provides a rectangular picture, as opposed to the "curved sided" image on the round viewing screen of the 21-inch tube.

Third, it has a larger viewing area — 295 square inches, in contrast to 267 on the 21-inch color tube.

In short, the new tube is bringing to color TV cabinets and color TV pictures the same proportions found in modern black-and-white television — compact console and rectangular pictures.

For some time to come, the new sets with rectangular pictures will be more expensive than conventional 21-inch models, owing to the inherently higher cost of the picture tubes and the receiver circuits required. Because of this, it is expected that rectangular-tube sets will represent only a minor fraction of color TV set sales during 1965.

In the evolution from the round-faced tube to the shorter rectangular-screen tube, color is following the pattern established by black-and-white television at the time of its fastest growth rate. The first black-and-white tubes also had round faceplates, and their depth was far greater than that of today's tubes. From the time television began to be mass marketed in 1947, it took only three

...no tube in the history of commercial television has been so completely evaluated and tested...

Employee at RCA Lancaster, Pa., plant prepares to insert fine-mesh shadow mask into faceplate of 25-inch rectangular color picture tube.

years to develop a rectangular screen, and shorter tubes began appearing soon thereafter. Why, then, did the shortening and squaring-off process for color require so much time?

The answer lies in the almost incredible precision required in color tubes to produce both color and black-and-white pictures of high quality. Despite the description of the color picture tube as "the most demanding and precise device ever mass produced," its track record has been excellent, and in reliability and long life it equals — and may even excel — the common, garden-variety black-and-white tube. Both the old and the new color tubes are of the same basic type — the "shadow-mask" design — the only type of color tube that has ever been mass produced. But the change from a round to a rectangular tube, and the shortening of tube depth, posed obstacles which at times must have seemed almost insurmountable.

The shadow-mask tube has three electron guns mounted in its neck — one for each of the primary colors (which, in color TV, are red, green, and blue). The inside of the faceplate is coated with nearly one and one-quarter million tiny phosphor dots, placed in groups of three — one red, one green, one blue — which glow in response to the barrages of electrons fired by the electron guns. Close to the faceplate, between it and the electron guns, is the steel shadow mask, in which are etched hundreds of thousands of tiny holes. It is positioned so that an electron beam from the "red" gun will strike only the red phosphor dots, a beam from the "green" gun only the green dots, and a beam from the "blue" gun only the blue dots.

In developing the new tube, RCA engineers faced two major problems in addition to hundreds of minor ones. One was the wider "deflection angle," the other the rectangular shape of the screen.

"Deflection angle" is a fancy term for the factor which governs the front-to-back depth of a picture tube. As a picture tube is shortened, the deflection angle must be increased. The greater the deflection angle, the more sharply the electron beams must be bent from the tube access to sweep the edges of the picture screen. The 21-inch tube has a deflection angle of 70 degrees, while the new 25-inch tube has 90-degree deflection.

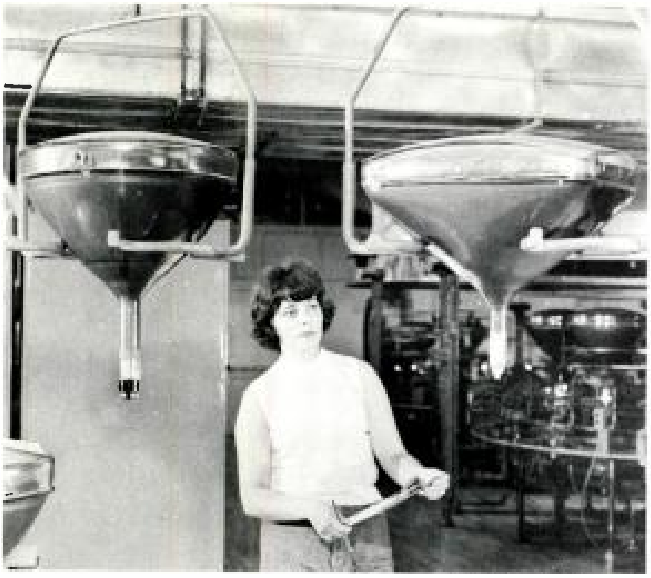
The rectangular shape of the new screen raised the problem of corners, which, of course, did not exist in the earlier rounded screens. Among the bugaboos hiding in the corners was the question of how to maintain color purity without sacrificing brightness.

If the engineers were not cornered by these problems, there were enough others to worry about. Not only was it necessary to redesign every element in the tube but new techniques and machinery had to be devised to produce it, and new television set circuits developed to operate it.

Although basic research for the shorter rectangular tubes was initiated at about the time the first round color tube went into production, the intensive homestretch effort dates from 1962.

The largest part of any picture tube is the glass bulb, or "envelope." Color tube envelopes generally are made from glass of a type different from that used for black-and-white tubes, and must be built to far greater standards of accuracy. In 1962, Corning Glass Works embarked on a major long-range program to develop the bulb that is now being used for the RCA 25-inch rectangular color tube.

Among other requirements for the new tube are a completely new shadow mask and electron guns. Probably the most critical step in the production of a color tube is depositing the million and a quarter color dots on the faceplate. Because the positioning of these dots in relation to the



The new shorter RCA 25-inch rectangular color television picture tube side by side with a 21-inch round tube on an overhead conveyor.

shadow mask is all-important, they are located on the screen by a photographic process, in which the shadow mask itself is used as the "negative." To place the dots precisely on the screen of the wide-angle 25-inch rectangular tube, a radically new lens system had to be developed. The process, as finally adopted – according to Douglas Y. Smith, Vice President, RCA Electronic Components and Devices – "compares favorably in all respects with the process used on round tubes."

A new technique for applying the phosphor dots to the screen has resulted in the added bonus of a brighter picture.

Meanwhile, the RCA Victor Home Instruments Division was developing circuits and components to drive the new picture tube. In effect, the 25-inch tube required a new color TV chassis.

After all the developmental work was completed, and hundreds of tubes had been built, the job still was not finished. Before a single production-model tube could be shipped to a customer, there remained the arduous, time-consuming task of testing. The new RCA tube had a challenge to meet the quality record set by the 21-inch round tube.

The testing process is anything but routine. Back in 1962, an RCA-developed, 90-degree version of the 21-inch round tube was suddenly dropped (before a single tube had been shipped) when an exhaustive testing program showed that problems might develop during the life of the tube. At that time, RCA announced frankly: "It is now recognized that the goals of reliability established for the 90-degree tube have not been fully realized."

But the new 25-inch tube came through the tests with its colors flying proudly. Said Smith: "To our knowledge, no tube in the history of commercial television has been so completely evaluated and tested for life and reliability, at this point in its development, as has the RCA 90-degree rectangular color picture tube."

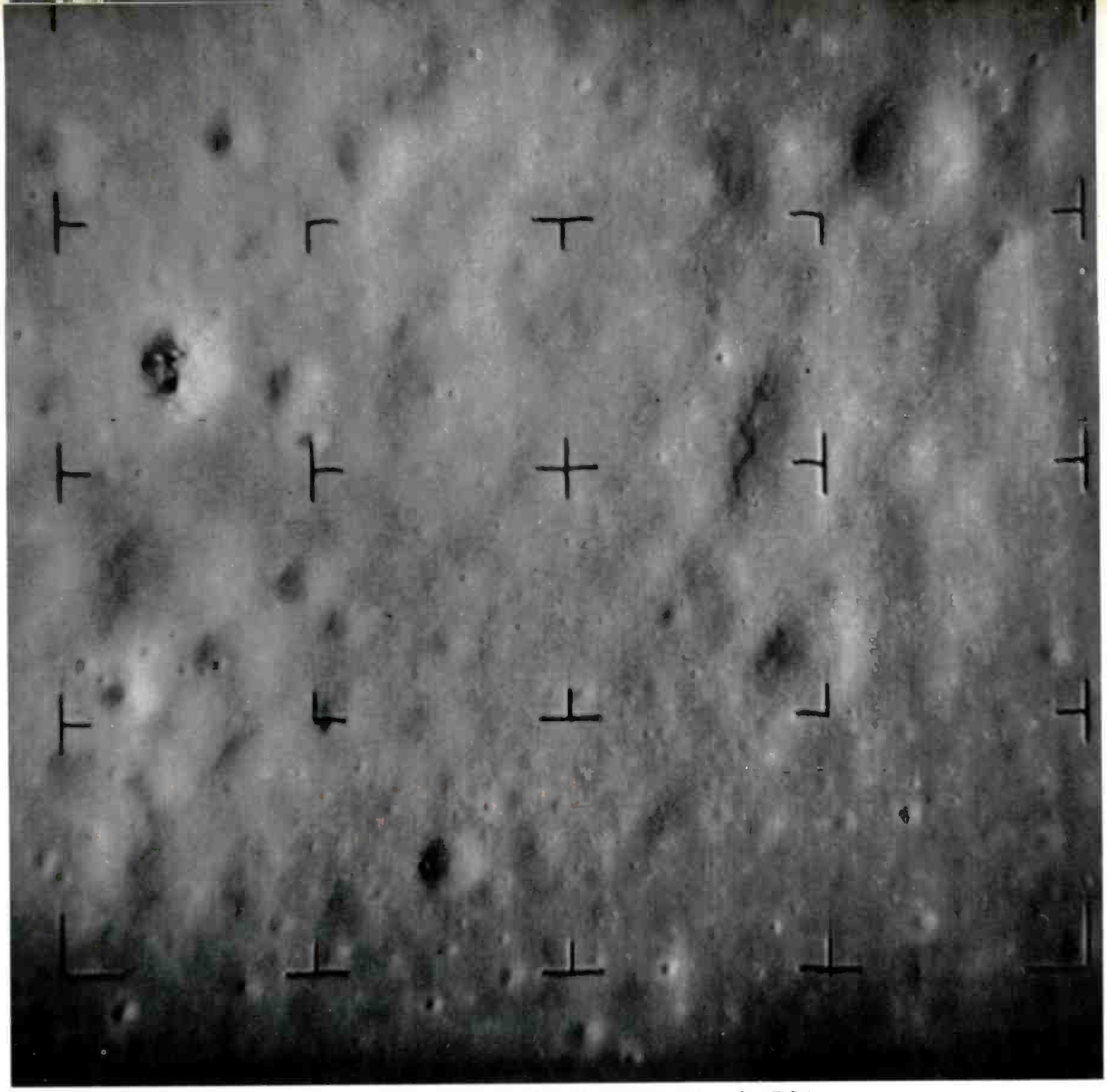
Approximately 1,000 of the new tubes were placed on "life test" for more than 4,000 hours. That is the equivalent of more than three and a half years of viewing at the rate of three hours a day per tube.

The 25-inch tube is expected to take its place alongside the 21-inch as a "standard" size for color television. Like the 21-inch tube, the 25-inch size will be offered by several picture tube manufacturers. At press time, a 25-inch rectangular color picture tube was scheduled for production by the Rauland Corporation (owned by Zenith Radio Corporation), and deliveries of a Sylvania 25-inch color tube were being planned for the first quarter of 1965. A 23-inch rectangular color tube is being produced by National Video Corporation, Chicago.

The experience and know-how gained in producing the 25-inch rectangular 90-degree tube can now be applied fairly rapidly to other new sizes. A scaled-down version with a 19-inch screen is expected to be available commercially in limited quantities during the second quarter of 1965. Already being studied is the potential of a still smaller tube – possibly 16 inches.

According to a survey by the U.S. Bureau of the Census, American television manufacturers sold 438,000 color sets in 1962 and 747,000 in 1963. This year, the total could be as high as one and one-half million – and color now accounts for more than one third of the television industry's dollar sales volume.

The introduction of compact, rectangular, color picture tubes, and the promise of additional new sizes, marks a major milestone on the road to further sharp increases in color sales. Together with the new lower prices for 21-inch sets, the new sizes will make color television more attractive and available to a far greater number of people next year. Largely as a result of this increased variety, it is conceivable that nearly as many families will buy color sets in 1965 as in all of color's 11 previous years combined. ■

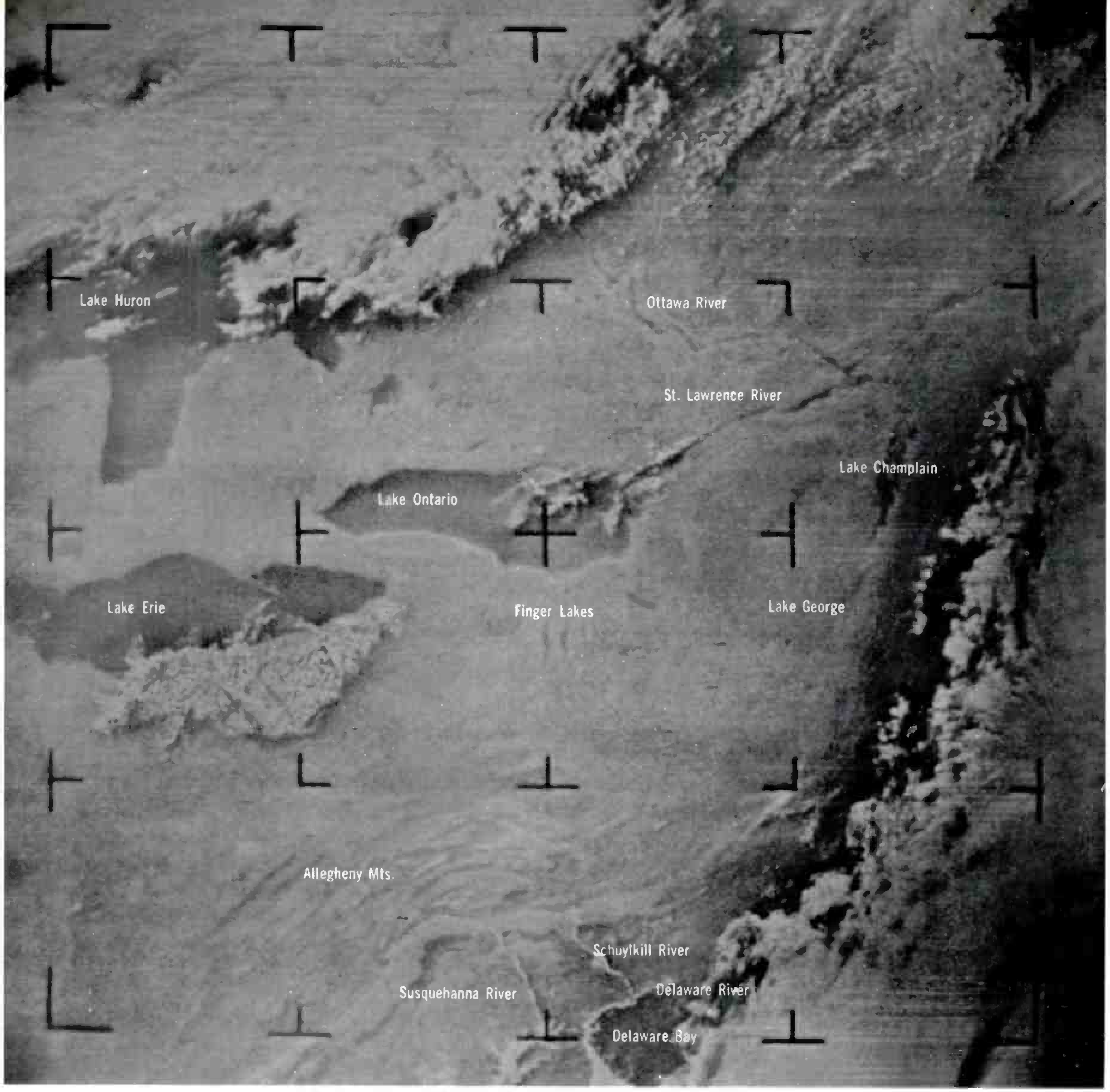


Lunar craters appear in this photograph taken by RCA television cameras aboard Ranger VII spacecraft from an altitude of three miles above the surface of the moon.

TV IN SPACE

The fast-developing art of space television brings the promise of a clearer picture of the universe.

Ranger VII was launched from Cape Kennedy, Florida, at 16:50 GMT, July 28, 1964. At approximately 13:06 on July 31, F channel was placed in warmup by a command from the TV subsystem clock. Then 80 seconds later, F channel went into full-power operation and began taking pictures. The P channel was placed in warmup at approximately 13:09 and was placed in full-power operation 80 seconds later by a command stored in the spacecraft. Picture taking continued for approximately 17 minutes until impact in the Sea of Clouds just southwest of Guericke at 13:25:50 GMT. (From an article on the Ranger TV sub-



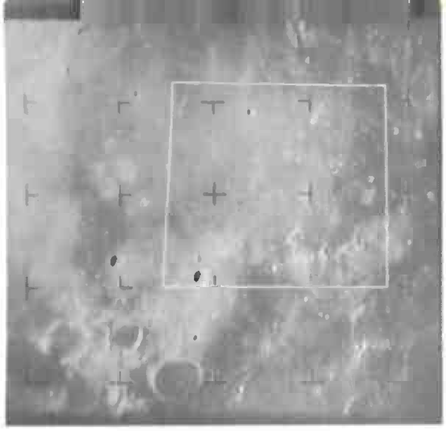
A large area of the northeastern United States is visible in this image televised from the Nimbus weather satellite at an orbital altitude of about 600 miles on September 14, 1964.

system, by B. P. Miller, Ranger Project Manager, Astro-Electronics Division of RCA.)

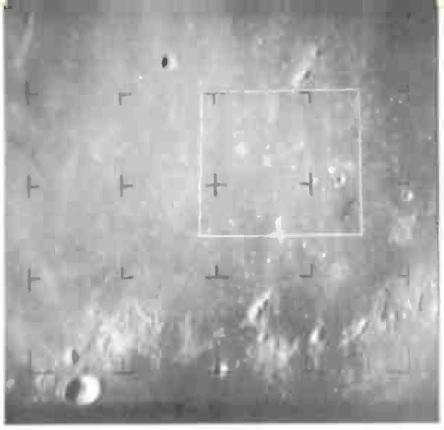
These austere phrases from an engineering report summarize an achievement that has been hailed by scientists as the most dramatic forward leap in astronomy since Galileo first directed his telescope toward the heavens: the extension of man's vision to within a few hundred yards of the moon's surface by means of a high-resolution six-camera television system carried aboard a complex and ingenious space vehicle.

In one stroke, electronics and space technology transcended by 2,000 times the limit of resolution of the most powerful earth-bound telescopes to provide in more than 4,000 pictures information needed for landing of men on the moon.

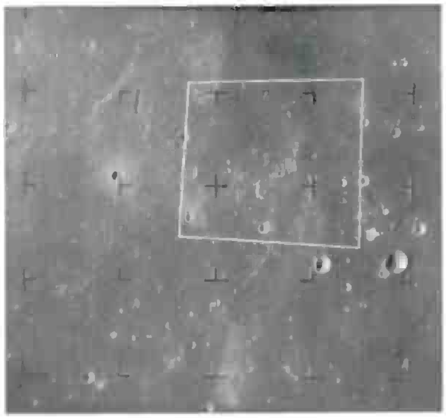
A few weeks later, a further demonstration of the mounting potential of space television came with the successful launch into polar orbit of Nimbus, an advanced experimental weather observation satellite. Where Ranger had extended man's vision to the very surface of the moon, the complex of four cameras aboard Nimbus lifted the eye to an altitude of about 600 miles above the earth to obtain the most comprehensive and detailed views yet recorded of the world's weather patterns.



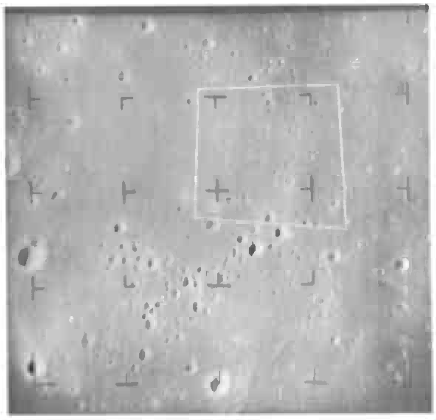
Altitude: 480 miles



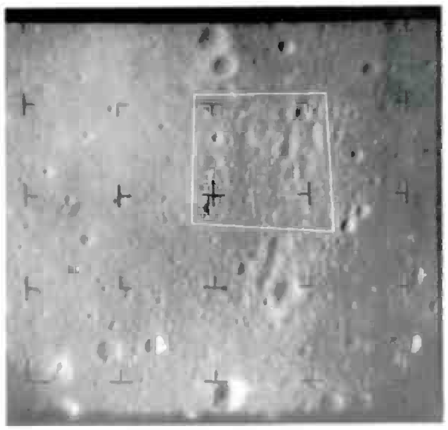
Altitude: 235 miles



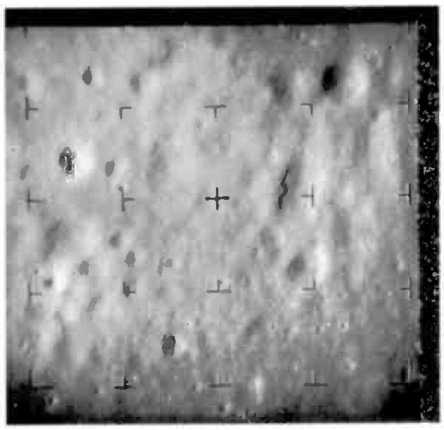
Altitude: 85 miles



Altitude: 34 miles

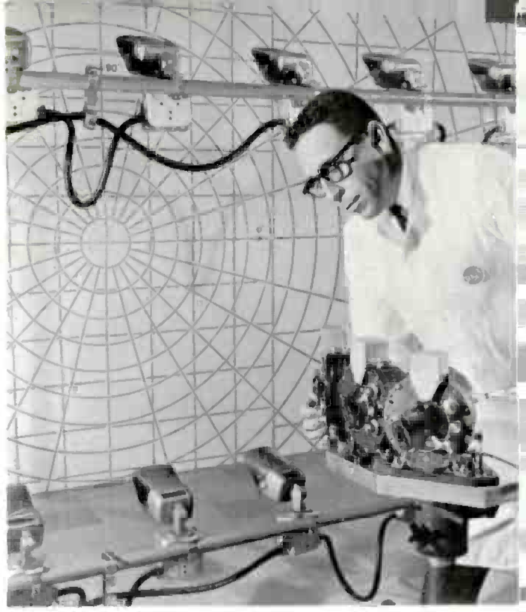


Altitude: 12 miles



Altitude: 3 miles

MOON PHOTOS. *Photo at 3 miles was taken 2.3 seconds before impact.*



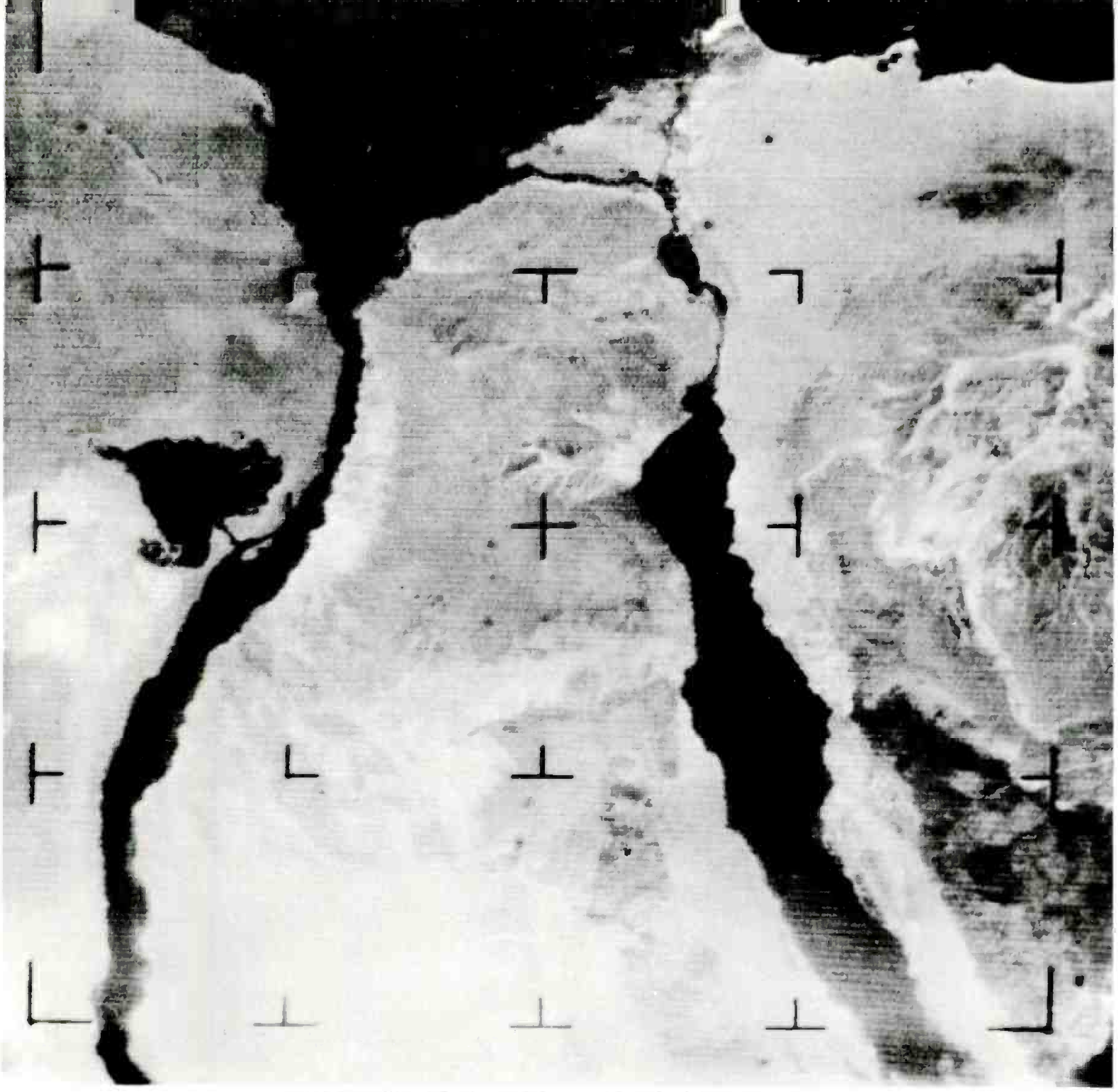
Advanced vidicon camera system for the Nimbus weather satellite was designed and built by RCA's Astro-Electronics Division.

Six TV cameras of the Ranger VII television system, designed and built by RCA, returned first closeup photos of the lunar surface.

Along with its visual report on cloud formations and movements, Nimbus sent back astonishingly clear pictures of the familiar shapes of earth – the Great Lakes of North America, the Nile delta in flood, the Mediterranean littoral, and the British Isles, among many others.

In the four and a half years that have passed since the launching by the National Aeronautics and Space Administration (NASA) of the first TIROS weather satellite in the spring of 1960, the world has become accustomed to a flow of visual information from space. TIROS was the first vehicle to carry television cameras beyond the atmosphere, and the eight satellites so far launched in the amazingly successful series have produced pictures of excellent quality for study by meteorologists. Now Nimbus and Ranger, carrying even more advanced systems, have advanced the art of space television still further.

Through these NASA projects – TIROS, Nimbus, and Ranger – has come, perhaps, the most striking vindication yet for the early concept of television as a means for extending the extreme distances of space for observation and point-to-point communication, as distinct from broadcasting. In this role, television has embarked on a new career that will eventually include not only the observation of the earth and the moon but also the study of the planets at close range, the scanning of the universe through space environment, and



The Nile River in flood, photographed by RCA television camera system aboard Nimbus. Intended as a research spacecraft, Nimbus was designed to observe weather patterns everywhere in the world on a daily basis.

channels of communication linking astronauts visually with their bases on earth.

Two statistics demonstrate the potential of television in space. Beginning with the voyage of TIROS I in 1960, nearly 420,000 television pictures have been sent to earth from satellites and other spacecraft. Yet this vast output has come from only 26 cameras – two in each of the eight TIROS satellites, four in Nimbus, and six in Ranger VII. The flood of visual information will mount in the near future with the launching of additional TIROS and Nimbus vehicles, further Ranger shots, and the use of television cameras in the Gemini and Apollo manned vehicles, the Orbiting Astronomical Observatory, and other forthcoming projects.

All of the space television cameras employed in the TIROS, Nimbus, and Ranger projects have been designed and built by RCA, and all have employed rugged variants of the RCA vidicon pickup tube designed for long persistence, high resolution, and other special characteristics. Unlike conventional TV cameras, those so far used to scan weather patterns and lunar features have provided a succession of still photos rather than the moving images of broadcast TV. There has been no need to record motion in any of the space projects up to now, and the slower transmission rate required for stills has enabled engineers to keep the weight and power requirements of the TV equipment well within acceptable limits for space flight. ■

Sound and Movie-Making

by John Ott

Artistry and technical skill combine to reproduce sound on film.

When the movie-going public accepted the marriage of sound to motion pictures in 1927, the result was a shotgun wedding that destroyed an entire industry almost overnight and created a brand-new one the next day.

It happened with precise and dramatic suddenness on the evening of October 6, 1927, when Al Jolson's "The Jazz Singer" first opened in New York. Ironically, the picture that spelled the end of the silent era was essentially a silent film itself. But within the footage were four talking and singing sequences that apparently were enough to capture the public's imagination. From that point on, movies meant "talkies."

As with most so-called overnight sensations, the event itself was preceded by years of patient work, not only to perfect a satisfactory sound system but to persuade the public to accept it. Sound synchronized to motion picture film was not a new concept in 1927. Thomas Edison was tinkering with the idea as early as 1888. He turned the problem over to his assistant, William Dickson, who succeeded in producing a short motion picture linked to Edison's invention of the phonograph. Dickson made his presentation to Edison on October 6, 1889, 38 years to the day before "The Jazz Singer" finally broke through the sound barrier.

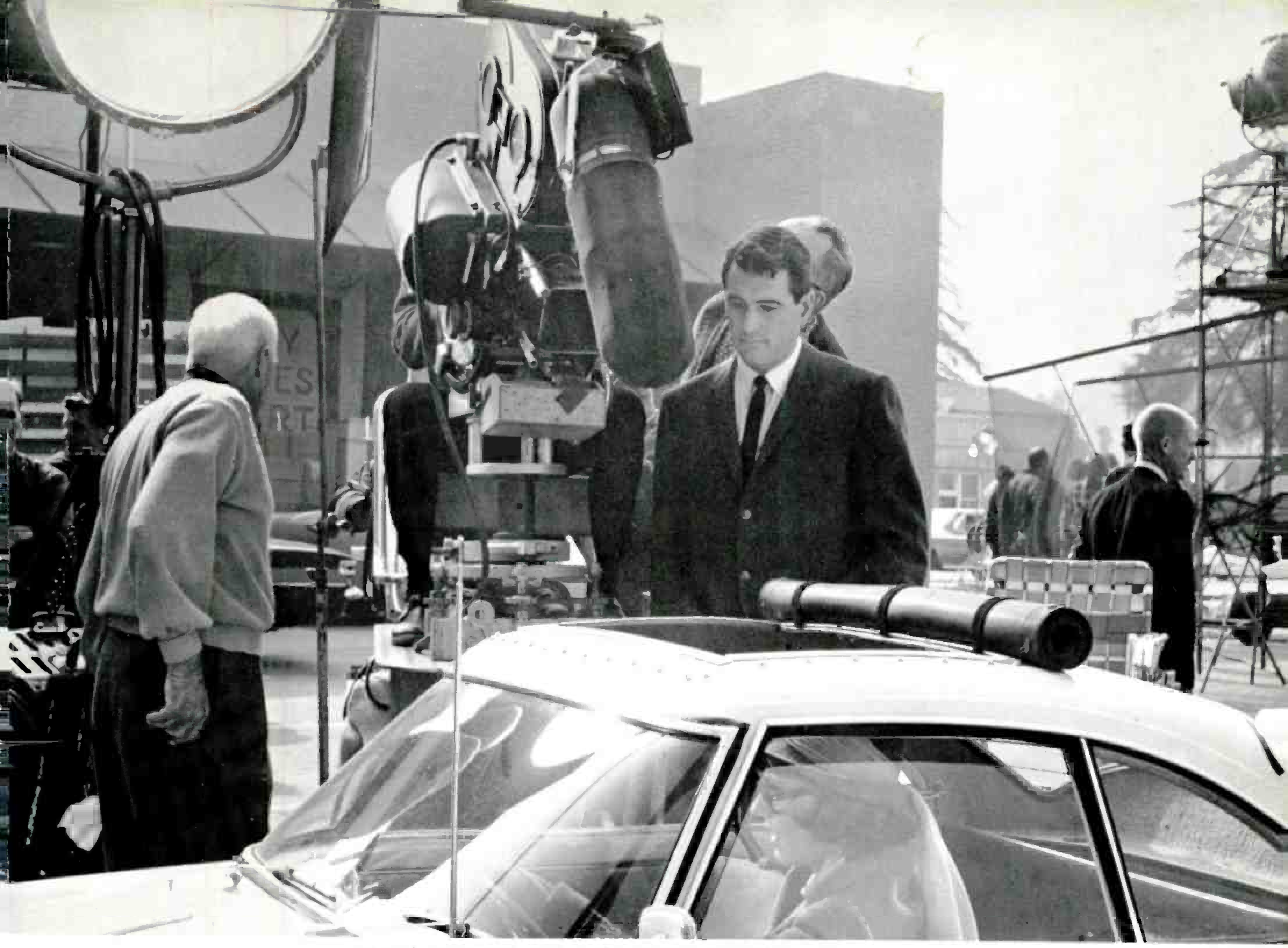
Actually, by 1927, the public had long been accustomed to some sort of sound with its movies. Initially, it came from the upright piano in an orchestra pit where a musician with an extraordinary repertoire matched on-screen mood or action with appropriate background selections. Larger de luxe movie palaces in principal cities boasted huge symphony orchestras, and even modest neighborhood houses provided their customers with a trio, which invariably included a percussionist for on-cue sound effects.

The logical replacement for the pit band was a phonograph record pre-recorded with synchronized music and sound effects to be played along with the picture. But it was logical in theory only because existing sound equipment was not powerful enough to fill a large theater. Then, shortly before World War I, Lee De Forest developed the audion amplifier. This silenium tube gave sound systems the authority they needed, and productions were planned with elaborate sound tracks prerecorded on phonograph discs. One of these featured the voice of John Barrymore.

Despite the care and expense involved, the public was indifferent — and with good reason. Motion picture sound on discs was unsatisfactory because matching was not always exact. Whenever a film was torn — not an infrequent occurrence — several frames were lost in splicing it back together. This immediately threw sound and film out of synchronization. With each tear and subsequent splice, sound and picture drifted farther apart until amused audiences were treated to the diminutive heroine speaking with the bass growl of the villain.

Again it was Lee De Forest who provided an answer. In 1923, he devised a method of photographing sound directly on film. He called the process Phonofilm and presented it in theaters throughout the country, featuring vaudeville stars doing their popular turns.

Public response was one of polite interest but not overwhelming enthusiasm. It took the peculiar chemistry of Al Jolson's performance in "The Jazz Singer" to create the insatiable demand for "100 per cent all-talking motion pictures."



Special equipment, such as the muffled microphone above car, cuts extraneous noise in outdoor film shooting. Rock Hudson stands by for last-minute adjustments.

The subsequent scramble to jump on the sound bandwagon literally turned the entire motion picture industry upside down. Over the next two years, movie theaters across the country were feverishly converting to sound at the rate of about 12 a day. Theater owners who could not afford the changeover were forced to close their doors. Customers insisted upon sound. During the same two-year period, from 1927 to 1929, audiences nearly doubled from 60 million paid admissions a week to 110 million. An industry that had been big to start with was bigger still — and entirely different.

Movies are an art as well as an industry, and the silent motion picture was a carefully developed medium with techniques and forms of its own. Directors, producers, writers, actors, film editors, and cameramen by the thousands were forced to master the new tyranny of sound or get out of the business. Many of them failed.

Particularly hard-hit were actors. Favorites of the silent era, quite a few of them established stars, were laughed off the screen when the merciless microphone revealed a speech impediment, a squeaky falsetto, or a flat, toneless monotone.

Dialogue imposed a completely new rhythm to the composition of a motion picture, and world-famous film-makers, accustomed to the single dimension of visual action, struggled to understand its capabilities and limitations.

Not unnaturally, there was a rush to transpose successful stage plays to the talking screen. It seemed a sensible move. The words were already written, and there were trained actors to speak them. But, by and large, the experiment was a failure. What

As actress prepares to enter, microphone boom operator adjusts closeup microphone.

had seemed fresh and sparkling on the stage projected as dull and stale on the screen. Eventually, the fact was made plain that the talking motion picture was a new, demanding art form, quite different from the silent movie.

This realization prompted an exciting period of experimentation and change, especially in the application of sound equipment. One of the pioneers in this field was RCA, whose engineers had long been convinced of the advantages of sound on film. In 1927, the year of "The Jazz Singer," RCA transferred its movie sound work from general engineering to the Radio Department and, in 1928, RCA Photophone, Inc., was organized as a subsidiary to carry on the commercial exploitation of the new system.

Techniques have changed, and there have been vast improvements in the sophistication of equipment, but the process of photographing a sound track on a strip of motion picture film remains, with one important modification, essentially the same as it was 35 years ago. The modification was the introduction of magnetic tape in the late 1940s and early 1950s.

A visit to a shooting location today reveals a spectacle of controlled chaos where as many as half a hundred technicians are paying the closest attention to the words and actions of perhaps two people. Among the technicians are four men who make up the all-important sound crew.

Chief of the crew is the "mixer," a man who decides when the volume level is correct and who keeps track of the footage. The "recordist" operates the sound recording equipment. The "boom man" operates the unidirectional microphone, which is attached to the end of a boom and swung into proper place on cue. The boom man must be as familiar with the script as the actors or director, since it is his responsibility to make sure the microphone is in the correct position at all times. The fourth man is known as the "cabler," and it is his job to make certain nothing interferes with the physical operation of the over-all sound equipment.

The crew on the sound stage, as well as other sound technicians, uses a bewildering variety of specialized equipment in its work. Microphones, magnetic recorders, mixing consoles, multiple-track

Experts at mixing console can blend as many as fourteen separate sound tracks into one composite track.

playback reproducers, re-recording consoles, mobile units — these are only a few of the instruments regularly supplied by RCA's Broadcast and Communications Products Division at Burbank to the film production centers of California and elsewhere.

These units can be used throughout the world because the medium of film is truly international. No matter where the picture is produced, at the end of a day's shooting two products emerge — 16-mm. or 35-mm. film, upon which has been recorded picture, and a dialogue sound track which has been recorded on 17½-mm. or 16-mm. film coated with a magnetic strip or on ¼-inch magnetic tape. If the picture film is defective in any way, the entire scene must be reshot. However, if the dialogue track is marred, the scene can be re-recorded in a dubbing studio. There, the picture is projected as actors repeat their dialogue, synchronizing words with their own lip movements on screen. Not only does this provide a relatively inexpensive way of patching up a sound take, but the same technique is universally used to dub films into any number of foreign languages.

After satisfactory picture and sound tracks have been produced, the two products travel separate ways and do not join each other for some time. The 35-mm. picture film is developed and printed into a second generation copy known as the "answerprint" or "picture workprint." The original negative is carefully put away for future use. The dialogue track is transferred to a second generation 35-mm. copy known as the "sound workprint."

During the course of production, hundreds, perhaps thousands, of these short sequences of sound and picture are prepared, each on its separate roll of 35-mm. film. When shooting is completed, the editor assembles these sections, discarding duplicate or unsatisfactory material, until he has the picture in coherent story-telling order. When he is finished, he has two rolls of film — one carrying the picture, the other carrying dialogue. Each sequence matches exactly, and both rolls are the same length.

At this point, at least two additional sound tracks are created. One carries sound effects, such as slamming doors and howling wind, while the other carries the background musical score. These three tracks — dialogue, sound effects, and music — are then "mixed" together into a single, balanced sound track. Actually, this is an oversimplification. The average motion picture will have seven separate sound tracks, and it is not unusual for as many as 14 to 20 tracks to be mixed together.

What emerges is a single mixed "composite" sound track on magnetic tape coated over regulation 35-mm. motion picture film. The track now goes to an optical recorder where it is photographed directly on film negative.

Imagine a beam of light reflected from a small mirror through a W-shaped aperture in a round disc about the size of a dime. As the beam travels through the aperture, it throws a pattern of light along a vertically moving roll of photographic raw stock film. This pattern emerges as a thin strip on the edge of the film that changes in area whenever there is a variation in the beam of light.

Variations occur because the reflecting mirror is coupled to a modulation coil that vibrates at the frequency of the applied audio signal, in this case the composite sound track. The chain of events follows this order: variations in the sound track set up corresponding variations in the coil, the mirror, the beam of light reflected from the mirror, and, finally, in the area being exposed on the film. This is the process of printing sound on film.

The assembled picture negative and the 35-mm. optical sound negative are contact printed, or "married" into a "composite" print which becomes the finished product ready for distribution.

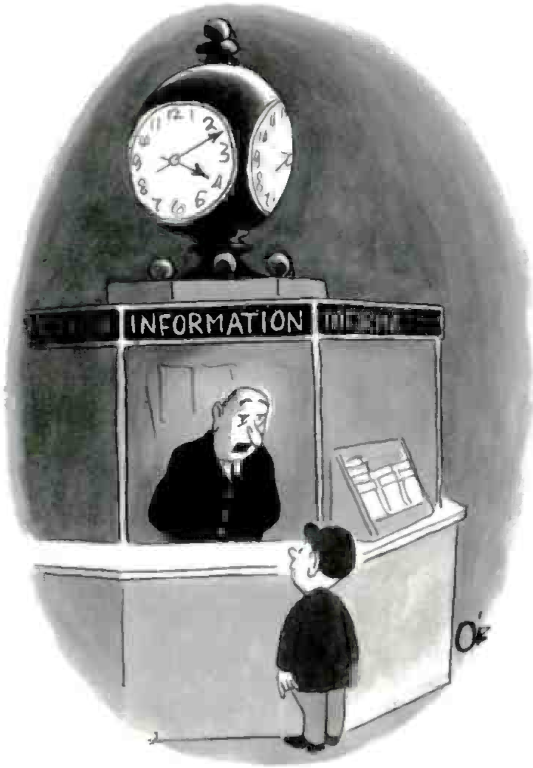
Modern-day movie-making is as much a science as it is an art, and, consequently, sound engineers

Composer-conductor Henry Mancini (left) and producer Howard Hawks review film score before recording session.

are called upon constantly to develop new processes such as Vitasound, Cinerama, Cinemascope, Fantasound, and similar techniques designed to increase the "presence" of sound.

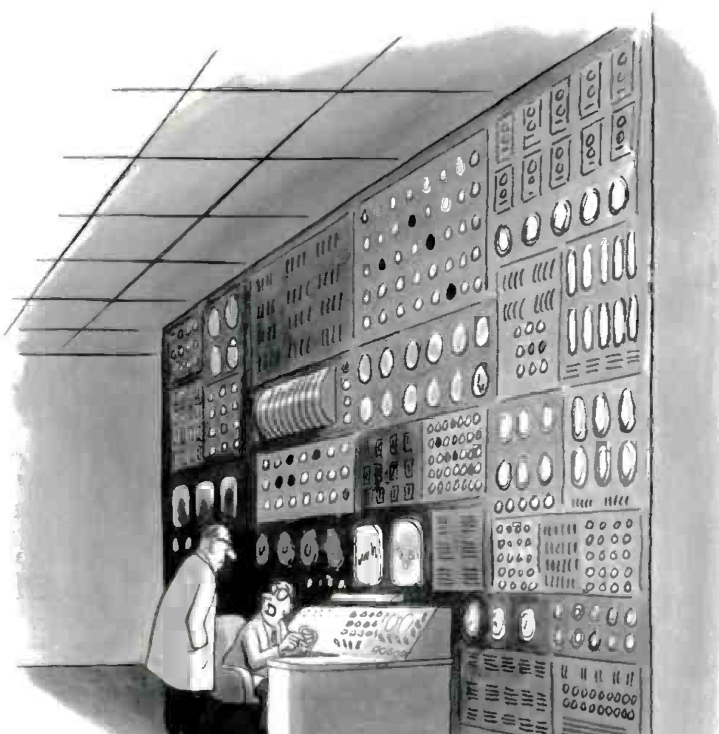
Basically, these new techniques are nearly all stereophonic in nature, employing multiple sound tracks, each to be hooked up with its own speaker-system in a specially prepared theater. These tracks are not photographed on the film. They are separate strips of magnetic tape upon which sound has been recorded. The tape is fixed to the film, and the projector is equipped with the required number of magnetic playback heads. An elaborate stereophonic sound motion picture may have as many as five or six of these individual tracks of magnetic tape moving simultaneously through a projector in an attempt to provide a new dimension to a unique art that reproduces not only the image but the sound of the world around us. ■

This Electronic Age...



"E = MC²"

"What a night! The moon, the stars . . . the Van Allen Belt . . ."



"If I'm reading this correctly, it wants a goat sacrificed to it."

Window on the Invisible

by Edward J. Dudley

TV joins the electron microscope to provide scientists with a brighter view of the tiniest world.

A new and brighter window on the world of the infinitely small was opened recently by RCA scientists who successfully merged the techniques of television and the electron microscope. The system holds promise of new knowledge that could help speed man's exploration of space, his conquest of disease, and his insatiable search for new creature comforts and conveniences.

The combination of the two techniques, known formally as a Television Image Intensification System for the RCA Electron Microscope, is essentially an ingenious way of extending man's vision to see and study the building blocks of matter.

Both partners brought impressive assets to the merger. The electron microscope, for its part, is recognized as one of the world's most powerful scientific instruments. With its 200,000 times magnification and great resolving power, the microscope has illuminated many dark corners of the miniature world.

The television partner could claim even wider renown. It is every man's window on the world. It is news, entertainment, education, and more. One of television's major contributions to the merger was an image intensifier, a device that can make images many times brighter.

What brought these two electronic techniques together? The answer lay with the electron microscope that, for all its vast power, had some specific limitations. These centered around the nature of certain specimens that produced images too dim to be useful.

The microscope functions by directing an electron beam at a specimen. The electrons that pass through are focused by magnetic lenses, creating a pattern or image of the specimen as they strike the fluorescent viewing screen. The question arose: if the picture on the screen is too faint, why not strengthen the electron beam and brighten it?

The answer, as microscope men had known for some time, was that plastics and other materials of interest to science are radiation-sensitive and are destroyed or altered by electronic energy strong enough to illuminate them. With the help of image intensification, a relatively weak beam could be fired at the specimen, and the resulting weak images – some so dim as to be invisible to the eye – could be brightened by the intensifier until they were visible.

A startling effect of combining the two electronic techniques is to produce images up to two million times as large as the original specimen. These visible images are ten times as large as the electron microscope alone can show before it runs out of enough brightness for vision.

Although the increase in magnification is a spectacular feat, scientists note that most observations in electron microscopy are made at magnifications well below theoretical limits. More significant to the researcher is the instrument's vast resolving power. This is the ability to distinguish, or visibly separate, infinitesimal objects. The human eye, for example, resolves or sees objects as small as 1/250th of an inch in diameter. With the help

RCA's TV image intensification system ...is so new that its impact on scientific progress is yet to be assessed.

of the light microscope, objects as minute as 1/125,000th of an inch can be distinguished. But when the same scene is viewed with the electron microscope we can even see particles 1/25,000,000th of an inch in diameter! Because of this tremendous resolving power, images photographed with the instrument's camera produce such sharp pictures that they can be "blown up" many times and still retain meaningful detail and contrast.

RCA's TV image intensification system, which was demonstrated for the first time in September, 1964, at the company's Camden, N.J., laboratories, is so new that its impact on scientific progress is yet to be assessed. But it is being hailed as the most important single advance in microscope design since the perfection of the electron microscope itself.

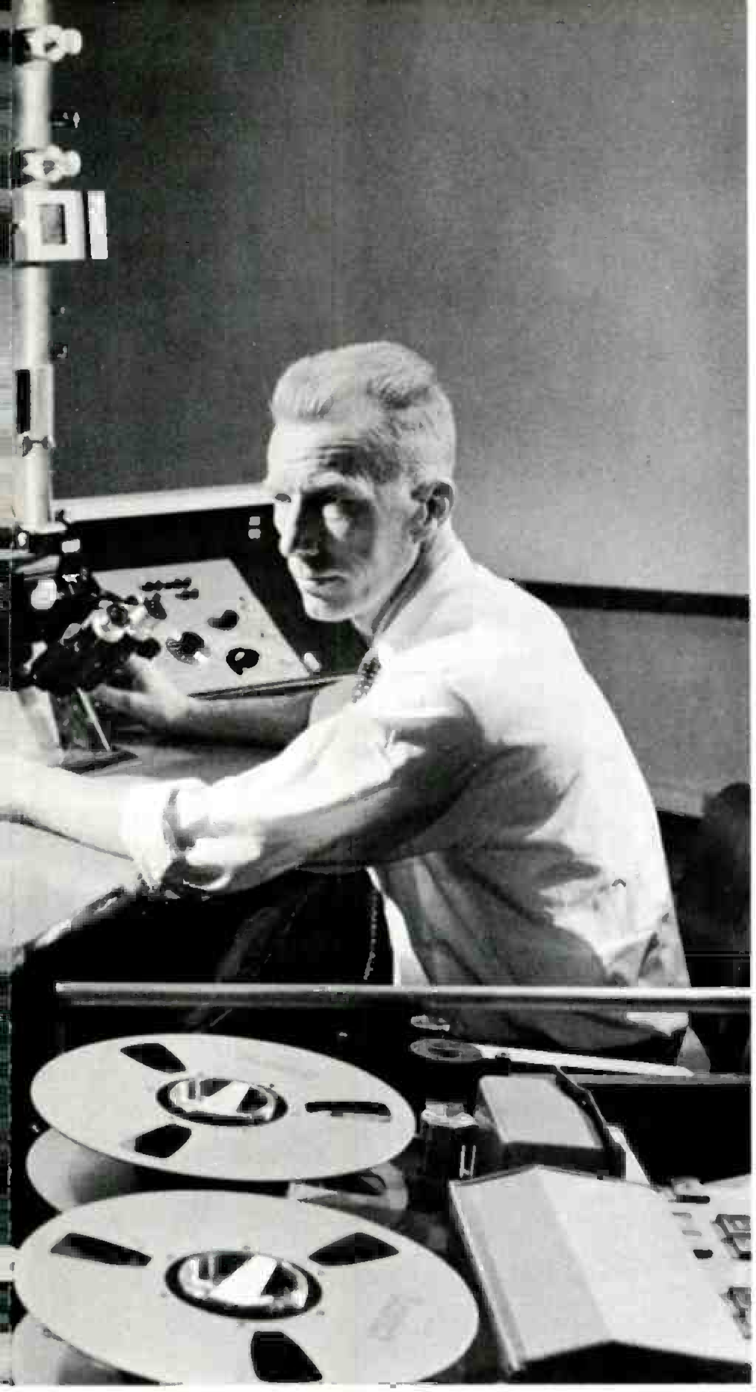
The system holds a great many other advantages beyond the major one of allowing researchers to view for the first time specimen images that had been beyond the reach of electron microscopy.

The TV system enhances the microscope image by providing a greater degree of picture contrast. Specimens difficult to distinguish because of poor contrast can be made to project "good pictures" that are meaningful to the microscopist.

Another benefit TV brings to microscopy is its ability to invert images. Because of the nature of their preparation, some specimens appear on the viewing screen as photographic negatives. By a flick of the switch, which reverses the polarity of the TV signal, the images can be made positive and quickly become understandable.

Other advantages are inherent in the ability of television to portray motion. Scientists frequently are interested in how the appearance of a specimen changes as temperature is raised or lowered, as the specimen is stretched, or as a magnetic field is applied. These events can be made to happen in the microscope's specimen chamber, and the results watched on a TV monitor. And, by connecting a video tape recorder to the system, the changing picture can be captured on tape for playback immediately or at any future time. Thus, the microscopist has a pictorial record of "transient phenomena" – events that happen only once or at unpredictable times – to study over and over again.

Taped or live television pictures of specimens under examination can be fed into a closed-circuit TV system for viewing at any number of locations, or used on the air in broadcast programs. The addition of TV takes the electron microscope out of the essentially "one-man" class and permits classrooms of students to share the microscopist's view as he manipulates the controls.



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

The television recording and display features of the new system will enhance the microscope as a teaching tool, especially in medicine and other life sciences, and in the formal training of microscopists.

In earlier years, this training process was a long one, for the student had to know as much about the instrument as he did about preparing specimens and interpreting what they revealed. Modern technology has sharply reduced the equipment end of such training by automating many of the functions of the electron microscope, allowing the researcher to concentrate on his viewing screen.

This is evident in the new TV system, which uses a small transistorized camera with many self-adjusting features. The camera is equipped with a three-inch image orthicon of extremely high sensitivity. This is the pickup tube type used in broadcast studio cameras.

The fact that a TV camera with associated image intensifier could be added to a complex assembly, already crowded with 4,300 parts and 80 miles of wiring, points up the extent of the engineering achievement. Moreover, the merger had to avoid any interaction between the magnetic fields and high-voltage equipment of the two electronic systems.

RCA's first commercial electron microscope was itself as much a victory over space as it was an electrical, mechanical, and optical triumph. A veritable roomful of equipment had to be compressed into a small space and made to work reliably before the instrument could be marketed.

Experience in electron optics gained in RCA's years of television research played a major role in the design of the first commercial microscope. When the first one was delivered in 1940, the company had reduced the complicated procedures of manufacture – previously attempted only under laboratory conditions – to factory assembly on a volume basis.

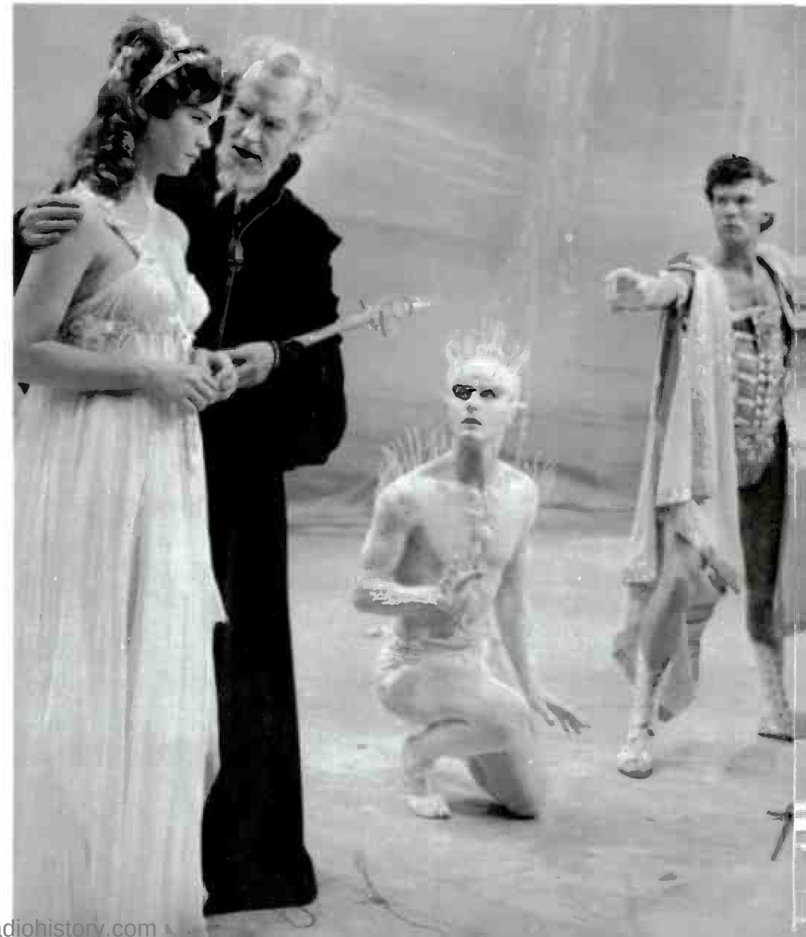
The 1,200 RCA microscopes produced during the past 24 years are making their influence felt in every branch of science. They have uncovered clues that may help to find a cure for cancer and have given medical researchers their first view of polio and other viruses. Metallurgists use electron microscopes in building the exact alloys demanded by the space age. Tire manufacturers study and re-create molecules of natural rubber with them. Governments use them to examine minutely the air we breathe and the ground we walk on.

The period since 1940 has seen constant improvement, refinement, and simplification of the RCA electron microscope. The long-term aim is to broaden the instrument's area of usefulness by making it as easy to use as the light microscope.

In the new breakthroughs it foreshadows and the new knowledge it promises, television image intensification appears to surpass all of the advances made thus far in electron microscope design. With it, science has more powerful eyes to explore the mysteries of the molecular realm. ■

Cast and crew rehearse in elaborate studio set for TV production of "Richard II."

NBC TV's presentations of "Hamlet" and "The Tempest" were among the most widely seen television productions of Shakespeare's works. Left, in a scene from "Hamlet," Sarah Churchill, Barry Jones, Ruth Chatterton, and Maurice Evans. Right, in a scene from "The Tempest," Lee Remick, Maurice Evans, Roddy McDowall, and William H. Bassett.



Shakespeare on Television

by Arthur Oppenheimer

This is Shakespeare's year—the 400th anniversary of his birth. We cannot know what Shakespeare would have made of television. Here is what TV has made of Shakespeare.

There was no doubt about it. London was theater-mad. The pulpit deplored the immorality of play-going while merchants predicted dire economic consequences unless something were done to curb the wasteful practice. Apprentices and journeymen alike were deserting guildhall and countinghouse whenever a play flag announced a performance that day.

Across the river on the other side of the Thames, the appearance of a flag over the Globe Theatre was the signal for a mass exodus. As many as 2,000 tradesmen and shopkeepers, gentility, and even nobility swarmed into rented punts and ferries to see Master William Shakespeare's latest production. He was without question the darling of the groundlings, the public's favorite playwright.

Today, 400 years after his birth, Shakespeare has not lost his popularity; in fact, his public has grown immensely. One broadcast of a Shakespeare play on network television, for example, will reach more people than all of the combined audiences that have watched the play on stage since it was first written.

The first television production of a Shakespearean play was in 1940, when NBC produced *Julius Caesar.* A press release at the time noted: "NBC's first [television] venture into the classics" — would be in modern dress "with television woven into the plot of a slightly rakish version of the play." It went on to say that "although the classic has been completely modernized, only three words in the text have been changed." It didn't say which three. *(Et tu, Brute?)*

In stage arrangements, however, there were many changes. Caesar's triumphal entry into Rome was witnessed by the conspirators on a television receiver, which also was the device for bringing the final scenes of the civil war before the viewer. Motion picture sequences were cut into the play at several points. Characterizations and costumes were likewise "modernized."

This production came just before the close of NBC's first full year of telecasting. In those pre-network days, the play was seen only in the metropolitan New York area, where there were then approximately 2,000 owners of TV sets. The audience for *Julius Caesar* was estimated at about 8,000 persons — the equivalent of four or five SRO performances at the old Globe.

During World War II, TV program service for the public was curtailed. It was not until 1949 that NBC resumed its Shakespeare production. That year there were five performances: *Twelfth Night, Julius Caesar, Macbeth, Romeo and Juliet,* and *The Comedy of Errors.* These were telecast on a network basis, with a consequent increase in the size of the audience.

It was, perhaps, the "Hallmark Hall of Fame" program on NBC-TV that brought Shakespeare production to maturity over a 10-year span, starting in 1953. That year, Maurice Evans starred in a two-hour *Hamlet* with a cast that included Ruth Chatterton, Sarah Churchill, and Barry Jones. Subsequent productions in this series, starring Maurice Evans, were a two-hour *Richard II* (1954), a two-hour *Macbeth* (with Judith Anderson, 1954); a 90-minute *Taming of the Shrew* (with Lilli Palmer, 1956); a 90-minute *Twelfth Night* (1957); a 90-

...the eternally youthful plays of Shakespeare will continue to hold millions of viewers spellbound...

Rich comic talents of Maurice Evans, Lilli Palmer, and Diane Cilento find full expression in color television broadcast of "The Taming of the Shrew."

minute *Tempest* (1960); a new two-hour color production of *Macbeth* filmed on location in Scotland and England (with Judith Anderson, 1960); a repeat of *Macbeth* (1961); and a repeat of *The Tempest* (1963).

Maurice Evans, who had played Hamlet 777 times on the legitimate stage, agreed to do a television production of the drama only when he was assured of a two-hour show. Though he described himself as a complete novice in television, he was determined to "protect the full values of the play." He produced the TV version personally, as he had previously produced his highly acclaimed stage version. He now set it in the Middle Europe of the 19th century because he thought Elizabethan costume too archaic to make the television audience see the play in modern terms.

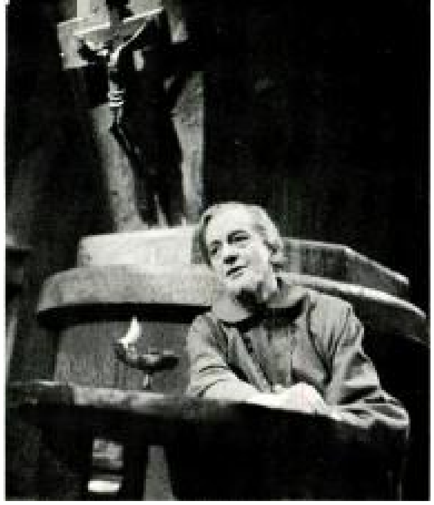
The main difficulty, Evans reported, was compressing the play, which runs four hours uncut. "A lot had to be sacrificed, but we wielded the blue pencil with meticulous care," he said. "We strove to retain all the cardinal points of plot and character development while eliminating passages, odd lines, and even whole scenes in an effort to keep the play taut and swift." Only one of Hamlet's soliloquies ("How all occasions do inform against me . . .") was bypassed.

In a memoir of his television experience with the play, Evans confessed that he had to unlearn nearly all the stagecraft he had amassed in playing *Hamlet* in the theater. "The consciousness that in television some of the viewers are thousands of miles away makes problems for the actor," he wrote. "During my first experiment in the medium, the two-hour *Hamlet,* the stage director had constantly to remind me of the actual proximity of the audience. Although people would be sitting before their sets in all parts of the country, I had to remember that on the screen the distance between their noses and mine would average six feet, not six miles or 600. Accustomed to playing *Hamlet* in the wide spaces of the theater, I found it excruciatingly difficult to deliver certain passages with the requisite vehemence without looking ridiculous at such close quarters. In the theater, Hamlet can really let rip when he exclaims, 'Bloody, bawdy villain!' — but in television he must modify his passion or he looks as though he is blowing up a balloon."

In rehearsal, Evans found that the best way to scale the performance down to TV proportions was to have an assistant hold a piece of cardboard before the actors' faces. "This represented the exact size of the image which would appear on the screen," he said. "This device helped me enormously, and I gave it undeviating attention until the very last moment of the play. It seemed superfluous to hold up the cardboard before the face of the dead Hamlet as he was being borne out. But, as a result, when the program was on the air, the eyelids of the corpse were seen by millions to be perceptibly fluttering." (Evans did not make that mistake in 1954, when he appeared in *Richard II,* his second Shakespeare television production. "The cardboard technique was again employed," he said, "only this time it was used until the absolute finale when Richard is seen lying in his coffin. No batting eyelids this time!")

The Evans *Hamlet* on TV was adjudged a considerable triumph. "It made for memorable and exciting viewing," said *The New York Times.* "The tragedy was played for its sheer dramatic value and proved superbly arresting theater." *Time* termed it "one of the best TV shows ever."

The first five of the "Hallmark Hall of Fame" productions of Shakespeare were telecast live. The



Maurice Evans in the title roles of "Richard II" (left) and "Macbeth" (right). The latter includes Judith Anderson as Lady Macbeth.

NBC TV camera crew at Harlech Castle, Wales, for filming of "Richard II."

sixth, in 1960, was *The Tempest,* with Evans playing Prospero, and this was the first to be videotaped. The introduction of video tape in TV drama production meant, among other things, that fluffs could be eliminated before air time. One critic had complained bitterly of the live *Hamlet* that right in the middle of "To be or not to be . . ." somebody dropped what sounded like a pail with enormous clatter, and that when Hamlet remarked, "Now I am alone . . ." you could hear the low murmur of an army of technicians around him.

An outstanding NBC-TV Network special in 1956 was the three-hour color film of Laurence Olivier in *Richard III,* the program coinciding with the British film's theatrical premiere. The following year, NBC televised an Old Vic production of *Romeo and Juliet* with John Neville and Claire Bloom.

It was in 1949 that CBS stepped into Shakespeare TV production with a "Studio One" performance of *Julius Caesar.* That program series also offered *The Taming of the Shrew* (1950), *Coriolanus* (1951), *Macbeth* (1951), and *Julius Caesar* (1955). The CBS Network also presented a three-installment *Hamlet* (1955) and an Old Vic production of that play four years later. For the past three years, WCBS-TV has telecast locally some of the productions of Shakespeare in New York's Central Park: *The Merchant of Venice* (1962); *Antony and Cleopatra* (1963), and *Hamlet* (1964). There is no record of Shakespeare production by the ABC Network.

Of the 15 plays of Shakespeare presented on U.S. television, the most frequently produced — five performances on NBC, one on CBS — is *Macbeth.* One reason, perhaps, is that *Macbeth* is a very short play, the shortest of all Shakespeare's except for *The Comedy of Errors.* Another reason for its special popularity may be, in William Hazlitt's words, "the wildness of the imagination and the rapidity of the action."

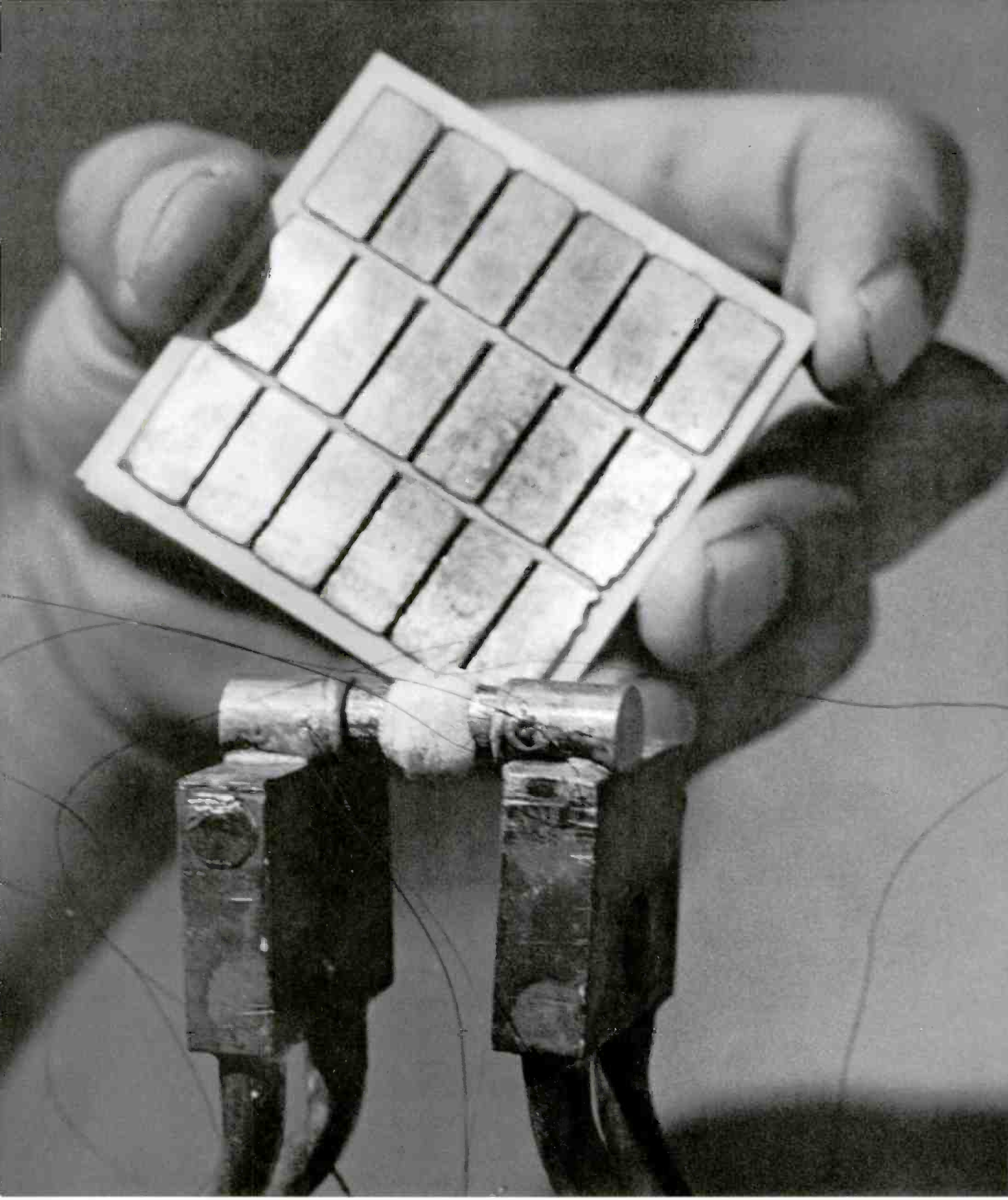
In any event, the dark, brooding story of Macbeth, Duncan, and the bloody succession to the throne of Scotland has captured the imagination of millions the world over. But *Macbeth* has a basis in fact, as do so many of Shakespeare's plays.

A splendid reminder of this was a full-hour color TV program produced in anticipation of the 400th anniversary of Shakespeare's birth, entitled *Shakespeare: Soul of an Age.* This exciting blend of journalism and theater, featuring the voices of Michael Redgrave and Ralph Richardson, was a reconstruction of Shakespeare's life.

The TV cameras followed in the footsteps of the poet and many of the characters of his plays. Doing their best to ignore girls in bikinis, TV aerials atop thatch-roofed cottages, trailer parks, laundry lines, and tourists, the film crew managed to record Shakespeare's England — the Tower of London, Windsor Castle, Southampton Beach, the Forest of Arden, Harlech Castle in Wales, and even Iona, the island where Duncan and Macbeth are buried among the other Scottish kings.

Critics acclaimed *Shakespeare: Soul of an Age* as "a magnificent accomplishment and tribute to our greatest writer," and "an excellent memorial program."

Because of its excellence, the program will probably have many repeat performances on the NBC-TV Network in the years to come, but certainly not more than the eternally youthful plays of Shakespeare, which will continue to hold tens of millions of viewers spellbound before their television sets. And this, of course, is the memorial that Shakespeare himself would probably have appreciated most. ■



This refrigeration module, the basic thermoelectric building block, was developed by RCA's Defense Electronic Products division for use in a noiseless air conditioner for submarines. Here it forms background for single couple shown in operation. Frost is being generated around the single couple as moisture in the air condenses on it.

The Thermoelectric World

by William C. Moore

The story of thermoelectrics, a technology that may someday revolutionize household heating and cooling.

Within the span of most of our lifetimes, the materials that contractors will use to build our houses will consist not only of wood, bricks, stones, and nails but of modules made of semiconducting materials similar to those that operate our pocket transistor radios.

These modules will be built right into the walls of our new house. Their function will be another priceless inheritance of today's progress in electronics — completely silent and highly efficient electronic heating and air conditioning of the home with about the same reliability and life expectancy as the timbers that hold up the roof.

In this new electronic house there will be a refrigerator and freezer that will chill or freeze our foods with unprecedented accuracy as well as a toaster and clothes drier, cooking range and oven, all operating with basically the same, solid-state modules. A small attachment, which can be affixed to the baby's crib, will keep his milk to a tenth of a degree of the desired temperature.

Even the car we park outside will be heated by these modules emplaced in seats, doors, and roof. It will be cooled in summer by these very same devices powered by a solid-state generator that has no moving parts and derives its energy from waste exhaust heat.

All these miracles will result from a science called thermoelectrics, which is now forming the basis of a dynamic new industry.

These predictions were made by engineers and scientists of an RCA Defense Electronic Products activity called Applied Research, an organization charged with the responsibility for taking developments emanating from the test tubes and microscopes of the laboratory and turning them into practical, usable devices.

They speak with authority because they have already produced an air conditioner for submarines, spot coolers for electronic devices, cryogenic cooling for lasers — all with thermoelectrics.

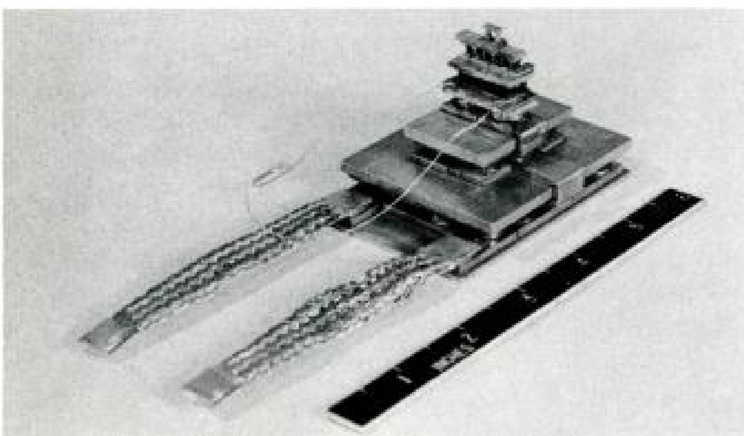
These practical researchers could say that "today, science is at the threshold of a new, space-age industry," but they use no such trite expression because thermoelectrics, now newly rediscovered, is almost as old a science as electricity itself. Actually, we have been standing at that threshold since 1821.

The first discovery of a thermoelectric phenomenon was made by the German physicist Thomas Seebeck, except for whose blunder the prophetic paragraphs above might by now have become commonplace. Only a year after the famous Danish Professor Hans Christian Oersted learned in 1820 that a magnetic needle, or compass needle, was deflected by the flow of electricity in a nearby wire — the basis of today's electromagnetic world of motors, generators, and doorbells — Seebeck observed that, if the same magnetic needle is held near a circuit comprised of two different types of conductors, it will be deflected when this circuit is heated.

This is the basis of direct energy conversion by thermoelectric phenomenon. The heat produced the current in the circuit made of two types of conductors, and the electromagnetic field set up by the current moved the needle. Today, air conditioners, refrigerators, and automobile generators wear out and there are the whir and whine of motors and generators because Seebeck missed the boat completely, convinced as he was that he had discovered that magnetization could be produced by a difference in temperature. So adamant was he about this interpretation that he proposed theories about the earth's magnetic field based on the difference in temperature from pole to pole. He was so convincing that none of his contemporaries looked further into his discovery in search of the truth.

Thus, Seebeck's era was deprived of an electricity-producing device as efficient as steam engines of that day, and not until 50 years later was electricity produced by a steam-driven generator.

But Seebeck was not alone in misinterpreting significant breakthroughs. In 1834, a Frenchman by the name of Jean Charles Athanase Peltier passed a current through the junction of two different conductors, and one side of the circuit got



Six-stage RCA thermoelectric experiment achieved cooling of minus 135 degrees F. this year. Columns holding up plates are semiconductors.

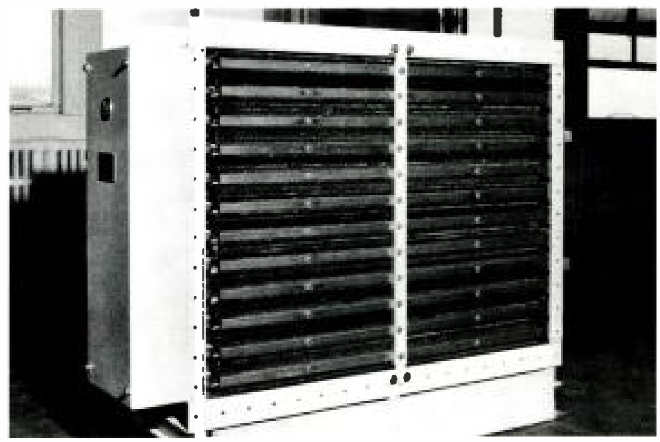
cooler and the other got warmer. This thermal phenomenon, which bears his name, he also misconstrued, thinking he had found an exception to Ohm's law. Four years later, Emil Lenz built a Peltier-effect circuit, placed a drop of water on it, and ran a current through it. The water froze. He reversed the current and the ice melted rapidly. But even Lenz, with such dramatic evidence of thermoelectric action, put the device on the shelf and forgot about it.

Why were all these scientists so confused, so misled by the results of their experiments? Probably because it took a new technology of "holes" and charge carriers, of "N" and "P" type materials — the domain of solid-state physics — to explain and utilize fully the phenomena that were occurring. Significantly, this era has begun only recently.

In addition, the thermoelectric effects obtained from today's semiconductors and semimetals are far more efficient than those of the metals used by Seebeck, Peltier, and their contemporaries.

To explain fully thermoelectric effects, scientists tell us we must delve into the mysteries of quantum theories, but for our purposes here we can simply state that, if we heat one end of a semiconductor, electrons will flow to the cold end. Conversely, if we run the electrons to one end of the semiconductor with an applied voltage, that end will attempt to acquire heat from its surroundings (turn cold), and the acquired heat will be transferred to the opposite end, which will, of course, become hot.

One more element needs to be added to this recipe for today's Peltier-effect thermoelectric action. The semiconductor described above is an "N,"



RCA nine-ton thermoelectric air conditioner for submarines is completely silent and is only a fraction of the size and weight of conventional units.

or negative type, wherein electron current flow is similar to that in metals. The compatriot of the N-type material is the "P," or positive type, semiconductor, whose energy transmission is accomplished by "holes" — or the places where electrons have been. This concept seems a bit confusing, but we are told these holes wander about in the transistors in our radios, computers, and other places where semiconductors are at work, and it appears we are obliged to accept them. In any event, the holes, essentially positive charges of the same but opposite value as the negatively charged electrons, when moved to the positive end of the semiconductor, acquire heat, or turn that end cold.

Now we can build a fairly efficient thermoelectric device. We put the negative end of the N-type bar- or ingot-shaped semiconductor against a piece of metal, and against the same metal plate we put the positive end of the P-type. Then, if we run a current, from a battery perhaps, through the N-type semiconductor, the bar, and back through the P-type, the plate will get cold. If we take away the heat transferred by the semiconductors from the plate to their opposite ends with water or by some other heat-exchanger action, we have the primary building unit of Peltier-effect thermoelectric cooling devices. Then, if we reverse the semiconductors, we get heat at the plate and we have Peltier-effect heating.

Of course, if we heat the metal plate and complete the circuit with wire and a load at the ends of the semiconductors, we obtain the opposite effect — direct energy conversion to electricity by Seebeck effect — because we will set up a current in the circuit.

With these basic elements — called thermoelectric pairs — we can make refrigerators, air conditioners, heating units, and electricity generators that, compared with present equipment, are more reliable, more compact, completely silent, precisely controllable, and that operate with no moving parts.

But where are these wondrous devices?

They are beginning to emerge from such laboratories as RCA's David Sarnoff Research Center, where, in 1954, the first known thermoelectric refrigerator, a one-cubic-foot affair, was built by scientist Nils Lindenblad. He followed this with a four-cubic-foot model in 1955, and, in the same year, built the first thermoelectrically air-conditioned room.

Organizations such as RCA's Applied Research are today applying these laboratory experiments to practical although specialized applications, some of which are even reaching the consumer. For instance, a large retail chain features a thermoelectric buffet bar that will cool food and drinks, and, with the flip of a switch that reverses the current through the semiconductors, will become a warmer to keep a turkey ready for the table.

However, because of the prohibitive cost for home use of this and other new technologies, practical consumer thermoelectric devices await mass production. RCA engineers explain that a basic, 17-pair thermoelectric module used in many of their applications costs today about $35. Approximately 100 of these would make a one-ton household air conditioner, and $3,500-plus is a little hard on the family coffers. However, they note that mass production would quickly lower this unit cost to $2 or less, and $200 for an air conditioner that probably would last a lifetime is a good investment.

Special applications of thermoelectric devices like the nine-ton submarine air conditioner that RCA built for the Navy, highly accurate thermocouples, coolers for biological specimens, and the pioneer snack bar are making inroads on production requirements. But according to RCA's Applied Research engineers, progress is slow and no production revolution is in sight. They are quick to point out, however, that an evolution toward thermoelectric devices for our heating, cooling, and power generation is definitely under way.

New concepts, for instance, are being explored to increase the efficiency and flexibility of the technology. In the laboratory, experiments with Ettinghousen effect — thermoelectric action from a single piece of material called a "semimetal" operated in a magnetic field — are producing encouraging results. The Applied Research organization, which has achieved cooling with Peltier effect down to minus 135 degrees F. and expects to reach minus 279 degrees F. by the end of the year by applying a magnetic field to cascaded Peltier pairs, plans to use Ettinghousen effect on top of this thermoelectric totem pole to reach a fully cryogenic minus 321 degrees F., the temperature of liquid nitrogen.

Application of thermoelectric techniques permits this buffet bar to keep food either warm or cold.

Everyone agrees that this old science with the bright new face will prove bountiful. Many envision the marriage of semiconductors and semimetals with the tremendous power of the sun's rays to turn all the earth's deserts into gardens. In any event, the technology Seebeck set in motion in 1821 now gains momentum, and its effect on our lives will be significant. ■

The Eastern Test Range: Laboratory for the Space Age

by Thomas Elliott

A 10,000-mile-long laboratory measures the heartbeat of the nation's spacecraft in flight.

On July 24, 1950, scientists in a plyboard blockhouse on isolated Cape Kennedy, Fla., prepared to fire a two-stage rocket consisting of a captured World War II German V-2 linked to an Army WAC-Corporal. The rocket's service gantry was a converted construction scaffold. The primary missile range safety facility was a heaped mound of dirt behind which all hands were expected to leap in case of an explosion.

Despite such makeshift support equipment, the Bumper rocket, as it was called, performed superbly. It rose above the Cape, arched into the cloud-flecked Florida sky, and followed its planned course before splashing into the ocean to usher the nation into the space age.

The test area, then known as the Long Range Proving Ground, extended 100 miles out into the Atlantic. Today, in contrast, the Range, now designated the Air Force Eastern Test Range (ETR), is a 10,000-mile-long data acquisition and processing laboratory studded with instrumentation that can search the very heartbeat of the missiles and spacecraft flown over it.

The story of the growth of the ETR from its meager beginning is the story of the most important and ambitious endeavor ever undertaken by this nation — its venture into outer space. Since that historic day in 1950, more than 1,500 missiles and space boosters, ranging from air-breathing cruise vehicles to superpowerful Saturns, have been launched from the Cape. Six of these spacecraft have propelled human beings — the Mercury astronauts — into the heavens.

Most of the instrumentation that gathers data from systems tested on the ETR is spotted on a series of major land tracking stations that begin at the Cape, then string outward on small islands across the Caribbean Sea and south Atlantic Ocean, to terminate at Pretoria, South Africa. Beyond Pretoria, and also uprange where no land sites are available, ships and aircraft fill the gaps.

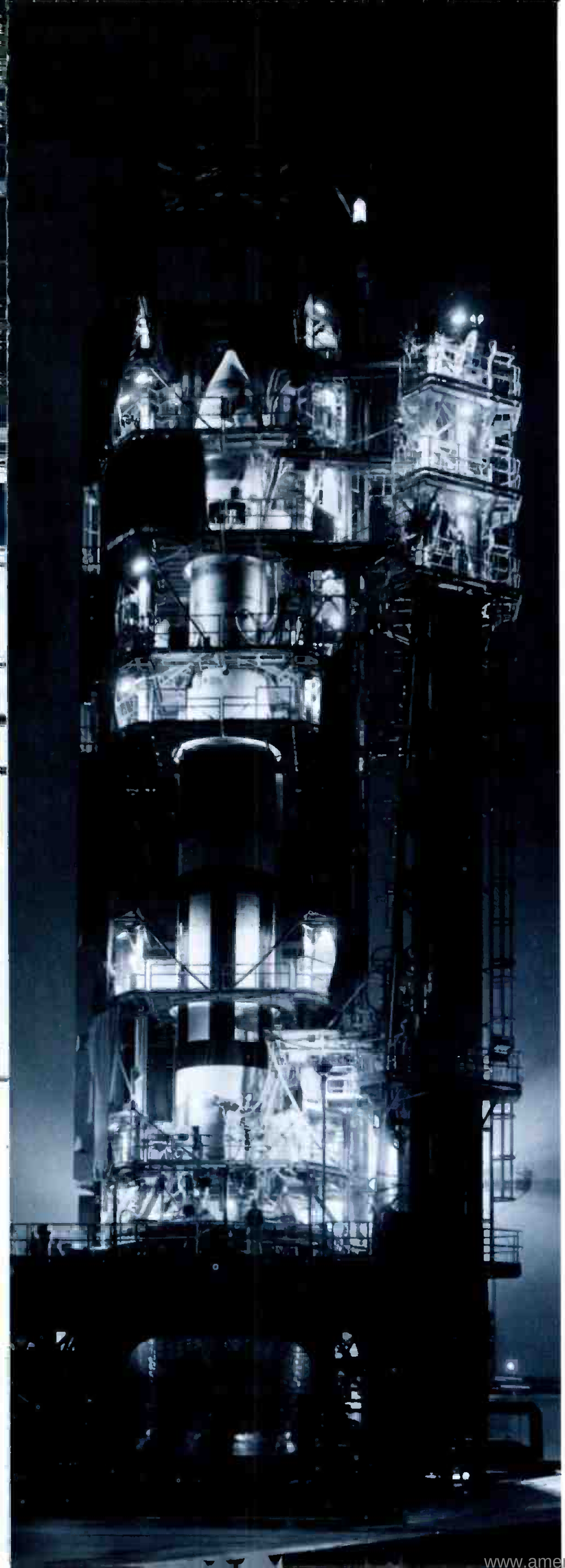
Management of these far-flung facilities is centered in the Air Force Eastern Test Range headquarters at Patrick Air Force Base, 15 miles south of Cape Kennedy. Since 1953, the RCA Service Company's Missile Test Project, working under subcontract to Range prime contractor Pan American World Airways, has been responsible for operation and maintenance of the ETR's information gathering, data processing, and communications systems.

So highly developed is the ETR's tracking technology that it can gather data sufficient to analyze completely the performance of the missile spacecraft being tested. This may require up to a quarter of a million individual readings on even a relatively brief ballistic mission of only 15 minutes.

Four general categories of instrumentation — pulse radar, continuous wave (CW) radar, telemetry, and optics — produce this volume of priceless information.

Like all ETR systems, pulse radars must fill new and more complex assignments almost daily. On the National Aeronautics and Space Administration's recent Project Fire test, for example, they had to train their pencil-like narrow beams on the craft, the fastest re-entering vehicle ever tracked on any U.S. missile range, as it blazed back into the atmosphere at 25,000 miles per hour.

Even more precise are the CW radars, some of which can measure velocity to within a fraction of a foot per second and position within less than a



foot of actual values. Four of these systems, each offering its own particular advantages, are utilized: UDOP (for UltraDOPpler), MISTRAM (for MISsile TRAjectory Measurement), GLOTRAC (for GLObal TRACking), and Azusa (for the California city of that name).

Although it represents only one type of system, telemetry accounts for some 80 per cent of all raw flight data gathered on the ETR. Hundreds of telemetry antennas of every size and shape dot the Range, ready to claim the information showered earthward by miniature radio transmitters that measure internal vehicle functions and return space environmental data.

With the acceleration of America's space exploration programs, telemetry is assuming an even more important role, and a $35-million project is now under way on the ETR to update 90 per cent of this equipment.

Perhaps the most fascinating of all ETR instrumentation is the optics systems. For example, the ballistic camera is so accurate that it is used to calibrate the other electronic and optical systems. It operates by photographing a vehicle-borne flashing light against a background of stars, enabling scientists to determine position with great precision.

Several other types of fixed and tracking cameras, one so powerful that it can photograph a bowling ball in a 100-mile-high orbit and another that can take up to 5,000 frames per second, are used on the ETR. On a typical mission, an average of 30 cameras is employed. They are especially important during early launch when "ground clutter" – signals that bounce off the ground to become confused with direct path signals – may interfere with electronic coverage.

Linking all the instrumentation systems situated on the Range's scattered stations is an extensive communications network. On Cape Kennedy alone, RCA maintains and operates a 5,500-line, 12,000-station telephone system – adequate to serve a city of 30,000 residents.

Snaking under the sea away from the Cape is a submarine cable, lifeline of the communications complex. With dropoffs at the major tracking sites, the subcable extends to the island of Antigua in the West Indies, providing high-speed transmission

A Titan ICBM prior to launch.

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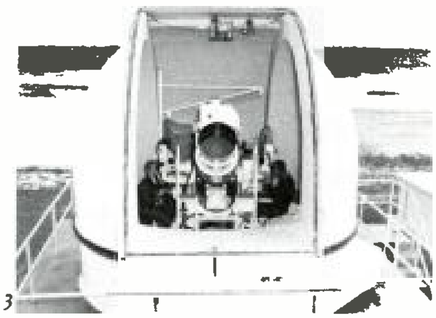

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(1) A Minuteman intercontinental ballistic missile streaks down the Eastern Test Range after launch from Cape Kennedy. (2) A Titan ICBM rises from its launch pad. (3) RCA technicians operate one of the ETR's powerful IGOR tracking cameras.

of tracking, timing, and teletype data as well as multiple voice channels. For the ship and land stations beyond Antigua, and also as a backup to the subcable, communications are maintained by an extremely reliable, high-power radio system.

Data gathered by these instrumentation systems must be reduced into usable form. This is the job of the huge RCA-operated data processing center at Patrick Air Force Base. Here, using programs created by RCA mathematicians and scientists, the ETR's vast bank of computers transforms raw data into meaningful answers.

A second major data processing center is located at Cape Kennedy. Able to process and display information within one-half second after it has been gathered, this real-time system plays a key role in the supremely important Range safety operation.

Taking inputs from the pulsed and CW radars, the computers provide a continuous track of the vehicle's position and predicted impact point, enabling Air Force Range safety officers sitting before their plotting boards in Central Control to monitor every step of the mission. If the missile wanders outside the limit of deviation, the officers can trigger the destruct mechanism so that the flaming debris will fall harmlessly into the sea.

Although many of the hurdles encountered during the infancy of America's space effort have been cleared, the ETR's greatest tasks still lie ahead as the trend toward fewer but more complex missions has emerged.

One of the new facilities that will enhance the ETR's ability to meet future requirements is called the Range Control Center. This three-story-high room, with its elaborate electronic systems and towering display boards, will allow engineers and scientists to control and view the status of individual instrumentation units supporting a mission from any point on the surface of the earth. When completed, the Range Control Center will move the ETR one step closer to the National Range Division's global range concept which will weld all of the NRD's instrumentation sites into a world-wide, integrated tracking network.

A host of major space programs aimed at accomplishing a wide variety of objectives are now under way. The first manned flight of NASA's dual-astronaut Gemini series, which will perfect techniques and conduct exploration necessary to land men on the moon, is scheduled for early 1965.

The Titan III has also begun its tests. By strapping two solid fuel boosters onto a Titan II, and adding a new and highly versatile third stage, the Air Force is creating an immensely powerful standard launch vehicle that will be used for a decade or more to power many different payloads, including manned craft, into space.

Another revolutionary Air Force program now proceeding on the ETR is Asset, termed "America's first space glider." After being launched into space, Asset actually flies and soars at hypersonic speeds, as contrasted to the "up and down" nature of a ballistic course.

Occupying much of the ETR's attention over the next few years, however, will be Project Apollo, aimed at meeting the national goal to land men on the lunar surface within this decade.

As these and other knowledge-seeking space programs are carried out, they will continue to press the Eastern Test Range ever further toward the fulfillment of its role as a laboratory for the space age—a destiny thrust upon it on that sunny July day in 1950 when the Bumper rocket made its historic debut. ■

"Fiddler" on the Record

by Tom Berman

The recording session of a Broadway musical can be a wearisome marathon—but not when Zero Mostel is there.

Tradition has it that Broadway show recording sessions end in complete exhaustion and that few persons other than the cast or recording personnel stay to the very end. To sit through 11 hours of takes and retakes is more than a filling diet of Broadway fare. But on September 27, the "Fiddler on the Roof" recording session ended in a defiance of tradition.

The RCA Victor recording session of "Fiddler on the Roof" was another marathon performance by the show's star, Zero Mostel. All eyes were fixed on him, waiting for a gesture, a slight movement, or an expression from those huge eyes that brings fits of laughter bordering on hysteria.

"If Sholem Aleichem had known Zero Mostel," wrote Howard Taubman in *The New York Times,* "he would have chosen him, one is sure, for Tevye. . . . He had a whole evening for Tevye, and Tevye for him. They were ordained to be one. . . . And in Mr. Mostel's Tevye, Broadway has one of the most glowing creations in the history of the musical theater."

Throughout the session, Zero's magnetism affected everyone. After the very haunting and reverent "Sabbath Prayer" was taped, a silence settled over the hall. Mostel paced the floor, looked up, made a sweeping arc with his hands, and finally shattered the quiet when he yelled, tongue in cheek, "I don't think we got the *fun* in the lines! Let's do it again!"

There was a never-ending barrage of picture taking by photographers from several major national magazines. At one point, Zero walked over to one of the cameras, put a towel over his head, and posed as an old-fashioned photographer.

Mostel recorded "If I Were a Rich Man" before breaking for dinner and sang it once. Composer Jerry Bock and lyricist Sheldon Harnick literally

At RCA Victor recording session of new Broadway musical "Fiddler on the Roof," Zero Mostel and Maria Karnilova join in singing the humorous, touching "Do You Love Me?"

stumbled over their feet as they rushed from the control room to Zero after the first take. Mostel was all but smothered from the ensuing hugs and embraces, and Harnick could be heard exclaiming, "Zee, you've never done it better! . . . Such feeling. . . . Gorgeous. . . . It can't be done better!" After the accolades and applause subsided, Zero looked up, raised his hand, made a nonchalant gesture, and said, beaming, "One-take Mostel. That's me."

During the session, George Marek, Vice President and General Manager of the RCA Victor Record Division and producer of the album, asked Mr. Harnick what it was like writing lyrics for Zero Mostel. "How do you write lyrics for a man who sings with his eyes?" quipped Harnick.

The play's message is stated in the opening number "Tradition." It serves to introduce Tevye, his family, and the townspeople, and reaches a climax when Tevye says, "Without tradition our life would be as shaky as a fiddler on the roof."

Tradition is the mainstay of Anatevka, an impoverished town in Tsarist Russia, populated largely by hard-working Jewish families. The story revolves around Tevye, the dairyman, and his five daughters. Three of them have reached the marriageable age, and as they marry, one by one, Tevye and his wife Golde find that the tradition that has governed their lives begins to break down.

As midnight approached, a quarter hour or so after the session was completed, the janitorial crew waited for the crowd of spectators to disperse and leave the hall. But like the townspeople of Anatevka, the crowd was reluctant to go. At least not until Zero Mostel made the first move to bring down the curtain on a brilliant day in the history of Broadway show recordings. ■

For the Records...

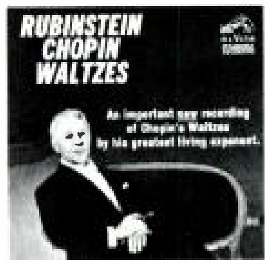
News of recent outstanding RCA Victor recordings.

BIZET: CARMEN: Leontyne Price, Soprano; Herbert Von Karajan, Musical Director (RCA Victor Soria Series LD/LDS-6164). Leontyne Price sings Carmen for the first time in this RCA Victor recording made in Vienna. The famous American soprano is co-starred with Franco Corelli as Don José, Robert Merrill as Escamillo, and Mirella Freni as Micaela. Herbert Von Karajan conducts the Vienna Philharmonic, the Vienna State Opera Chorus, and the Vienna Boys Choir. Included with the de luxe package are a 68-page book-libretto and a special 8-page color insert.

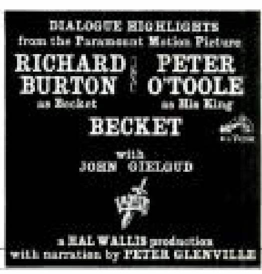
"THE KING AND I": Starring Risë Stevens and Darren McGavin (RCA Victor LOC/LSO-1092). Rodgers and Hammerstein's "The King and I," boasting a cast headed by Risë Stevens and Darren McGavin, was the Music Theater of Lincoln Center's first presentation. The critics gave it glowing reviews, and the audience responded enthusiastically. Until now, what "The King and I" audiences have generally agreed upon as the highlight of the show—"The Small House of Uncle Thomas"—has been reserved for them alone. Now, the number has been recorded for the first time on RCA Victor's original cast album. The orchestra and chorus are conducted by Franz Allers.

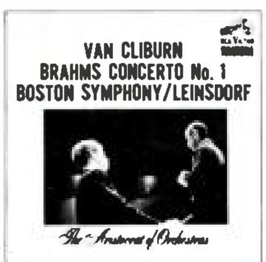
BALLADS, BLUES AND BOASTERS: Harry Belafonte (RCA Victor LPM/LSP-2953). An album of folk songs that encompasses a wide variety of emotions and moods. "Tone the Bell Easy," the opening selection, reaches a feverish intensity with ascending key changes and accelerations of tempo. Belafonte travels the blues route with "Blue Willow Moan" and then, steeped in the gospel tradition, he sings "Ananias." There are 11 songs in all. A chorus conducted by Howard A. Roberts and an instrumental section provide accompaniment.

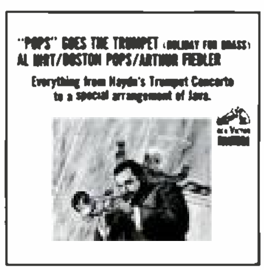
HEIFETZ – PIATIGORSKY CONCERTS, with Jacob Lateiner and Guests (RCA Victor LM/LSC-2770). For many years, Jascha Heifetz and Gregor Piatigorsky have enjoyed playing chamber music in the privacy of their homes, and were often joined by similarly enthusiastic colleagues. In August, 1961, they decided to share the music they most enjoyed at these informal gatherings with music lovers in surrounding communities and more recently in New York's Carnegie Hall. They founded the Heifetz – Piatigorsky Concerts, an intimate series dedicated to chamber music masterpieces. This recording, the fourth to be issued in the Heifetz – Piatigorsky series, is the first to be issued in Dynagroove sound. The contrasting repertoire includes Beethoven's *Piano Trio, Op. 1, No. 1;* the premiere recording of Miklós Rózsa's *Tema con Variazioni;* and the Haydn *Divertimento for Cello and Orchestra.*



CHOPIN WALTZES: Artur Rubinstein, Pianist (RCA Victor LM/LSC-2726). Exactly 10 years ago, Artur Rubinstein recorded the Chopin waltzes for RCA Victor. The decision to re-record them brought with it a windfall of good luck. Through the help of a German publishing firm, Rubinstein obtained access to original manuscripts which made possible these interpretations of Chopin that have never before been recorded. Now, Chopin is heard in its purest form without the ill effects of editorial "fussing." The packaging of the album is de luxe and includes a 12-page insert that features a detailed analysis of the music by Herbert Weinstock, a biography and photographs of Rubinstein, and a complete Rubinstein discography.







Other current releases

Electronically Speaking

News of current developments briefly told.

MUSEUM PIECE

It is difficult to conceive of our ultramodern space age producing a museum piece, but that is exactly what happened last August when the National Aeronautics and Space Administration presented Relay III to the Smithsonian Institution in Washington, D.C.

Built as backup for the first two Relay satellites by RCA's Astro-Electronics Division, Relay III found no operational use because its two predecessors are so outstandingly successful.

Relay I, launched in December, 1962, has already traveled more than 200 million miles, is continuing in orbit, and is still operational. Relay II, launched in January, 1964, is also performing to fullest expectations. Thus, NASA officials decided there was no need to send another Relay satellite into space. This made it possible to put Relay III on display at the Smithsonian and to give the general public a close-up view of one of the most reliable of all space vehicles.

LASER HOLES

There is a story, perhaps apocryphal, that concerns the rivalry between two aircraft companies in the late 1940s. A package arrived one day addressed to the machine shop foreman of aircraft company A. It contained a stand over which was set a magnifying glass. Under the glass stretched an almost invisible metal wire, the proud achievement of company B. A few days later company A returned the package, with a tiny hole drilled neatly through the center of the wire.

Twenty years ago that feat may have been considered quite an accomplishment. But not today. Recently, RCA's Aerospace Systems Division succeeded in drilling microscopic holes in tungsten wire as small as one ten-thousandth of an inch in diameter. The holes were punched by the concentrated light from a ruby laser.

This latest application for the laser could lead to extremely compact and fast microenergy memory units for computers. The key to achieving these qualities lies in drilling holes very close to each other in magnetic wire. The smaller the holes, the closer together they can be drilled.

Metal drills, even a hundredth of an inch in diameter, are too big, very slow, and can't get through tungsten. Electron beams need a vacuum to do the job and take several seconds, with resulting danger of heat injury to the metal. Laser beams, on the other hand, go through in a millionth of a second – so fast that the surrounding metal never gets a chance to heat up.

STREAMLINING THE SCHOOL SYSTEM

The rapidly rising school population in the United States has created a flood of paper work that threatens to overwhelm administrators. This situation is being eased in Florida's 1,900 public schools, thanks to an RCA computer system recently installed by the state's Department of Education.

Electronic data processing helps the department put together necessary reports and comparison charts within days rather than the months required to do the job manually. Built around an RCA 301 computer, the system employs two RCA 3488 random access memory units with a total storage capacity of more than a half-billion characters.

The computers keep track of just how well each school is performing its function, whether teachers are meeting standards of the state of Florida, and evaluate how students are progressing. The system is especially helpful in guiding students who plan to go to college. Counselors use periodic tests and computer-produced reports to help students improve their grades by advising them of their weak points.

SUPER RELIABILITY

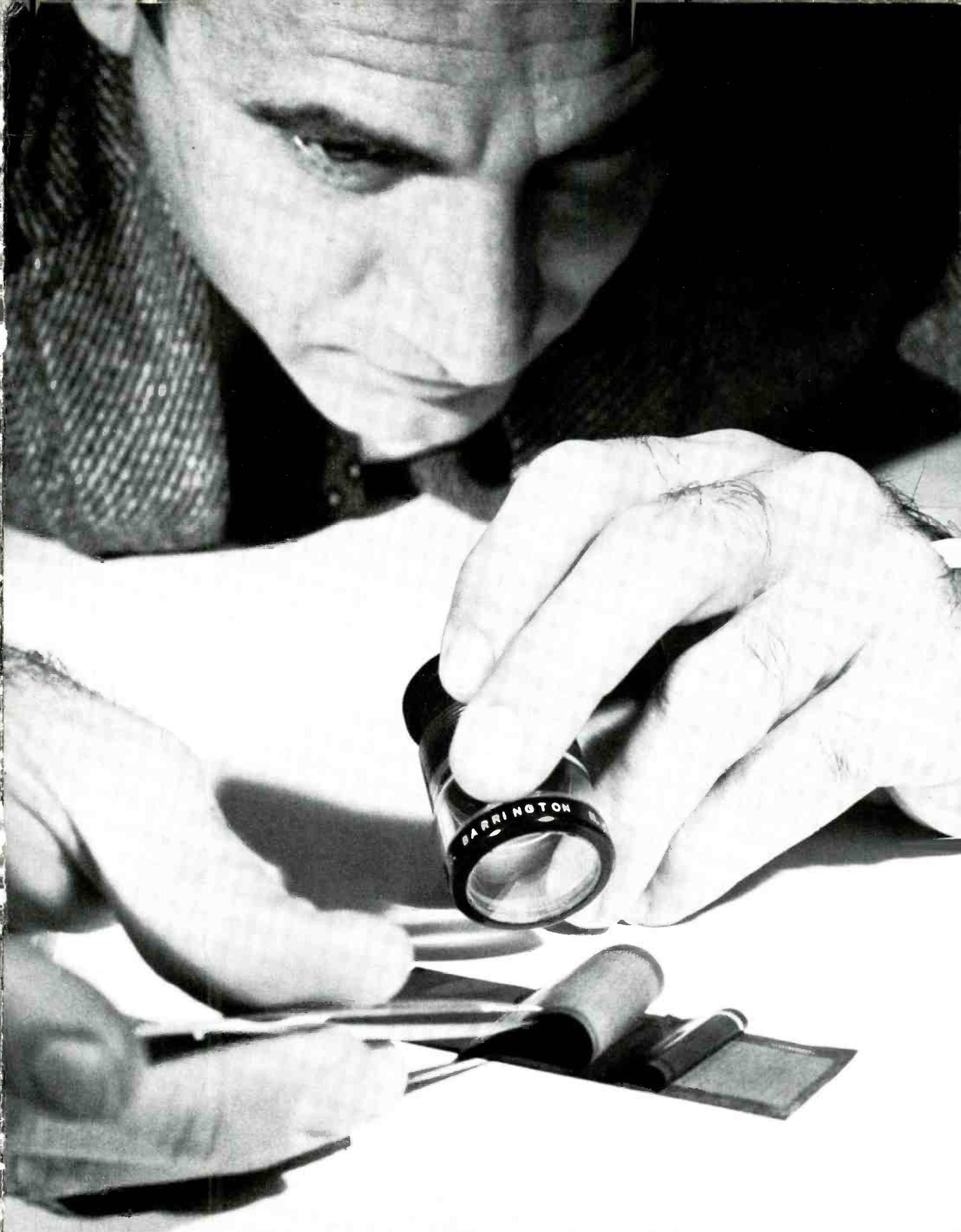
Unusually long failure-free life spans for transistorized electronic equipment have been predicted by RCA engineers on the basis of the equivalent of over 100,000 life years of reliability test data recorded on more than 2,225,000 RCA 404M Minuteman transistors.

During the testing of these super-reliable transistors, not more than one unit in 100,000 failed during 1,000 hours of continuous operation.

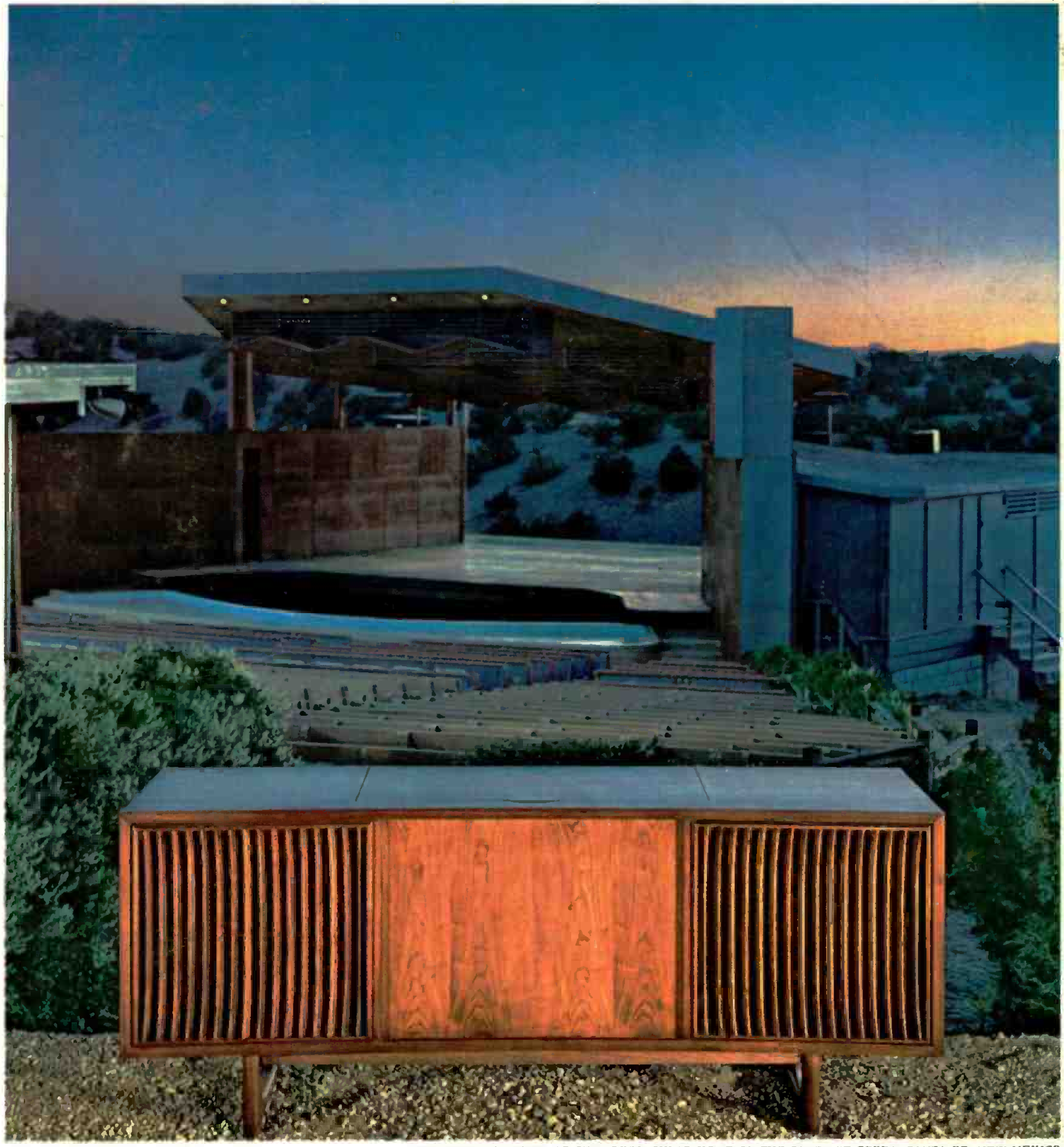
Under severe mechanical and shock tests, only five out of the 2,225,000 transistors failed to operate.

These results reflect one of the most stringent quality improvement and reliability design programs ever devised and hold out the promise of trouble-free performance in many other types of transistorized electronic equipment.

Dr. Rabah Shahbender of RCA Laboratories inspects thin ferrite sheets that will become a computer memory when laminated and cured. Sets of 128 parallel metal strips embedded in the top and bottom sheets are placed at right angles to each other across the middle sheet. Information is stored or retrieved at the points where the lines cross. A total of 16,384 bits of information can be stored in a total volume 3 inches square and .005 inch thick. →


BARRINGTON

SEE WALT DISNEY'S "WONDERFUL WORLD OF COLOR," SUNDAYS, NBC-TV NETWORK



THE MARK II SHOWN AT THE SPECTACULAR HOME OF THE SANTA FE OPERA, SANTA FE, NEW MEXICO

RCA Victor Stereo...realism that rivals the concert hall

For "at home" concerts that rival the original, choose RCA Victor Solid State stereo. The sweeping six-foot symmetry of the *Mark II* embodies an impressive array of audiophile treasures, including the precision Studiomatic Changer with Feather Action Tone Arm (inset above). This famous changer offers amazing protection for your records.

The new Solid State tuner and amplifier are the most powerful ever built by RCA Victor: 300 watts of peak power (150 watts EIA) drive a sumptuous 8-speaker sound system for startling realism. Solid State means tubes have been replaced by transistors. This makes for less heat, longer component life and crisp, clear sound. Solid State FM-AM and FM Stereo radio, too.

It's made by RCA Victor—people who know quality and know how to produce it. Before you buy *any* phonograph, compare RCA Victor's experience in sound reproduction, dating back to the earliest days of the famous "Victrola"® phonograph. Remember, more people own RCA Victor phonographs than *any* other kind. Discover new RCA Victor Solid State stereo for yourself—see it at your dealer's now.

"HIS MASTER'S VOICE"

RCA The Most Trusted Name in Sound

Tmk(s)®