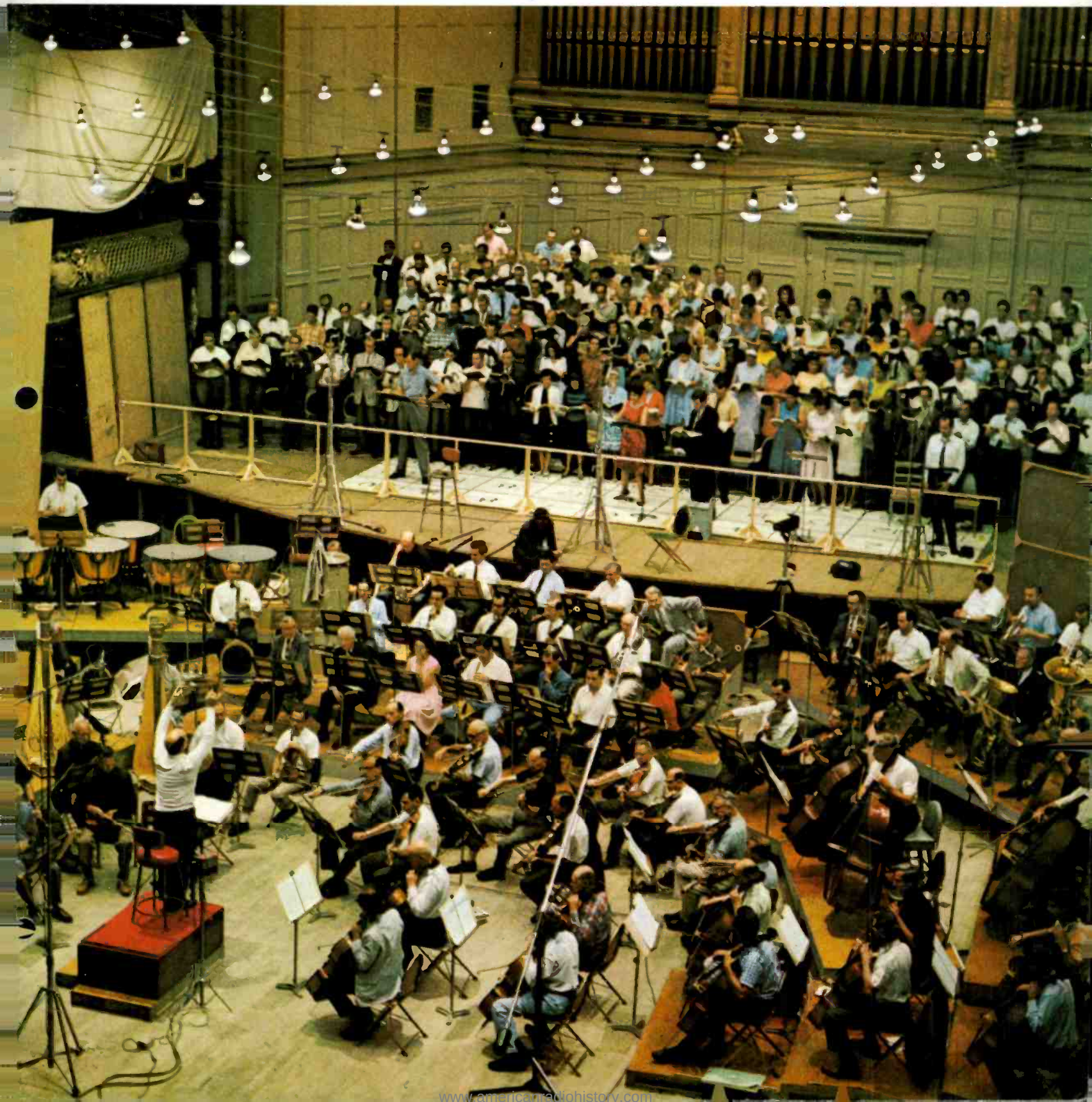
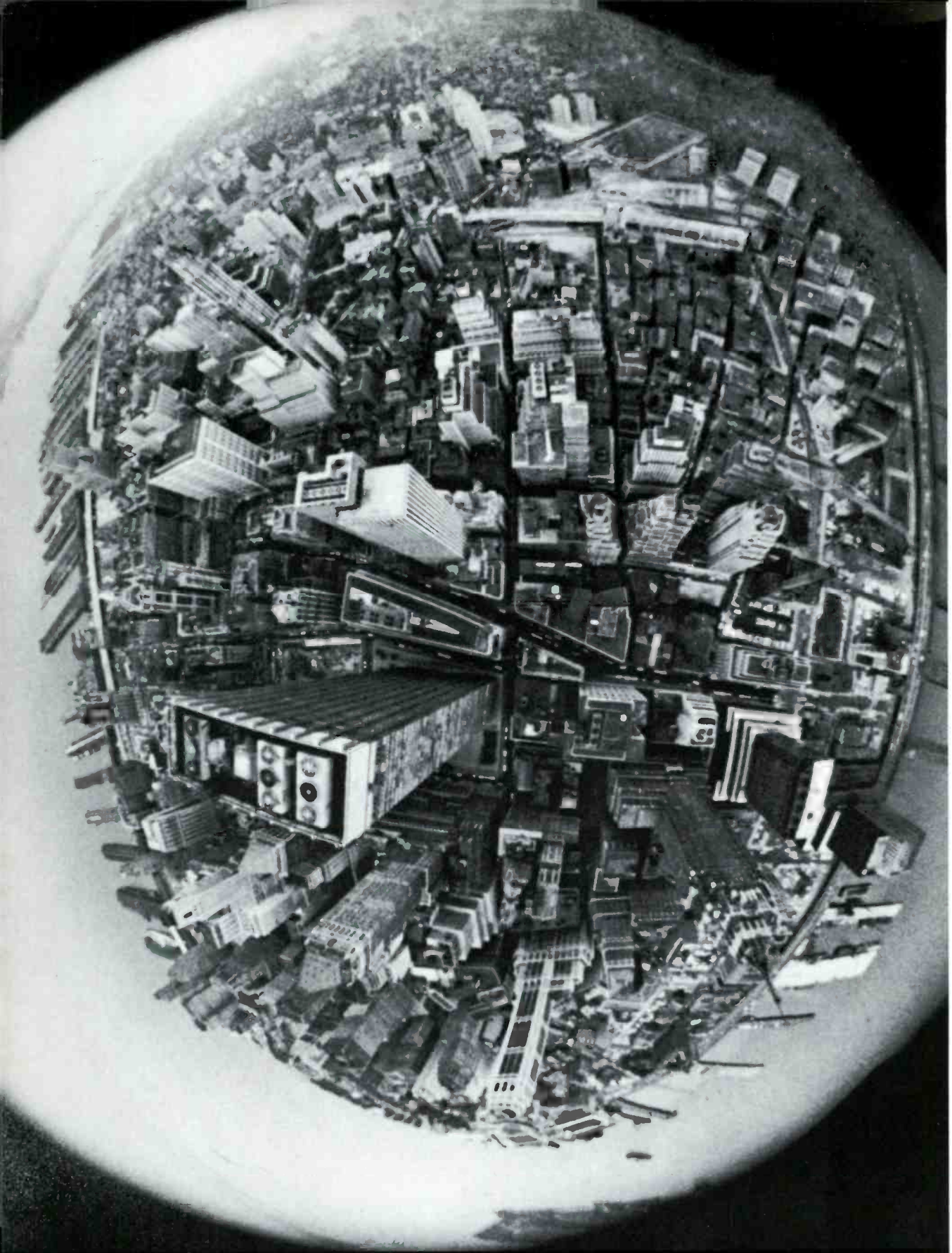
ELECTRONIC AGE

RCA

Autumn 1965

The Boston Symphony Orchestra recording "Lohengrin" for RCA Victor





"Fisheye" camera lens view of New York's downtown financial district. To cope with the flood of paperwork that daily threatens to inundate them, businesses have turned to the computer. The Chase Manhattan Bank, for example, at 1 Chase Manhattan Plaza (largest structure in left foreground), employs 21 RCA computer systems to help process 2.5 million checks a day and to handle routine banking operations.

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Cover: At Symphony Hall in Boston, Erich Leinsdorf conducts as the Boston Symphony Orchestra records "Lohengrin" for RCA Victor. "Lohengrin" is the first major opera to be recorded in the United States in several years and the first Wagnerian opera ever recorded in this country. For more about this noteworthy musical event, *turn to page 6.*

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Vol. 24/No. 4 Autumn 1965

Chart reflects rapid growth of tape recorder sales in the United States.

In home entertainment, outer space, and defense, magnetic tape recording is swiftly growing in popularity and use.

by David Lachenbruch

During World War II, Allied intelligence was puzzled by what appeared to be an amazing new German psychological warfare weapon. American and British radio monitors were picking up speeches of Adolf Hitler broadcast with lifelike clarity at the same time that there was proof he was somewhere else doing something else.

The voice was unmistakably Hitler's; the broadcasts were unmistakably of "live" quality. The intelligence officials came to the only possible conclusion — that German science had developed a recording system far superior to any previous type. They were correct, and this was the first known practical use of modern magnetic recording. It is from this "secret weapon" that all of today's tape recorders — from the simple $10 toy to the most sophisticated space satellite recording device — are descended.

Today, less than 25 years after the Germans unleashed their secret weapon, it is almost impossible to imagine modern life without magnetic recording. Computers, data processing, and sophisticated business machines depend on it. Without it, much of our program of space exploration could not have been attempted. Virtually every man, woman, and child in America encounters magnetic recording daily in home entertainment and information media — including live-quality television programs recorded on video tape, radio programs on audio tape, and modern phonograph records that have their origin in tape recordings carefully transferred to master disks.

Basically, magnetic recording is a highly efficient method of storing electrical impulses. These impulses can represent sounds, pictures, computer data, or conditions encountered in space — in short, any intelligence that can be converted into electrical terms.

To the average layman, a tape recorder is an extremely versatile machine that he will buy "some day," but which he does not own now. Nearly 100 different brands of home tape recorders are on the American market, varying in price from $10 to more than $1,000. The average consumer, while expressing an increasing interest in tape, is hopelessly confused. He is waiting to be told — and sold.

The very versatility of the modern recorder is one of its problems. It can be many things to many people. It is often thought of as a novelty, a source of family fun that lets people hear themselves in impromptu recording sessions. It is also a "snapshot album in sound," a collection of such important aural mementos as baby's first words and Junior's graduation ceremonies. It can supply a sound track for slides or home movies. It is the most personal of person-to-person correspondence, in the form of the "tape letter." It is a valuable learning-aid in the study of languages, speech, and music. As a fine musical instrument, it is a rival to the best phonograph.

And yet, the home recorder has failed to fulfill its potential. The proliferation of makes and models, from toys to professional-type machines, has created confusion in the mind of the consumer. Quality recorders too often seem so complex that even the average retailer — let alone the consumer — has been scared away. The toy machines, which fill a need for scientifically minded youngsters, have added to the confusion, causing some adults to feel that the tape recorder is an unreliable squawk-box that has not been perfected.

Lack of consumer exposure to home recorders has been at least partly responsible for these misconceptions. To date, tape machines have largely been retailed through

The Versatile Tape Recorder

audio dealers who specialize in component-type high-fidelity equipment, large camera stores that are accustomed to dealing with hobbyists and enthusiasts, and toy and novelty shops in the case of the low-priced "toy" recorders. The mass-marketing appliance dealer — who has largely been responsible for huge volume sales of television and the modern packaged phonograph — has not participated in tape recorder sales to any appreciable extent.

It is against this background that RCA Victor has introduced a complete line of popularly priced home tape recorders, with the avowed intention of placing this instrument on an equal footing with television, radio, and the phonograph as an electronic instrument for every home.

For this task of "mass-marketizing" the tape recorder, RCA is drawing on a unique background in the magnetic recording field. The following are a few of the company's recent military, space, and industrial accomplishments in tape recording: It built the telemetry recorders used in the Gemini space capsule, capable of four hours' recording time on two channels, in a tiny 12-pound package. It has developed a nine-channel recorder, for highly accurate operation in space for as long as 12 months, for NASA's Orbiting Geophysical Observatory program. Also for the government, it designed a giant recorder, holding up to seven miles of tape, running at more than 60 miles per hour, for detailed radar analysis of the characteristics of ballistic devices.

In the broadcast field, RCA's sound recording and playback equipment is installed in hundreds of radio stations across the nation. It has supplied more than 1,000 television recording and playback machines — both color and monochrome — to TV networks, stations, and producing companies. Its latest professional video and audio recorders employ solid-state circuitry throughout.

The RCA Victor Record Division manufactures raw magnetic tape for home, commercial, and defense applications and is producing prerecorded taped music albums in open-reel format and in two types of stereo cartridges for both home and automobile music systems.

RCA Victor recognized the mass-market potential of home tape recorders as early as 1959, when it set out to overcome one of the major drawbacks of home tape machines — the difficulty and complexity of handling open-reel tape. It introduced a line of recorders designed to accommodate a special tape cartridge that was virtually as simple to play as a phonograph record.

Although RCA then had no open-reel recorders in its line, the open-reel type continued to co-exist with, and overshadow, the RCA-type cartridge and other magazine-loading concepts introduced by other manufacturers. RCA, like most other manufacturers, had a limited line of recorders suited for special purposes, and made no attempt at real coverage of the recorder market.

For years, total industry sales of recorders hovered around 500,000 units annually, including toys. Sales began to move upward in the early 1960s, and in 1964 American consumers bought approximately 3 million recorders. Despite this increased interest, fewer than 10 per cent of all U.S. households own tape recorders today.

Even though recorder sales were in the start of what looked like a healthy rise, there was no predominant leader in the industry sparking an all-out drive keyed to the versatility of this instrument for the average family. No major manufacturer had ever offered a complete line of popularly

priced units backed by a really strong campaign to stimulate substantial dealer and consumer interest.

In an analysis of the tape recorder field, RCA determined that about 50 per cent of the sales are currently in the $50-and-up bracket, the remainder in the toy category. Of the non-toy half of the market, approximately 60 per cent of sales were represented by $50-to-$100 models, 40 per cent by the more-than-$100 class.

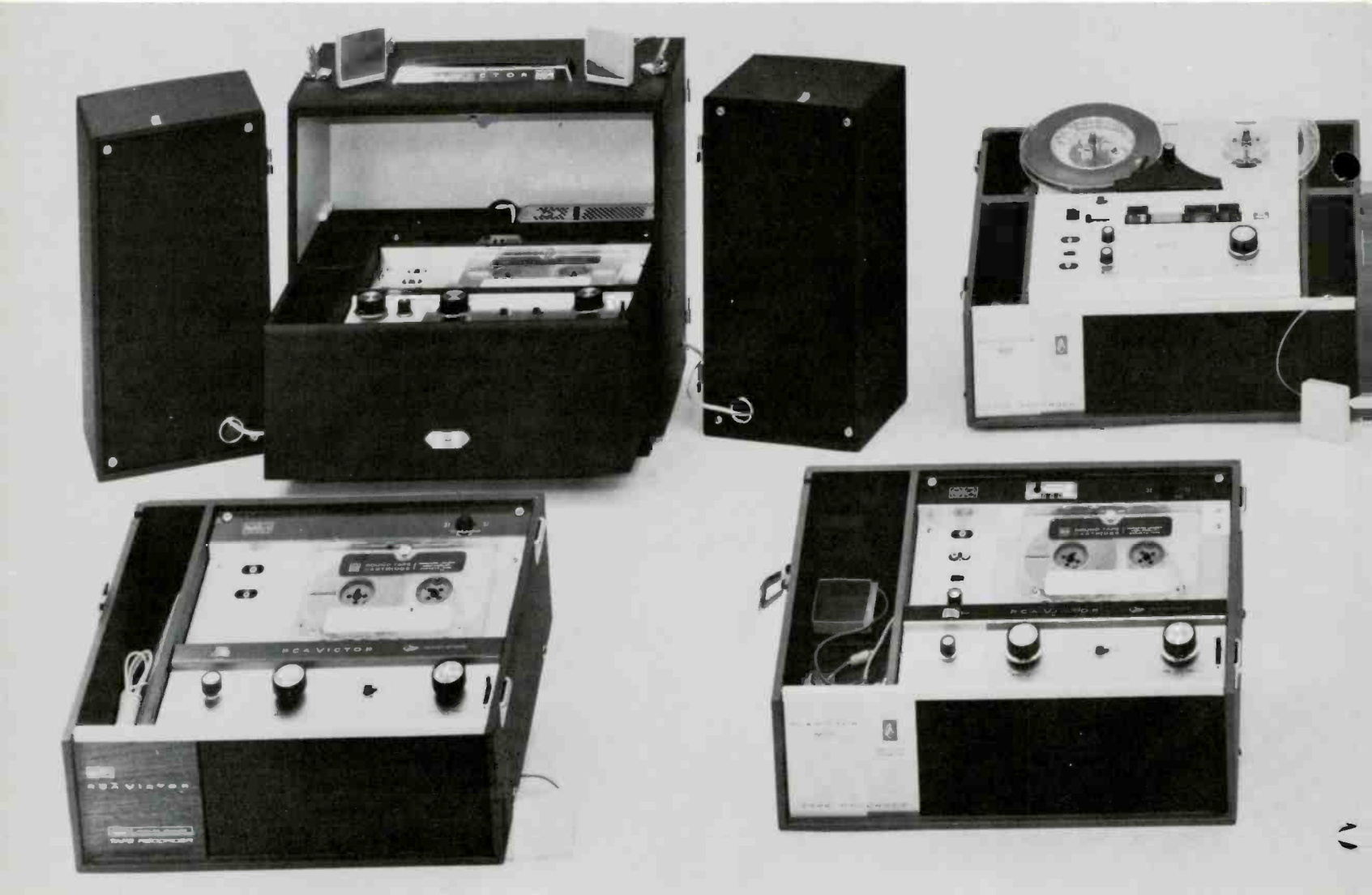
The company's new nine-model line of recorders was designed to cover all popular brackets above the toy category. Although cartridge units are featured (with a redesigned see-through cartridge), RCA is aiming for the first time at complete market coverage, including open-reel types.

The line starts with two battery-operated portables at $49.95 and about $65 — an increasingly popular price range, which is expected to account for industry-wide sales of about a million units this year. The remainder of the line is priced from $99.95 to $199.95, carefully calculated to cover every popular type, including tape-deck attachments designed to play through stereo consoles or modular sound systems. To an industry observer, one striking feature of the middle-of-the-line portables is their "phonograph-design" format, including the use of drop-down styling that has contributed so greatly to the popularity of stereo phonographs.

The phonograph analogy does not appear to be accidental. In introducing the new line, B. S. Durant, president of RCA Sales Corporation, predicted that recorder sales "could eventually equal the present strength of the stereo phonograph market." He forecast total industry-wide recorder sales this year at about 4 million units, rising to 4.5 million in 1966, and possibly going as high as 9 million by 1970.

A complete and well-designed line is only the first step in popularizing the tape recorder. The entire concept must be sold, first to the dealer and then to the public. RCA's market strategy is to back the product with the most com-

Complete line of RCA Victor 1966 model solid-state consumer tape recorders.



plete distribution and promotional programs ever undertaken in the field.

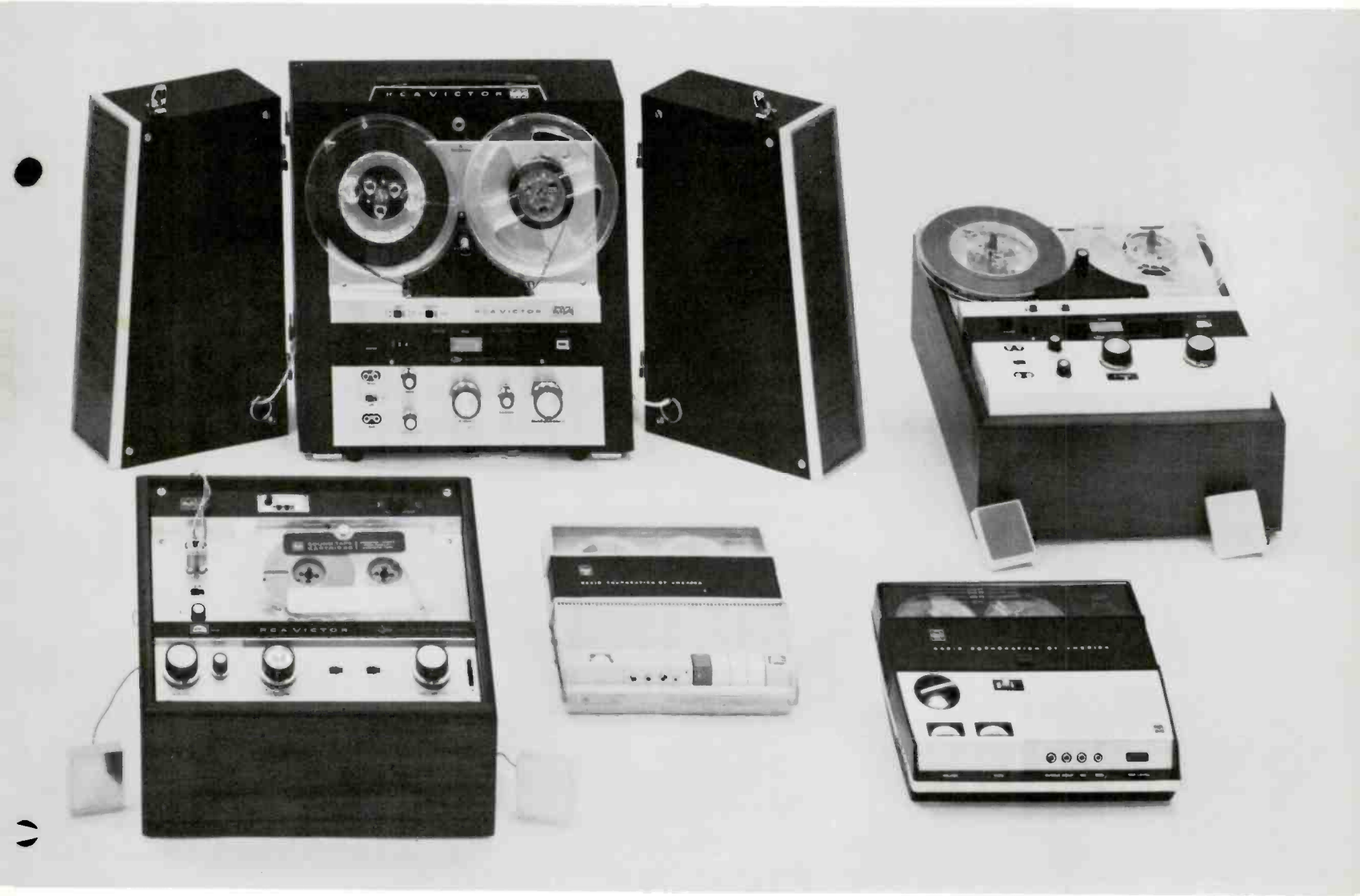
The recorders are scheduled to be merchandised by RCA Victor dealers, many of whom have never been in the tape recorder business. To simplify their entry into this untapped market, the company is making available some imaginative merchandising and promotional aids, including "instant-demonstration" display centers that can help prove to the public — and the dealer — just how simple and adaptable today's tape recorder actually is.

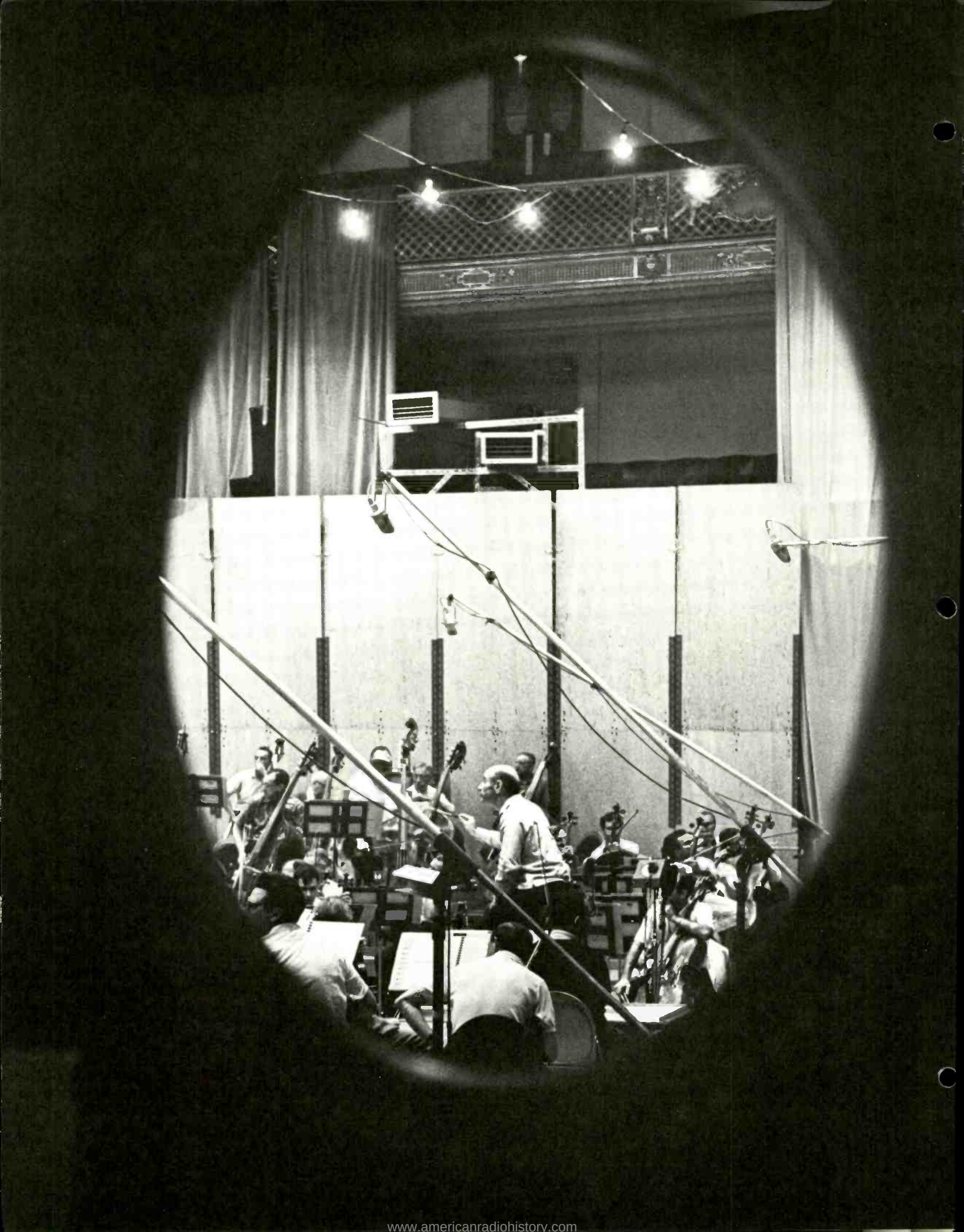
Perhaps the most significant part of the program is the budgeting of an unprecedented $1 million for advertising and sales promotion during the September–December period when one-half of the total annual recorder sales normally are made. The magnitude of this campaign — which will use network TV, magazines, and newspapers — becomes apparent when it is pointed out that industry-wide sales of tape recorders last year totaled only $100 million. This saturation ad campaign has already been hailed by rival manufacturers as a major step in accustoming the public to the concept of the tape recorder itself.

RCA's total commitment to the recorder as the fourth major electronic instrument for the home — after television, radio, and the phonograph — has interesting connotations for the future. Home taping today is an aural medium, but already the imagination of the public is being stirred by the arrival of relatively high-priced "home video recorders" which record picture as well as sound.

More than 10 years ago, RCA demonstrated a developmental version of what some day may be a moderately priced home color video tape recorder. There has been considerable industry speculation that the company, in seeking to build an identity as a leader in home tape recorders, may be preparing for the day when this status complements its leadership in the field of television.

Tape has come a long way from its start as a secret weapon. Nevertheless, its versatility and appeal as a mass-market home instrument have been kept secret too long. ■





The Recording of an Opera

Behind the scenes with the Boston Symphony Orchestra during the recording of "Lohengrin."

by Mary Campbell

Soprano Lucine Amara and tenor Sandor Konya.

For nearly an entire week last August, Symphony Hall in Boston looked as though some bustling housewife had decided to clean the closets in her house, had put everything out all over the floor, and left it just like that.

The lobby was an untidy grove of potted artificial trees with white blooms, a few statues such as found around small pools, and superfluous maroon doors leaning on the walls, each marked for its proper place by a stuck-on piece of paper — "Mass Ave Side Center Door Left Side."

Hallways were no better. Head-high fans turned the side halls into hot-air tunnels, and thick cables snaked along the floor. Inside the refined, elegant hall, tall plyboard strips rested on the floor and leaned against the first balcony, forming makeshift side walls. A huge, red, faded dropcloth hung from the back of the balcony, and another dropcloth covered a stage full of empty folding chairs. Seats in the orchestra section were missing all the way back to Row X.

But in that space of missing seats from Row X forward sat the Boston Symphony, in shirtsleeves, with their conductor Erich Leinsdorf facing them on a podium. Across the front of the stage, facing two microphones, stood four soloists from the Metropolitan Opera — a soprano with a heldentenor and a mezzo-soprano with a baritone.

In the midst of apparent chaos and a few onlookers in the balcony, these artists knew exactly what they were doing and, ignoring their surroundings, they were expertly going about doing it. They were recording the full, uncut "Lohengrin," the first major opera to be recorded in America in several years (how many years depends on which of several modern operas recorded here are considered of major importance) and the first Wagnerian opera ever recorded in this country.

Herman D. Kenin, president of the American Federation of Musicians, found the occasion so auspicious that he came from Chicago on one of the six days of recording to listen. He made a brief speech congratulating RCA Victor and the participants on the undertaking, saying that he hoped the general argument for recording operas in Europe instead of America — that orchestral musicians are paid less in Europe — will be refuted by sales of made-in-America "Lohengrin."

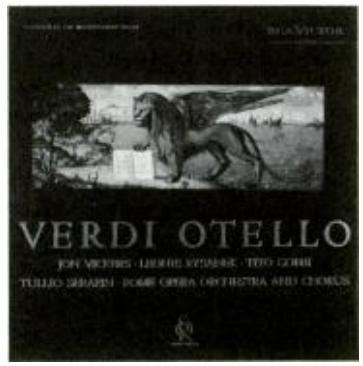
Soprano Lucine Amara and tenor Sandor Konya, both with feet astride and firmly planted, stood facing a microphone at stage left — she with outstretched arms gracefully waving in time to the music, fingers crossed on both hands, and he with right hand pumping up and down, right hand in a fist, knit shirt pulled up to midchest, revealing an expanse of undershirt. Although they stood side by side, they never looked at each other; they were completely intent on singing the opera's first love duet by Elsa and Lohengrin.

In the opera, beautiful, blonde Elsa is accused, on a riverbank, before a king, of having murdered her brother. Lohengrin, in silver armor, riding a boat pulled by a swan, arrives to say that he will fight Elsa's accuser, thus proving her innocent. And he will marry her — if she will trust him completely and never ask his name or origin. She promises, but soon after the marriage ceremony is enticed to ask the forbidden questions. Lohengrin then reveals that he is a knight of the Grail, who now must leave her, and the swan is her brother, who had been put under a spell.

Recording an opera, like shooting a movie, is not done from beginning to end. "Lohengrin," whose three acts are divided into 11 scenes, was recorded by scene. Three hours

Erich Leinsdorf and some members of the Boston Symphony Orchestra.

RCA Victor, long the leader in the field of classical music, offers one of the industry's most impressive lists of opera recordings. Displayed here are some of the notable opera albums RCA Victor has released.



in the afternoon and three in the evening were scheduled, Monday through Saturday — 36 hours of recording for a 3-hour-and-45-minute opera.

When Miss Amara and Konya finish their duet, baritone William Dooley, as Elsa's accuser, Telramund, and mezzo Rita Gorr, as Ortrud, his wife, who later gets Elsa into trouble, begin to sing. They face a mike at stage right, since, on a stage at that moment, the two couples would not be near each other. On the stereo record, their voices will come from separate speakers. Jerome Hines also will be heard on the recording, as the king, and Calvin Marsh, as the king's herald.

The scene finished, conductor Leinsdorf settles back on the high red leather chair on his red felt-topped podium and turns to a little box on a tripod at his right side. The red light on the box goes out, indicating that sounds in Symphony Hall are no longer being recorded. Leinsdorf picks up a telephone, also on the box, to talk with Richard Mohr, RCA Victor's producer for the "Lohengrin" recording, whose background in opera record production extends back to work with Toscanini. Mohr and Leinsdorf's musical assistant Andrew Raeburn have been sitting in the control room, simultaneously listening, poring over orchestral scores, conferring and making notes on the score to indicate why and how a certain passage has to be rerecorded.

Mohr says that measure 48A should be "a little softer in the harp part," and Leinsdorf tells the harpists they'll "play it with one harp instead of two." He also tells one instrumentalist that his "B flat is a little high in the fourth bar of 48B." They all get set to do it again, from the measure in the score marked "47" to the end of the scene.

However, it is clear that, over-all, "Lohengrin" is not being conducted by committee. Leinsdorf is definitely in charge. Once, stopping the music to correct a singer's tempo for the second time, he says, "I know you are singing it at the traditional tempo, but that is not what I consider the right tempo, and we are going to do it over until we get it the way I say."

Only a linguist, however, could understand all of the Vienna-born conductor's statements. He speaks to Miss Amara and Dooley, both Californians, in English. She answers in English, and Dooley, who has done most of his singing for the past eight years in Germany, answers in German. Leinsdorf speaks to Konya, who is Hungarian, in German, and Konya answers in English. He speaks to Miss Gorr, who is Belgian, sometimes in German and sometimes in French, and she answers in French.

The soloists talk to each other in English, except Miss Gorr and Dooley, who converse in French. Leinsdorf is apt to speak a few words of Italian to his orchestra, chide them with "Now you know you don't understand German" when they laugh at one of Dooley's remarks, and make himself the butt of his own joke when his heavily accented English is misunderstood and the orchestra starts playing in the wrong place in the score. He says, "Thirty-eight . . . thirty-eight. I'm going to take diction lessons, I promise you, probably from Shakespeare in the park."

Finally, Leinsdorf calls a 20-minute break and everybody scatters. Leinsdorf and soloists climb to the back upstairs room, which serves as the control room, to listen to

Listening to playback are (left to right) Sandor Konya, Lucine Amara, producer Richard Mohr, and musical director Erich Leinsdorf and his musical assistant, Andrew Raeburn. Dynagroove expert Jack Pfeiffer is in background.

the playback. There, amid piles of boxes of vinyl tape reels, two technicians operate tape machines, recording on 30-inch-per-second tape. A roll lasts 15 minutes. Most scenes to be recorded run longer than that, so the second man starts his machine before the first has completely filled his tape.

An engineer has been sitting at a large console watching pointers on dials that indicate the sound level at each microphone and turning knobs to regulate the sound levels and to mix or not mix sound for stereo separation.

During the playback, Leinsdorf makes suggestions to the soloists. He tells Miss Amara that she sang a part of the score too passionately. When Richard Woitach, assistant conductor of the Metropolitan Opera, in Boston to help with the recording by conducting off-stage musicians and coaching Miss Amara on her part, walks into the room, she explains, "I sang this too dark; I must sing it more maidenly."

Before they go out to rehearse the lines, less passionately, with a piano, Miss Amara and Konya pose for photographers. "Don't be afraid to hold her," Miss Amara's manager tells Konya. And somebody makes a pun, "What do you want him to be? A holdentenor?"

At break time, orchestra members might go to one of three rooms — a large one behind the stage for tuning up and practicing, a hall-like space half a flight down where concertmaster Joseph Silverstein could be found with his violin resting against his lap and chest while he reached around it to play cards, and a basement room where a waitress dispensed coffee and doughnuts. The basement is otherwise stacked with instrument cases and boxes for traveling and a metal cabinet plastered with the sign, "Happy Birthday, Beethoven."

Also during the breaks, 14 air-conditioning units are turned on to combat the late summer heat. These had been thrust, seven on each side, into doorjambs on the first balcony after the doors had been labeled and removed. The units could not operate during the recording because of noise of the motors but during breaks they ran at top speed, complete with hoses to drain condensed humidity into buckets in the halls and with powerful fans to blow the hot air down the corridors, away from the stage end and toward the back of the hall. The temperature in one of the business offices opening off a balcony hall registered 106 degrees F. one afternoon during a recording break.

Concertmaster Silverstein remembers a scientific test conducted one season on the Boston Symphony which indicated that the orchestra's sound is best in an atmosphere of between 71 and 78 degrees F. Above 78, metal instruments tend to go sharp, and, when humidity accompanies the heat, stringed instruments go flat.

Conscious of the optimum temperature, orchestra members kept a thermometer with them all during the recording. Sessions usually lasted 40 minutes, with a 20-minute rest every hour, but during one 80-minute-straight session, which was followed by a 40-minute break, they noted a temperature increase from 68 to 83 degrees F. in the hall.

The 104 members of the orchestra were augmented for the recording by 25 additional musicians, most of them performing as off-stage instruments. These people, of course, could not see Leinsdorf's conducting, so a TV camera set up behind the French-horn players automatically photographed him. Closed-circuit TV sets were watched by two "tower trumpets" on folding chairs in the nearly dark left hall, and two "vassal trumpets" in the right hall upstairs.

Beyond a door at the left rear of the stage sat two flutists and two oboists. When it is almost time for them to play, conductor Woitach quietly opens the door — Symphony Hall acoustics are so good they will be heard as

off-stage instruments without the use of a mike — and himself facing Leinsdorf on the TV monitor, he conducts his four men. Their part over, he cautiously shuts the door to the stage. As he starts up a back stairway to listen from the control room, one of the oboists forlornly calls, "Keep in touch."

Woitach's conducting was designed to solve one of the problems of recording — the time lag of sound. If off-stage musicians simply had followed Leinsdorf's beat, by the time their sound had traveled through the door onto the stage and then across the stage to the microphones, they would have sounded hopelessly behind. As it was, Woitach had to figure out how to conduct ahead of Leinsdorf, so that off-stage sound would arrive precisely at the correct time.

The relatively slow speed of sound also was a big problem facing the Chorus Pro Musica of Boston, which sang the choral parts of the opera. Soloists' scenes were scheduled for the 2 to 5 P.M. sessions, and all scenes requiring chorus were scheduled for 7 to 10 P.M., since the Chorus Pro Musica is a semiprofessional group whose members are employed as everything from typists to radiologists during the daytime.

As the chorus — which has recorded and has sung the Verdi "Requiem" with the Boston Symphony and has sung premieres of Britten's "War Requiem" in Tanglewood, Boston, and New York — stands on the stage and sings, it is some 75 feet from Leinsdorf and 30 feet behind the orchestra. When its sound arrives late, Leinsdorf stops the chorus for immediate retakes.

While the chorus sings the last 10 minutes of Act I, chorus director Alfred Nash Patterson explains that the normally 120-voice group was increased — by diligently advertising and screening 460 persons — to 180. They not only had to be able to sing, practice, and study German with Irmgard Zeitler nightly since April but they also had to be able to spend the week before the recording week at Tanglewood, where the same people making the record performed "Lohengrin" an act at a time for three nights.

The schedule set up for the week of recording was maintained, as chorus and orchestra strived mightily to perform without errors, and soloists remained in remarkably good voice all through the week.

Miss Amara also seemed to be in constant good spirits, charming some girls in the chorus during a break with an animated description of a pair of slacks, asking Mrs. Konya at a playback whether her enunciation was all right, admitting that not only does she sing with her fingers crossed but she listens to her own recordings the same way, brightly explaining to Dooley why she has never sung the part of Elsa before. "I'm not that gullible, why should I sing the role of such a gullible person?"

She asks Leinsdorf after one scene has been recorded whether she can try it again from No. 55. Leinsdorf replies, "I didn't like to ask you, but I'd be delighted." Then to the orchestra, "I don't want to tire her out, she is so brave. Everybody watch it."

Dooley, currently in his third season at the Met, is singing Telramund for the first time and also participating in his first opera recording. Telramund, he says, is still too heavy a role for him at 31, and he does not intend to sing it on stage for several more years. "Recording is a new discipline and type of work for me," he says, "more difficult than the stage. It is almost humanly impossible to sing six hours a day. But I'm enjoying it very much. I'm delighted working with Mr. Leinsdorf. He is a great inspiration and a powerhouse of energy."

Miss Gorr, who has recorded many times and who most likes to sing in the operas of Wagner and Verdi, also considers recording more difficult than singing opera on stage. "This is more difficult, much more. It makes me very nervous. You haven't the warmth of the public; the atmosphere is not the same. I've sung Ortrud many times on the stage, including the Met, Bayreuth, and Covent Garden. It helps to have sung it before." Miss Gorr prefers the afternoon sessions, when she is more rested and her voice is clearer.

Konya has sung the title role of "Lohengrin" 202 times, including this recording, many of those performances with Miss Gorr in the cast. He would rather sing at night, when his voice has warmed up.

One of the most noted and in-demand Wagnerian tenors in the world, Konya arranged during the week for his car to be driven from the port of New York to San Francisco where he would need it during his September-through-November appearances with the San Francisco Opera, before he returned to the Met for the opera season. During the summer, the Konyas and car had been on a busy schedule in Europe, with performances and recordings scheduled in several countries.

"Wieland Wagner [the composer's grandson] is calling me the world's champion in 'Lohengrin,' " he says. Konya was hired by Wieland Wagner to sing "Lohengrin" in Bayreuth and gave six performances each summer during 1958, 1959, and 1960. He made his debut in the same role at the Met in 1961, but his American debut had been the year before, in San Francisco, in "The Girl of the Golden West." He recalls, "A critic wrote, 'Konya was a big success but he didn't walk like a cowboy.'

"I think it is magnificently organized here," Konya continues. He pauses for a moment, reflects, and then comments: "In recording, a singer must concentrate more. Everything has to be perfect, and the finest little notes have to be projected."

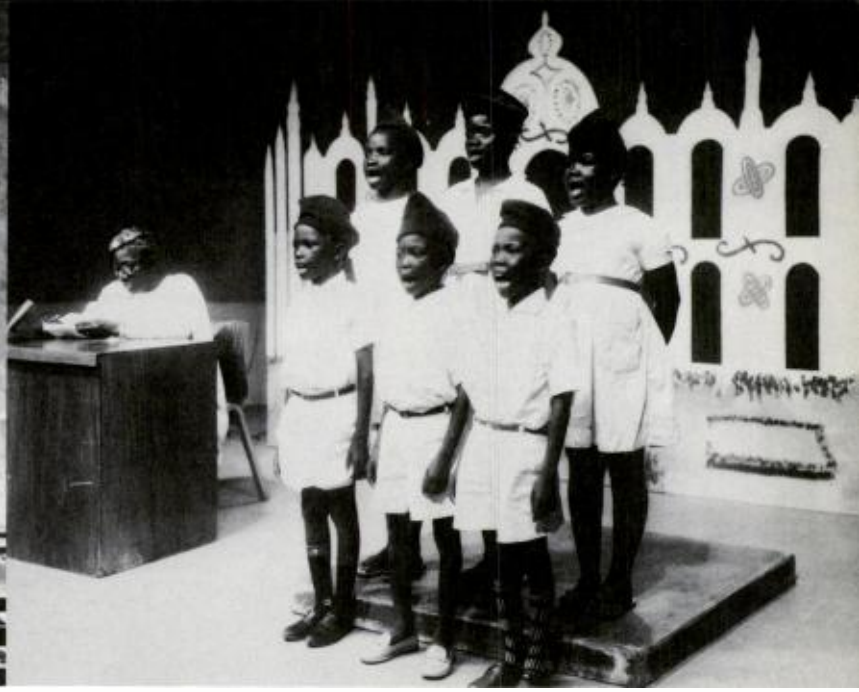
Plans for the American recording of "Lohengrin" have been under way for two years. Maestro Leinsdorf says, "To get a good cast together for two weeks is not the easiest thing in the world. There are very few casts that can be got together in 1965 for 1966."

As for the opera's release to the public, that will not be until March of 1966 at the earliest and probably not until the early fall of that year.

"Lohengrin" is uncut, including a portion that was restored in Bayreuth in 1936 and 1937 but never performed in this country. Leinsdorf says, "That has always been the principle of my recording with RCA, that portions never done in performance are included, making a complete record in two senses of the word.

"Our major intent," the conductor explains, "is to do the work as I think it stands in all its romantic grandeur. My concept is a real romantic fairy tale and, as such, I'm hoping that the recording will come out." ■

Filming a scene for the NBC documentary "The Kremlin."



Schoolchildren on program broadcast by Nigerian Television Service in Lagos.

NBC Around the World

Expanding worldwide activities range from spot news reporting to coverage-in-depth documentaries.

by Bert Schwartz

In generations past, schoolboys were reminded by their geography teachers that the sun never set on the British Empire. Today, that is an equally valid statement if it refers to the widely diversified activities of the National Broadcasting Company in all parts of the world.

During the waning weeks of the past summer, it was recorded that (1) producer Ted Yates had representatives in the Congo to plan an NBC television news special soon to be filmed there, (2) the network's news bureau in Saigon had been powered to a new efficiency level by the addition of several seasoned correspondents and cameramen, (3) producer George Vicas was filming another special, "The Spanish Armada," in England and northern Italy, and (4) NBC International was building, from the ground up, a modern television network in Saudi Arabia.

These are but a sampling of the network's rapidly expanding overseas activities. The network concept of radio transmission that NBC introduced in 1926, mainly to provide an improved quality of programming within our borders, has since burgeoned into a worldwide communications complex.

No single impetus or motivation seems adequate to explain this unprecedented expansion. There are many interrelated factors — the need to be represented by competent newsmen and facilities wherever and whenever newsworthy events take place; the network's ambitious program of specials, or documentaries, calling for a minimum of 50 during the current season; and the commitment to provide technological and management support for the inauguration of television broadcasting in underdeveloped countries.

Probably the most dramatic growth in overseas activity has been occasioned by the increased programming of special, full-hour documentaries, most of them in color. The number of such productions has been mounting consistently each year; 40 appeared during the calendar year 1963 and 44 in 1964. The minimum of 50 specials anticipated during the present calendar year, many believe, will be surpassed, and these do not include "instant" specials covering unforeseen news breaks.

Although many of these specials are "in depth" studies of political or social trends here in America, an increasing number are concerned with subjects that demand filming

abroad. Producer George Vicas' four-part series, "Of Men and Freedom," required the use of production crews in France for "The French Revolution"; in England, France, and Italy for "The Middle Ages"; and in additional countries for "The Spanish Armada" and "The Reformation."

Seven-league boots and passports are standard equipment for Ted Yates, one of NBC News most prolific architects of special programs. In addition to the rigors of foreign travel, an assignment from Yates is also likely to involve hazards above and beyond the call of duty. Few excursions to Paris or Cannes are to be found on Yates' production schedules, which usually turn out to be more similar to battle plans than to travel itineraries.

Vietcong snipers' bullets were part of the vivid background for those filming "Vietnam: It's a Mad War," and Yates' crew could not tell the friends from the enemies while filming "Santo Domingo: War Among Friends." During the action in the latter sector, a cameraman filming from a rooftop was almost dropped off the NBC roster by a U.S. soldier in a helicopter. Camera tripods, it was later explained, with appropriate apologies, bear a resemblance to machine-gun tripods when viewed from a distance vertically.

To produce one of last year's most provocative specials, the network's attention was turned to the boondocks of Guatemala. The program was "The Science of Spying," which former NBC News correspondent John Chancellor characterized as an exposure of espionage techniques accenting the dagger rather than the cloak.

But, as associate producer Bob Rogers discovered, the dagger hardly presented as lethal a threat as a live hand grenade gripped meaningfully by Communist guerrillas in a Guatemalan jungle. Rogers' unenviable assignment was to interview Communist chieftain Yon Sossa, a confrontation that was most difficult to arrange. During the interview, Yon Sossa's businesslike bodyguards each gripped hand grenades, with the pins pulled out for instant rebuttal.

The pen may be mightier than the sword — or the grenade — but, in NBC's peaceful peregrinations into distant regions, other secret weapons have proved to be useful. Not the least of these is the power of feminine persuasion.

Producer Lucy Jarvis demonstrated this admirably, not once but twice. First, as associate producer of "The Kremlin," she badgered and cajoled Soviet officials into allowing NBC cameras to enter the Russian citadel. The proud defenders of French culture were equally vulnerable to Miss Jarvis' wiles. They permitted her to roll television cameras into the Louvre, breaking precedent but damaging none of that ancient museum's priceless art treasures.

As this is written, an NBC News production crew plans to penetrate 3,000 miles into Siberia later this year to film a full-hour special program in color on the city of Irkutsk. Formal agreement permitting the documentary was signed in Moscow last July by George Bolshakov, television chief of APN, a Soviet news agency, and George Vicas, head of NBC News European Production Unit.

The product of this agreement, which establishes a new relationship with Soviet television executives, will be the special program "Twenty-Four Hours in a Siberian City," which will require three to four weeks of filming in the city of Irkutsk.

The most notable NBC News project of the current year was "American White Paper," the three-and-a-half-hour special tracing the growth of America's role in world affairs since World War II. Occupying the entire broadcast evening on September 7, from 7:30 to 11 P.M., EDT, the production required months of filming by three unit producers abroad, in Europe, the Near East, Africa, Asia, and Latin America. In addition to Chet Huntley and David Brinkley, who provided special commentary, the special had 16 NBC News correspondents reporting from strategic points around the world.

Although NBC News builds more and more documentaries to probe the critical issues that influence our daily lives, the hard core of this unit's activity is its coverage of spot news developments wherever they may occur. It is a gargantuan responsibility, weighted with imponderables and constantly confronted with world situations that are largely unpredictable. To maintain its primacy in the area of electronic communications, this vast, worldwide news organization employs more than 800 full-time personnel.

Thus far in the current year, the Vietnam conflict has been one of the top news stories, and to cover it completely NBC News has increased its complement of reporters, cameramen, and news bureau assistants to 22, the largest concentration of newsmen it has had in any foreign country since World War II. But social unrest, breaking out into overt violence or military action, has required instant coverage in many parts of the world, including, most recently, the Dominican Republic, the Pakistan-India fighting in Kashmir, the dispute between China and India, and the conflict between Greece and Turkey in Cyprus.

"The Huntley-Brinkley Report" — up to late September — had covered the Vietnam situation extensively, with 106 segments, on 140 broadcasts, devoted to the topic. NBC News four daytime reports to its television audience have compiled about 400 segments. In addition, the News Program Service to affiliated television stations has supplied 91 stories on Vietnam to 78 stations. NBC News has received approximately 112,000 feet of black-and-white film and 20,000 feet of color film on the events in Vietnam since January 1.

In the business of global hard news coverage, the operational procedures governing the management of news bureaus around the world are dictated by the need for speed and accuracy. Here the key word is "mobility."

NBC maintains 16 news-gathering centers in foreign countries, perhaps inadequately called news bureaus. These include not only such basic news centers as London, Paris, and Rome, but also Saigon, Karachi, New Delhi, Santo Domingo, Athens, and Nairobi. All are well staffed, but the thing to remember is that the traditional concept of a news bureau, as a group of working press inflexibly confined to one location, is now obsolete in terms of TV reporting. Virtually all of NBC News correspondents, cameramen, and soundmen assigned to overseas bureaus can be moved to other areas in a matter of hours if the news scene shifts. Very frequently, they are.

Dean Brelis, a correspondent nominally assigned to London, regards this city as merely his home base; he lives out of a suitcase. Correspondent Jack Perkins was recently

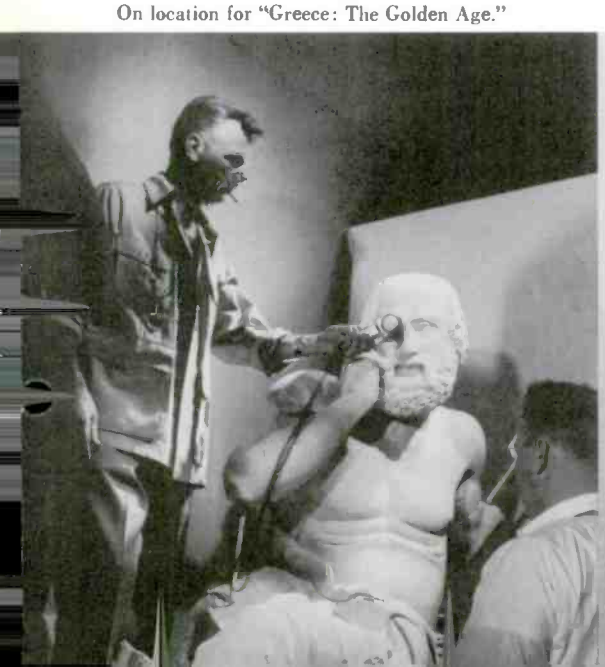
Production crew prepares to film painting for "The Louvre" show.

Volcano in Costa Rica is photographed for "Inter-American Highway."

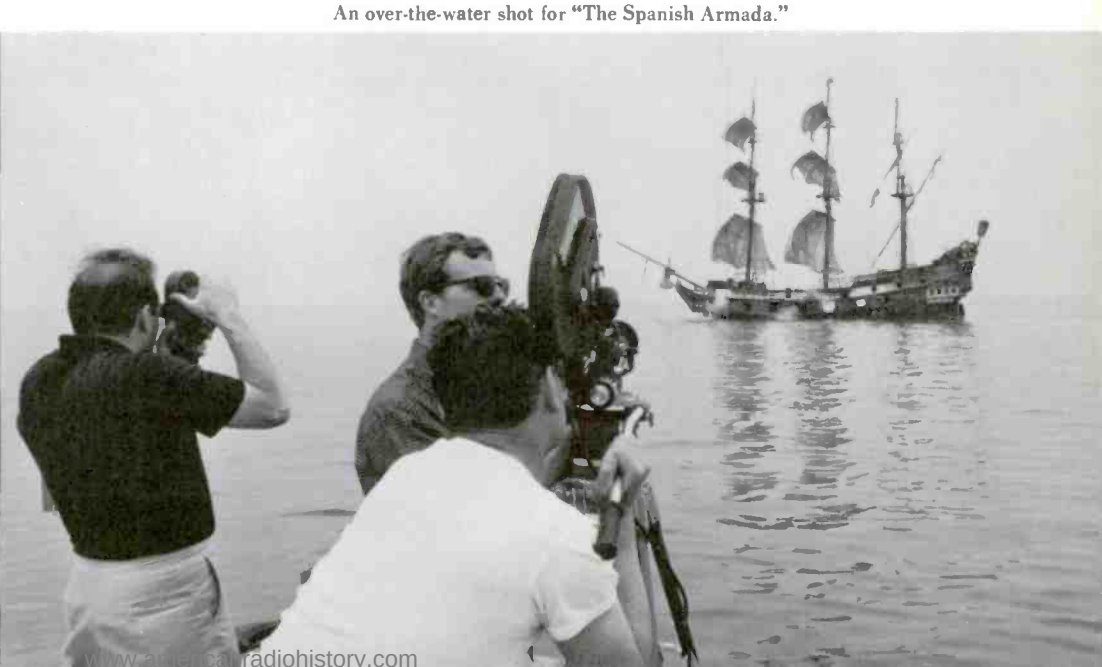
NBC News covers the war in Vietnam.

Extras hold weapons in scene for "The French Revolution."

On location for "Greece: The Golden Age."



An over-the-water shot for "The Spanish Armada."



Filming Hadrian's Temple in Athens for "Walk Beside Me."

Camera ready to film Venice for "The Middle Ages."

NBC News in Berlin.

dispatched from the Hong Kong bureau to Saigon, and Frank Donghi, a news coordinator, was flown from Santo Domingo to Saigon last June. You Young Sang, regarded as one of television's most dependable combat cameramen, calls Seoul his home base, but he is apt to be hauled off to some distant sector at any time for instant news coverage.

This reliance on mobility is made possible, of course, by the speed of modern air transportation. The jet plane has become a standard mode of travel for the overseas correspondent. From Madrid to Karachi is routine commutation, and he can be in flight as soon as he has packed his toothbrush and color film, unless airline schedules slow him down.

Major industries, by and large, have been utilizing the skills of natives of the locales in which they establish offices and manufacturing centers. This became accepted practice not only because it has helped the firms' community public relations but because it also opens the doors to new creative ideas and techniques.

This is no less true of broadcasting practices overseas. As clearly indicated by the roster of NBC News cameramen around the world, many gifted artisans in their native lands have been making useful contributions to foreign news coverage.

Besides You Young Sang, we hear about the excellent camera work under fire of such unfamiliar names as Hoang Xuan Yen and Hoang Trong Nghia in Saigon, Eddie Tan in Hong Kong, and Lym Youn Choul in Korea. The list grows constantly, and it results in enriching the quality and style as well as the accuracy of the network's worldwide coverage.

NBC International Enterprises — a highly diversified organization concerned, among other things, with encouraging the development of television, artistically and technically, throughout the world — is currently involved in the most ambitious program it has ever launched. It is working with the government of Saudi Arabia to provide that country with a multistation television network. The first two stations are located in Jidda and Riyadh. Eventually, it is planned to link each station in the country by microwave relay.

In Nigeria, with the inauguration of NTS (Nigerian Television Service), the capital city of Lagos has been provided with a station that broadcasts 40 hours each week. NBC International has placed a staff of technicians and personnel in that country with experience in programming, administration, and sales. They will continue to work there over a period of about five years, until native technicians can master the intricacies of broadcasting.

At the latest count, NBC International reports some form of association with more than 300 stations in 80 countries. Its services are predicated on the realistic view that communications is one of the most compelling needs in emerging nations, which have no adequate systems of roads, railways, or, in most cases, telephone service.

Advanced science and technology have forged the tools to promote international understanding and support the cause of peace. But — as Addison once noted — "To communicate to the world such things as are worth their observation," NBC has not neglected to add the human values of imagination and creative effort in its hourly contacts with the world around us. ■

The Challenging Game of Operations Research

By presenting "the likely consequences of any choice in a reasonably clear and precise manner," operations research helps management make difficult decisions.

by John Ott

Shakespeare's "Hamlet" has been described as the story of a man who can't make up his mind. Throughout the play, he is presented with so many alternatives, each with its own set of consequences, that he is torn with anxiety, almost totally incapable of reaching a decision.

Although Hamlet's situation and subsequent solution may have been unique, the problem he faced was not. The process of making a decision has always been an agonizing one and, throughout history, those willing to accept the responsibility for making important decisions have been held with respect, even a degree of awe.

Information, in one form or another, has usually been considered essential. If one could only get the relevant facts, or so the reasoning went, one could make a sensible decision based upon experience. And so, the emphasis in the decision-making process is more and more upon the collection and analysis of significant data and a reliance upon the lessons of past performance. This has generally worked out pretty well, provided the consequences of an error were not disastrous.

There is the widely quoted remark that a man who makes the right decision 51 per cent of the time is a good executive. Today, this rule of thumb no longer applies.

It does not apply in our economy where a combination of more analytic management and keener competition will no longer support such a marginal ratio. It does not apply in government where the consequences of even a slight error in the planning and implementation of a major domestic program may result in the waste of millions of dollars and the misuse of precious national human resources. It certainly does not apply to our vast national defense complex where there is a shrinking tolerance for any miscalculation in the deployment of nuclear capabilities.

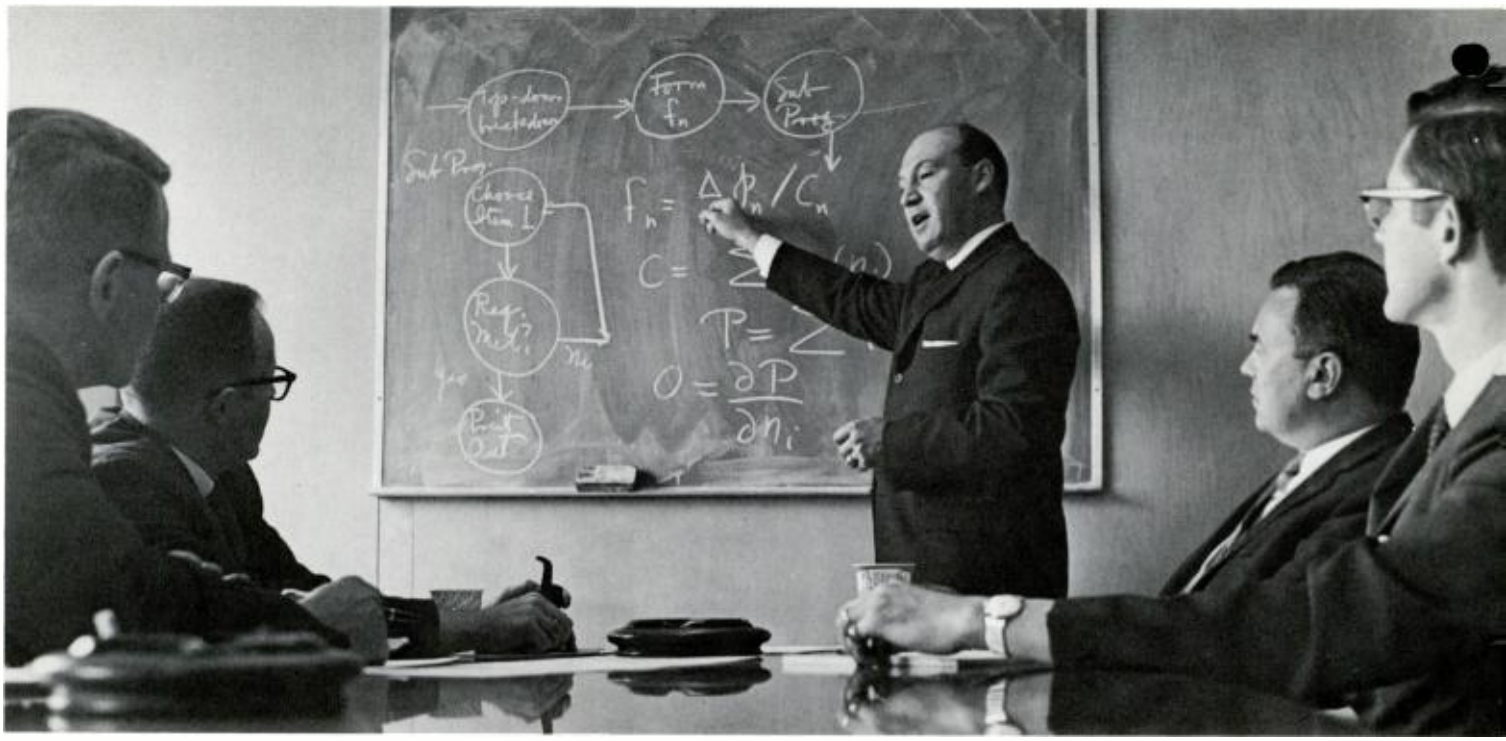
With the consequences of faulty judgment as grave as they are in business, in government, in the management of our military establishment, there is an urgent need to fashion techniques designed to reduce the risk of error in the decision-making process. Experience, intuition, and even the most painstaking staff support are simply not enough for those who manage today's complex society. They need more efficient analytic tools to help them evaluate judgment situations.

Fortunately, these tools and the techniques to go with them are being developed by a relatively small and uncommon breed of specialists who work in a discipline known as operations research.

O.R. men, as they call themselves, are not strictly advisers or management consultants attempting to uncover the absolute best solution to a problem. An Oriental potentate, on the other hand, sitting in a council of state surrounded by his viziers, did exactly that. The evidence of factual information was weighed against experience, and recommendations were made for a particular decision. The decision was expected to be the right one. If his recommendation led to a reversal, the grand vizier's future was gloomy.

Today's operations research practitioners sensibly adopt a more cautious approach. They begin by defining, as precisely as possible, the nature of the problem as well as the ultimate objective. They recognize that certain actions will probably result in certain patterns of behavior, and they attempt to take into consideration all factors that might influence the structure of the situation. They then determine the probability of certain occurrences under all conditions. This is totally different from recommending a course of action. It is saying, instead, if you do so-and-so, here is the statistical probability of your return and risk. All possible courses of action are plotted in the same way, and the overall picture is presented for selection.

This admittedly oversimplified description of operations research procedure suggests that the field is essentially a modern application of quite a venerable tradition in mathematical inquiry, that of probability theory or, as it is sometimes known, game theory. Such a view is very close to the truth.



Blackboard is used by O.R. group under Norman S. Potter (standing) in discussing management information system problem . . .

One O.R. man credits the eminent 18th century French mathematician Pierre Simon Laplace with being one of the first operations research practitioners to boast a consulting service and a regular clientele. Recognized throughout Europe as the greatest living mathematical theoretician, Laplace was retained by members of the nobility to act as a consultant at the gaming table. Watching the progress of a card game, Laplace would advise his clients on the wager and play with the greatest probability of maximum return with least risk. If the client elected to take a plunge, Laplace was prepared to calculate the discouraging probability of his meeting with success. The final decision was always left to the client.

What Laplace did was to provide a mathematical description of the probable consequences of alternative choices of capital investment, a function that is widely performed by operations research people today. But modern operations research did not find its first significant application in business strategy. That occurred during World War II when mathematicians were enlisted to solve several military problems, the most famous one being the determination of the safest method of transporting men and supplies across a hostile ocean.

Allied intelligence could predict, more or less, how many enemy submarines were engaged in Atlantic patrol at any given instant. But there was no way to fix their positions. Still, the Atlantic is a vast expanse and enemy patrols could not be expected to cover it all. Intuition led to the conclusion that the least loss to shipping would result if vessels were widely scattered, traveling singly or in very small groups. There would be some loss, of course, but a target, if found, would be a limited one. This reasoning seemed sound, but losses were still disturbingly high. Military men began to have second thoughts about their intuition and turned the project over to mathematicians for a more orderly study.

This type of problem was especially well suited for operations research analysis. The objective was clear: obtain a maximum flow of transport at a minimum risk. There were several known quantities and a number of variables. Within the environment, the task was to select, among many possible combinations, the traveling pattern with the greatest probability of a safe crossing. The O.R. solution led to the development of the modern convoy concept and resulted in a significant reduction in shipping loss.

Having written this success story, O.R. was given additional wartime assignments, such as the scheduling of bombing strikes for maximum effect, optimum selection of alternative targets, and the development of effective search patterns to locate small objects moving in vast areas. All these problems had one factor in common. Their solution rested upon the mathematical consideration of a number of variables in order to establish the most likely statistical occurrence of a predetermined future objective.

It took no great imagination to realize that O.R. techniques could be adapted to a wide variety of peacetime uses, especially in business management. One of the major problems facing any management has always been anticipating the future. What will people really want five years from now? How much will they be able to spend? Will traditional marketing concepts be sufficient for this new market? Will current distribution systems be ade-

quate? When, where, and how will advertising be most effective?

The answers to these questions were normally sought through sampling techniques. But this was not a very reliable tool. A small error in the quality of the sample can cause a gross error in the prediction. It was thought that O.R. analysis could be brought to bear upon this problem. But, although the techniques of operations research analysis were theoretically adequate to meet the requirements of business management, the problems themselves proved too cumbersome and complex.

It is, for example, a relatively simple matter to draw up a probability table for a throw of dice. The most likely outcome is a combination that results in a seven. The least likely outcome is either a pair of sixes or a pair of ones. But this is based on a cast of only two six-sided dice. The problem is tremendously more complex if each die has, say, 100 sides and there are eight dice. Yet this situation is comparable to an analysis of business investment where there may be scores of variables that must be taken into consideration. Without question, operations research had the methodology to solve the problem, but the sheer number of calculations that had to be made seriously reduced the effectiveness of using such analysis.

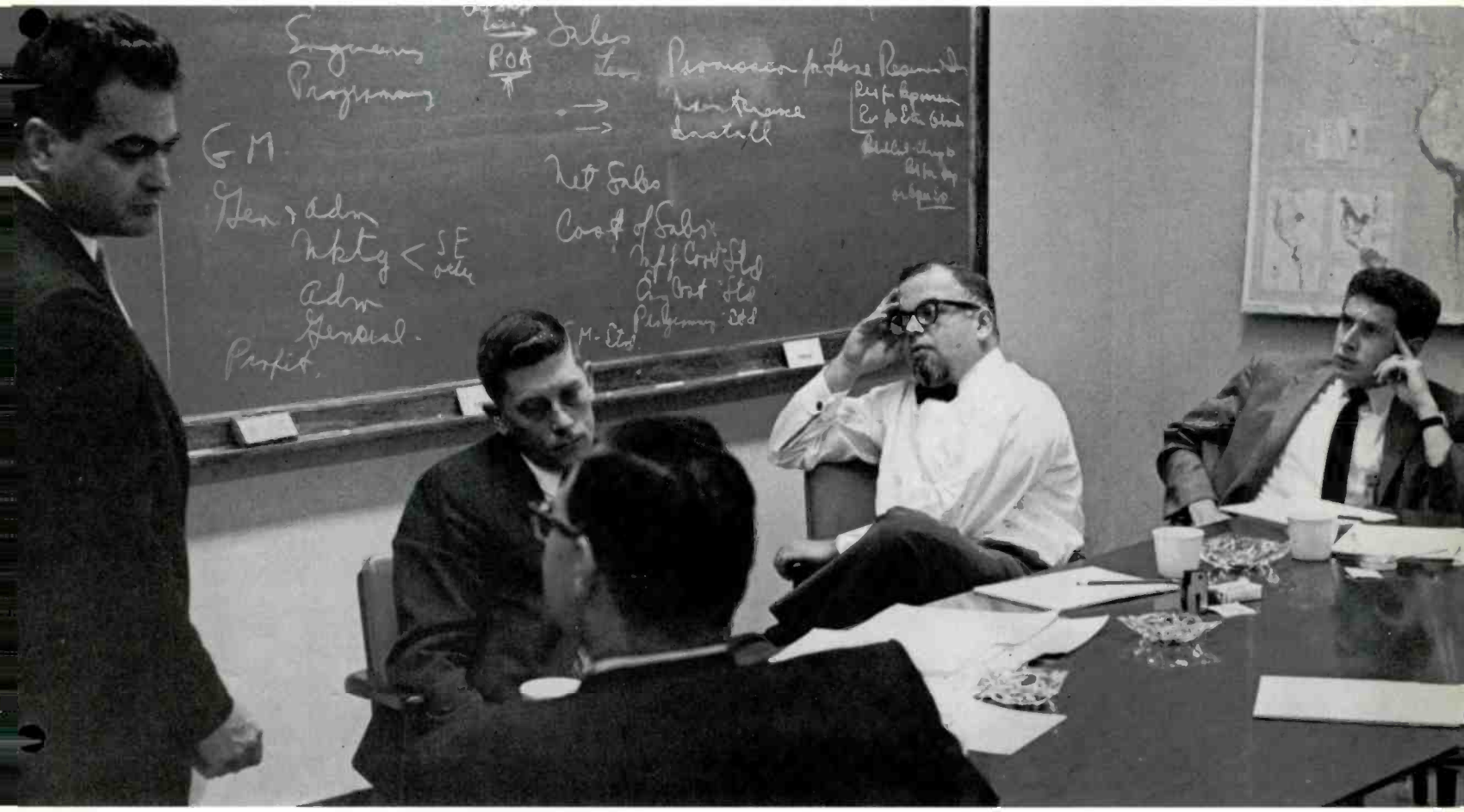
This state of affairs changed radically with the advent of the commercial computer. Suddenly, all restrictions were removed. Calculations no longer had to be made manually; they could be performed electronically, and at speeds that could accommodate even the most complex problem. Operations research as a practical management tool had finally come of age.

RCA became extensively involved in the area of operations research in 1957 when the company set up an O.R. activity at the David Sarnoff Research Center in Princeton, N.J., under the direction of Dr. Franz Edelman.

Operations research can take several forms, but Dr. Edelman defines his function as "the development of mathematical models that provide for the evaluation of the economic consequences of alternatives for planning and operations in quantitative terms." Dr. Edelman's reference to the construction of a mathematical model means precisely that. He sees a business activity as a series of relationships all of which can be described algebraically.

When Dr. Edelman and his associates are asked to build a model, their first step is to confer at length with key divisional managers who have an intimate knowledge of the activity. Together, the two groups dissect the total operation, reducing each relationship to the form of an equation.

and by Dr. Franz Edelman (in shirtsleeves) and staff in designing business model with RCA divisional manager (standing).



For example, it is possible to state mathematically product price as a function of the price of raw material. Product price, of course, ultimately depends upon many factors, all of them potentially variable. But an equation can be, and is, written for each one.

As each succeeding relationship is identified and various interdependencies are discovered and expressed algebraically, the model grows more complex. A mathematical simulation of a company's total business may contain hundreds of equations. But even that, Dr. Edelman points out, is only the beginning. The model is presumably to be used for something. Perhaps the purpose is to determine the desirability of increasing production facilities in order to meet an anticipated expansion of the existing market.

Faced with the prospect of an imminent market growth, it is not necessarily the best response to expand production facilities. The sales curve may go up, but there is the possibility that added costs will weaken the net profit figure. If, on the other hand, it is decided to respond by increasing production, there is the question of how much to expand.

At this point, certain qualitative judgments must be introduced. What is the best estimate of the size of the expected market expansion? What will be the company's share of this new market? Will it remain constant or drop? Will it be proportionately higher and, if so, by how much?

These questions are painfully familiar to most business managers. The accuracy of their answers is often the yardstick by which performance is measured and, consequently, many anxious hours are ordinarily invested before an opinion is hazarded.

Dr. Edelman and his group offer a comparatively pleasant alternative by framing their questions differently. What is the probability, they ask, that the market will expand by 10 to 14 per cent? What is the probability of it being between 15 and 18 per cent? Requesting an informed estimate of the probability of a range of possible outcomes, rather than demanding pinpoint predictions, actually results in improved analytic procedures. For one thing, the manager being queried is not tempted to modify his assessment in the interest of self-protection. Almost invariably, he gives accurate judgments within the assigned possibility limits.

These probabilistic predictions about future environment are mixed into the model, together with the complete set of algebraic equations describing the total business. These are then converted into a computer code for programming. The operations research team is now almost ready to manipulate the model, running through as many combinations and permutations of variables and fixed relationships as are desirable or practical.

But first, one final all-important step must be taken. The model must be verified. This is done by programming sample runs based on historical data. Next year's environment, for example, may be a variable, but last year's is a matter of record. These historical data are fed into the model, and the results are compared with what actually happened. If the two match, then the model is valid. If there is a discrepancy, the model must be taken apart and each equation reexamined. This, Dr. Edelman says, can be a frustrating experience, but one that forces management into an extremely precise examination of business relationships that had previously been assumed as understood.

Business management is by no means the only area in which RCA employs the resources of operations research. Norman S. Potter, Manager of Systems Analysis in SEER (Systems Engineering Evaluation and Research), an activity under the direction of Dr. H. J. Watters, Chief Defense Engineer of Defense Electronic Products, reports that O.R. techniques are regularly used in a wide variety of systems design and control problems.

The design of a communications system to balance traffic flow against circuit requirements is essentially an operations research inquiry. SEER has conducted analyses for the Department of Defense to determine the optimum inventory level for spare parts. The defense establishment ordinarily maintains an enormous stockpile of spares to support its widely dispersed weapons systems. Since this is an investment that runs into many millions of dollars, highly sophisticated purchasing schedules, based on many years of experience, were perfected. Still, using the operations research approach, SEER developed purchasing and inventory programs that resulted in savings of 50 to 75 per cent.

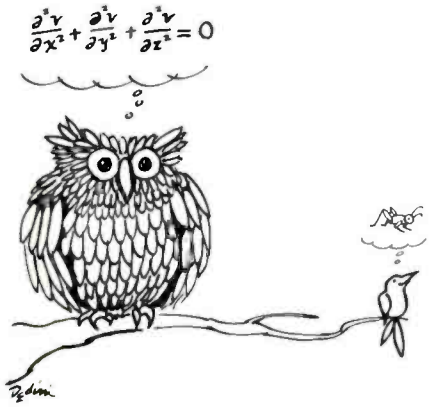
The manpower assignment problem is another that lends itself to operations research analysis. Skilled technical personnel is in short supply and is expensive. How to make best use of available personnel to perform a particular task at the least possible cost is a problem that is being probed by Mr. Potter's group. In one RCA activity, involving several hundred engineers, it was discovered that conventional methods of selecting and assigning supplementary personnel called for the employment of five to six times as many people as was necessary. SEER's methods are now under consideration by the National Aeronautics and Space Administration in an effort to make the most efficient use of NASA's technical and professional manpower pool.

There is a growing appreciation for the effectiveness of operations research methods in a wide variety of endeavors — in hospital administration and planning, urban transportation, education, general finance, banking, portfolio analysis — in any activity, in fact, that involves an evaluation of the consequences of alternatives.

Even that most unpredictable variable of all, man himself, has been subjected to operations research study. In the behavioral sciences, researchers have speculated on the likelihood of predicting the statistical probability of group behavior under varying conditions. This, of course, leads to the alarming specter of a controlled and guided society.

But Dr. Franz Edelman discounts that possibility. "Operations research," he points out, "dictates no particular course of action. All it does is to express the likely consequences of any choice in a reasonably clear and precise manner. Ultimate selection is still the responsibility of the decision-maker."

It seems, then, that reaching a decision will remain the agonizing process it has always been. Perhaps even more so, since there will be less excuse for a misinterpretation of information. Just like Laplace's client, there may still be the executive with the inclination to take a long shot. But before he makes the plunge, operations research will be able to quote him the odds. The consequences of this could be far-reaching, indeed. ■



THIS ELECTRONIC AGE...

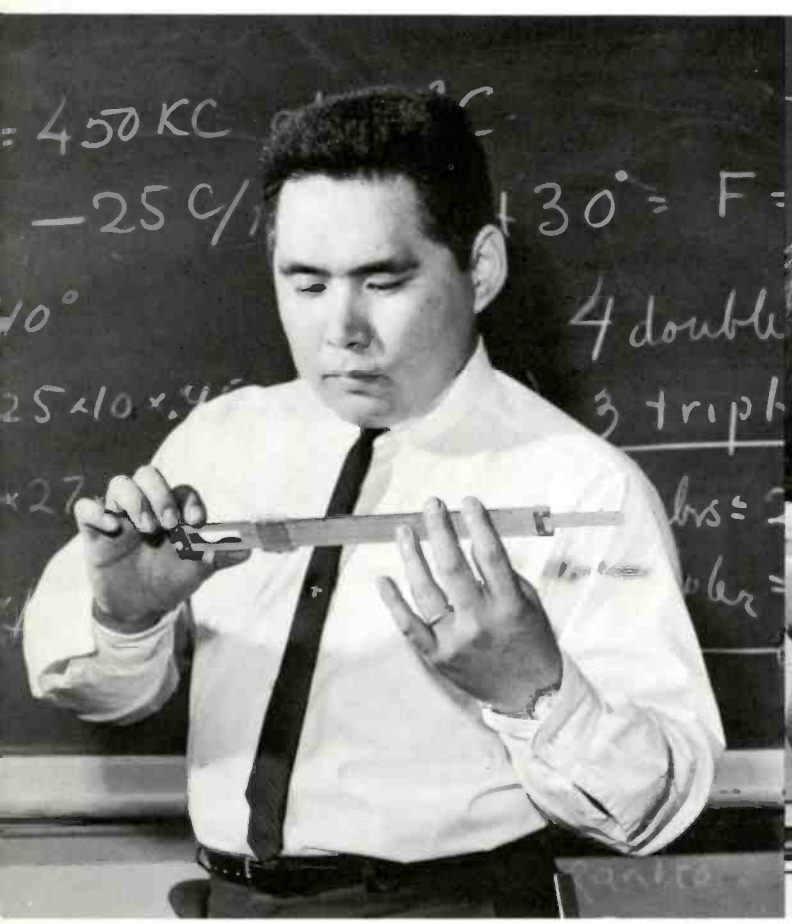
"I wish it would just give the answers without always adding 'correct me if I'm wrong!' "

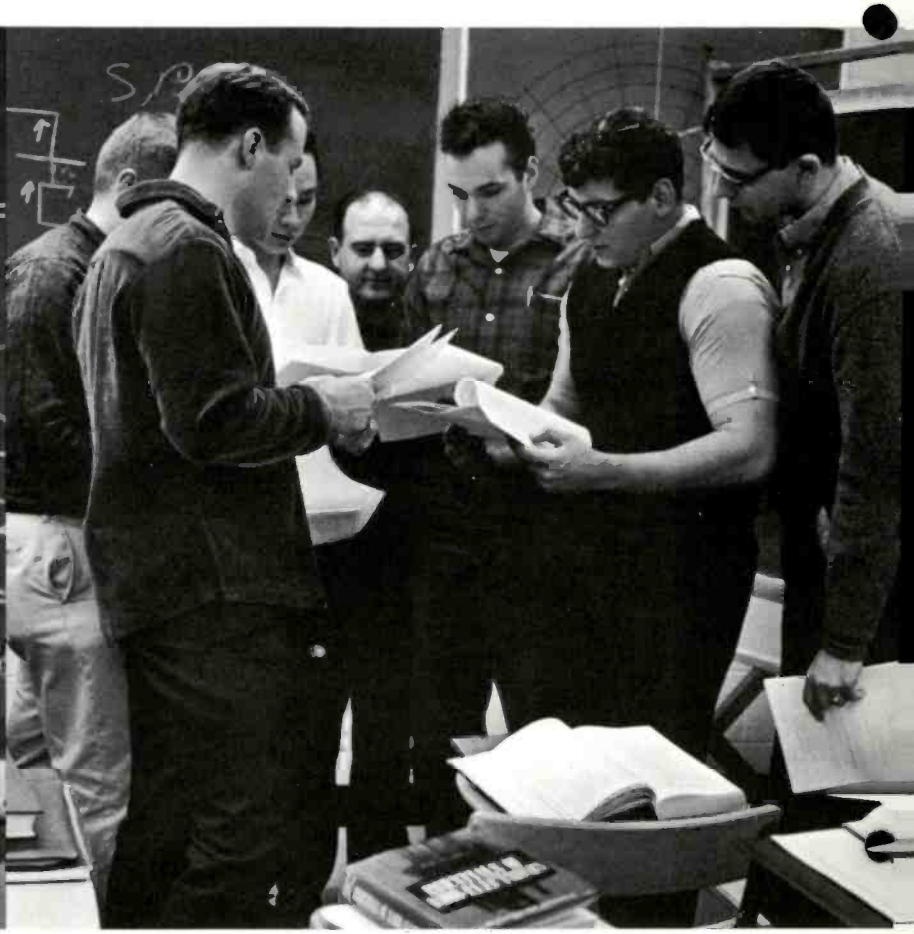
"Dear Miss Jones, Billy will not be able to complete Lesson 34, 35 and 36, due to parts failure, as soon as..."

"I feel a bit silly, sir."

Custom-Designed Education

Employer-financed courses, the fastest growing form of adult education, are helping employees to keep abreast of continuously changing technology.





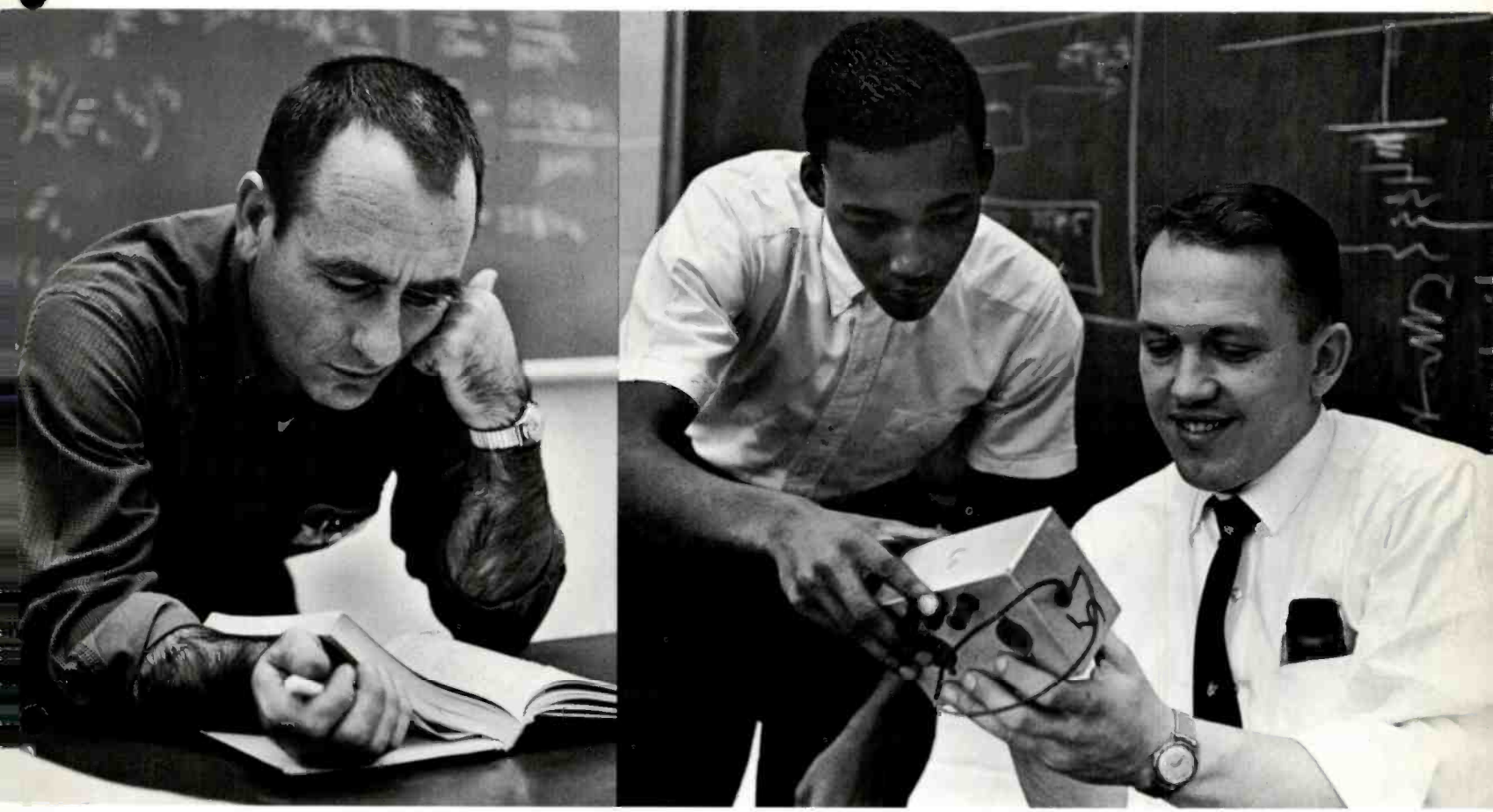
by Mitchel Levitas

"Knowledge keeps no better than fish," philosopher-mathematician Alfred North Whitehead declared. And in today's "hot" technologies, a contract or a career depends on remaining fresh. A decade from now, half the knowledge of a 1965 engineering graduate will be obsolete, and half of what he will need to know will not have been discovered. Merely to keep pace, industry in the United States is spending millions of dollars this year to re-educate scientists, engineers, and technicians in a variety of back-to-school programs: graduate fellowships, work-study scholarships, in-plant courses, and tuition-refund arrangements with outside institutions.

The effort to stay abreast of continually expanding knowledge has made company-financed schooling the fastest growing form of adult education in the country. At the same time, the boom has levied new demands on a little-known but increasingly important type of school — the handful of privately run, blue-ribbon technical institutes that train the technicians who are vital to every headline-making breakthrough in science and industry.

One of the few schools equipped to train both technicians beginning their career or "retread" senior specialists to travel the just-discovered road ahead is RCA Institutes, Inc., one of the oldest and most adventuresome technical teaching institutions in the United States. The Institutes had its beginning in 1909, when the United Wireless Telegraph Company of America established the Marconi Institute in lower Manhattan to train wireless operators for ships and shore stations; for most of its 56 years the school has concentrated on turning out technicians for radio, television, and noncommunications electronics (such as radar) by devising a curriculum that changed as rapidly as the technology itself. As long ago as 1938, for example, when television was hardly out of the laboratory, the Institutes had anticipated the market and had inaugurated a course in servicing TV receivers.

Shown below are full-time students at the RCA Institutes, which also provides special courses of study designed to bring scientists and technicians abreast of new developments in their fields. To supplement this program, the Institutes has developed technical seminars that move from one major metropolitan area to another.



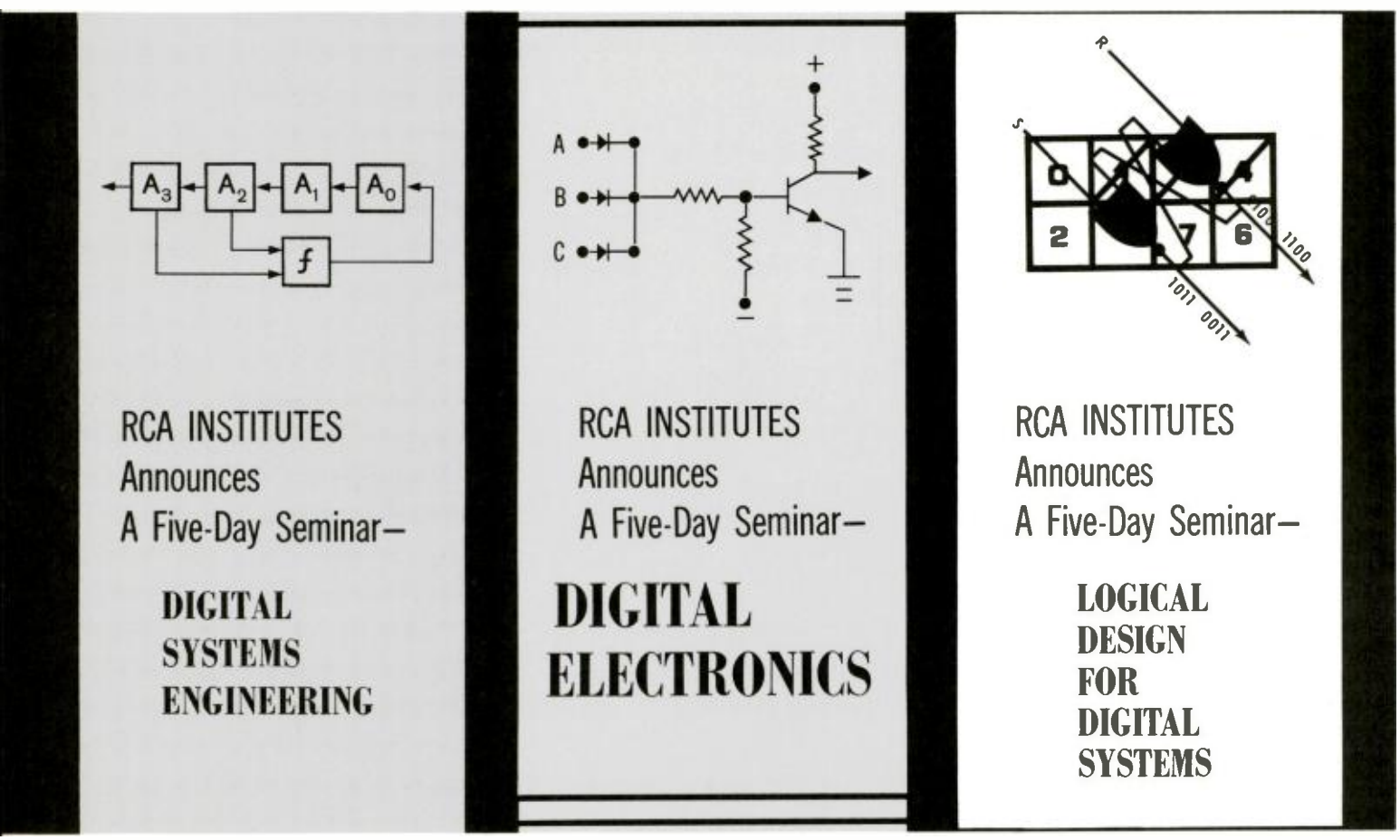
Now, in addition to its New York Schools of Television and Electronics Technology for 3,500 students (including 350 from 55 foreign countries), a home study division for 15,000 students, and a Studio School that teaches radio and TV production techniques, the Institutes, through its School of Custom Educational Programs, has developed highly specialized courses for scientists and engineers who are anxious not to fall behind in the race for tomorrow's knowledge.

These courses, custom-designed for a corporation — including RCA competitors — government agency, or trade union that seeks to upgrade its professional personnel, began about three years ago in such fields as nuclear instrumentation, computers, and communications systems engineering. Then about a year ago, the Institutes went on the road, staging five-day seminars (Logical Design for Digital Systems, Digital Electronics, Digital Systems Engineering) in major cities before knowledgeable audiences that included many Ph.Ds. Each participant, or his employer, paid $300 for the program.

Some seminars originally were designed for one customer before they went public; a seminar on computer technology, for instance, was developed exclusively for the National Aeronautics and Space Administration and the Defense Department, and later will travel. The custom courses are fashioned strictly to the client's measure and may last days or months, depending on need. "A client's problem is analyzed, and a special program is prepared to answer his particular problem. This is done on a contract basis," says A. L. Baker, president of RCA Institutes. "Our instructors go into a customer's plants or offices to help engineers and technicians bone up on the latest developments in a specialized field."

Within the past few years, there has been an expanded effort by the Institutes to assist governments in setting up schools of electronics technology in countries where a

Covers of booklets announcing seminars conducted by RCA Institutes in the "hot" technologies. Studies have shown that technical people must spend at least 10 per cent of their time keeping up with new developments in their field and another 10 per cent in refresher training. As a result, industry, government, and labor unions are turning to technical schools for assistance. Approximately 80 per cent of those attending the RCA Institutes' custom education programs have college degrees; most participants are graduate engineers or scientists.



shortage of specialists and facilities hampers the growth of mass communications. Recently, the Institutes, under a contract with the U.S. Agency for International Development, helped to establish a school in Cairo for 200–300 students. Now being discussed are AID contracts to establish other schools in Kenya, Mexico, Algeria, and Spain.

The prototype for the network is the Institutes' own headquarters — five stories in a white brick building at 350 West Fourth Street, a mixed industrial-residential section of Greenwich Village in New York City. The school has no campus and no panty raids (though it is modestly coeducational, with about 15 women in a computer programming course); the "dorms" are a suite of rooms at a nearby hotel that students can rent at reasonable prices. But crammed with laboratory equipment worth well over $500,000 and busy from 8 A.M. to 10 P.M. with serious-minded students — almost half of whom also hold down full-time jobs — the school offers a blend of theory and practice matching that offered by most colleges.

Most colleges, in fact, accept RCA Institutes' students in the academic program and give them advanced standing credit toward a bachelor's degree. "We're very narrow," cheerfully concedes Resident School Director Harold Fezer. "But we're very deep. Our students are not here to get an education in the broad meaning of the term. They're here to get a job as quickly as possible at the highest possible salary."

And they do. Of the 758 students in the 1964 graduating class, 600 found jobs immediately at salaries ranging from $70 to $145 a week with such blue-chip giants as American Oil, Bell Labs, and Xerox. Many graduates do not use the Placement Service because they are headed for military service; are foreign students planning to return home, such as a group of 35 Saudi Arabians who are part of a big push toward educational television in Saudi Arabia; or already have jobs lined up, such as the Alaskan Indians and Eskimos who went back to man remote posts along the White Alice communications network at annual incomes that started at $9,400.

Then, too, many graduates do not apply for jobs because they plan to attend college. Eli Gordon, 24, a member of this year's graduating class, has been taking the college-level program at night for more than six years; he credits the schooling with winning him a series of job promotions that have made him a control technician for a firm manufacturing transistorized equipment. "It takes something out of you, working during the day and going to class at night," Gordon says. "But in a regular college it would be many more years at night before I'd be taking the courses I've already had here."

Rupert Alberga, 41, service manager for a firm that designs and installs audio-visual systems, has been attending the Institutes for three and a half years "just to keep up with what's new." Jack Daley, 28, an electronics technician at the U.S. Merchant Marine Academy at Kings Point, has found going to school almost a necessity for doing his job well. Daley has a small government budget of $500 a year to keep about 140 pieces of training gear in operating condition. To save money, he has made some 600 modifications in a 20-year-old RCA loran device, using the information he has learned at the Institutes. "If something goes wrong," says Daley, "I know where to look. What I want to find out is why they put it there in the first place."

Teaching Daley and his fellow students "why" is the aim of more than 100 faculty members and a curriculum that is overhauled every three to five years to keep up with the latest scientific advances. "The field is changing faster than we can learn it," says Evening School Dean Nathan S. Buch. "The engineers come out of school and, before they know it, they're obsolete." Adds Fezer: "Years ago we went from a service-oriented program to a technologically oriented program, from training repairmen for relatively simple equipment to training technicians to install and maintain very sophisticated stuff." In the works: an even more sophisticated course in the electronics of space.

The most advanced program at the Resident School is the college-level curriculum intended to train highly skilled technicians in many branches of the electronics industry. Accredited by the Engineers' Council for Professional Development, which represents the combined professional societies, the course takes 27 months for a day student to complete (it takes three times longer in evening session because the classes meet less frequently) and costs $2,488 in tuition on a pay-as-you-learn schedule of $24.75 a week. The cost — 97 cents an hour — is about one-third the hourly cost of a regular college class, but, unlike a college, the Institutes' school does not have to maintain money-losing facilities, operates more efficiently on a year-round basis, and boasts a 99 per cent room occupancy rate for 14 hours a day, five days a week, and about seven hours on Saturday.

The most expensive courses ($1.40 an hour) are in computer programming; they take less time to complete, however — three months. Other specialized programs include a course in color television and courses for Spanish-speaking students.

The vocational program, enrolling about half the students, is actually two sets of courses arranged in sequence. The entire applied electronics curriculum can be completed by a day student in 18 months, but it is a tight schedule. Nevertheless, students rarely miss school or doze off in class. "I don't like to see people wasting their time," says Dean Buch. "If they do, I ask them to leave. It's not very businesslike, but the school has a good reputation and it's important to keep it. We're here to let some students earn a profit on their lives."

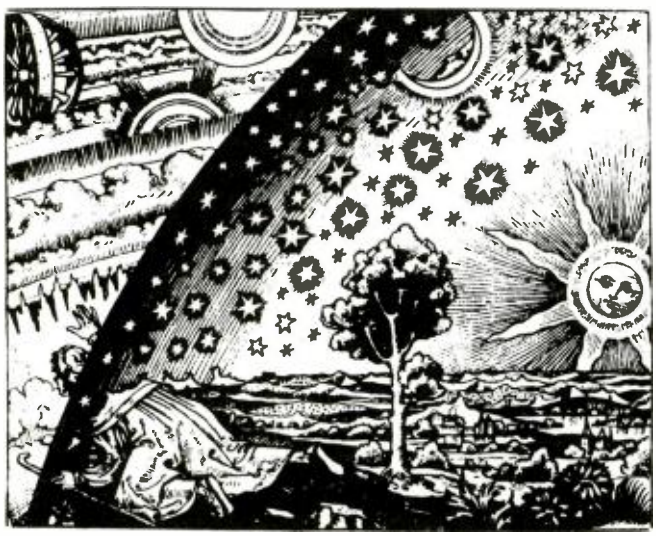
Gabino Suarez, for example, is a Cuban refugee who would rather be a television technician than a bookkeeper, his present job. "This is more interesting, and maybe more profitable," he says.

"Then there are the students," says Buch, "who eke out a living at some menial job but who have brains they're not using. The Institutes gives them a chance to better themselves, to learn a profession, and move up in the world."

And when they move up high enough, they will be ready to enroll in the Institutes' custom-designed advanced courses or attend a seminar. For education is a never-ending cycle of discovery and, in the fast-spinning world of science and engineering, three out of four technicians and scientists need "retreading" while the fourth man probably has just gone through the process. ■

The requirements are examined for the existence of life on other planets.

by Andrew Holmes-Siedle



System of the world according to ideas prevalent in the Middle Ages.

In our impressions of the size and shape of things in space, we have progressed from those of the Middle Ages. However, even now, when the layman thinks of the universe neighboring our planet, he probably thinks of the artist's impressions of the solar system which he has seen. A bright, colorful company of planets jostle a flaming sun against a crowded backdrop of comets and star clusters. Almost inevitably, however, the artist's impression has been a false one, as we will see below. The astronaut will not get the same impression. The solar system is a very empty place. It is, on average, very dark and cold. In several other ways, it is very inhospitable to any living thing. This article sets out to consider how living things could ever arise there; and what the prospects are for living things when they venture out of the one small, warm enclave that we know will support them — our own atmosphere.

Artists' pictures, of necessity, show the solar system as more crowded than it really is. This is for the simple reason that, if the artist were true to his scale, and then drew the solar system to fit on a six-inch sheet, the sun (to scale) would be a dot smaller than a period, and the earth would be completely invisible as a dot one-millionth of an inch across. To visualize these relations at a more familiar level, let us imagine the sun as a very large balloon on the White House porch: then the earth would be a softball on the Capitol terrace. The planet Venus would be another softball halfway down Pennsylvania Avenue, and Mercury would be a pinhead on the pavement outside the White House. Pluto, the farthest planet, would be another pinhead way out past Baltimore, while the rest of the planets would turn inside Pluto and outside earth. No other star or sizable body would exist in the rest of the Americas. Only downtown Washington really feels the glow of that hot balloon on the White House porch.

If we lived on the planet Pluto, we would know that the universe is, indeed, a dark, cold place. The light of its "day" is no more than our starlight, since the sun is so distant that, ordinary little star that it is, it merges into the background of the others. The cold is so intense that air liquefies. With no protecting gaseous blanket of air, the planet bears the full rigors of the "interplanetary medium" — a rain of solid particles (ranging from sand size to rock size) and of charged atomic particles, all moving at several miles a second. The result must be a waste of craters and dust, the dust perhaps so chemically active that a rubber boot, placed upon it, would burst into flame.

Such an account may make us ask two basic questions: *How, then, did we manage to get here? How can we possibly live out there?*

The answer is that our planet is one of the lucky celestial bodies large enough and temperate enough to hold to itself a thin skin of gas. On our "softball" scale, this skin is only five-thousandths of an inch thick. It is still enough to make us a "greenhouse," protected from the inhospitability of outer space. We will live out there only if we take our greenhouse with us. This quickly raises a third question, perhaps the most fascinating one: *Beyond our own greenhouse, then, is there anything else alive?* This we will try to answer as well, but first we will see what the greenhouse is like and how to take it with us.

We find that, quite apart from giving us air to breathe, our greenhouse atmosphere serves us in many ways:

(1) It provides a cooling or a warming system, whichever is needed, to even out extremes of temperature.

(2) It absorbs the harmful ultraviolet light from the sun and the fast atomic particles from space, letting through only a little of each.

(3) It acts as a "meteor bumper," burning up the

Life Outside Our Atmosphere

showers of dust and larger stones that cross our path at thousands of miles per hour.

(4) It acts as a diffuser, softening the sun's light by scattering it; hence, we see a blue and not a black sky and have "twilight" after sunset.

(5) The even distribution of moisture allows the formation of a firm soil that produces plants, which, in turn, produce oxygen and food to keep animals alive; the soil also acts as a disposal system for the husks, bones, hair, or horns of dead animals or of the wastes that our bodies reject from food.

Any manned spacecraft, or moon base, is mainly a device that reproduces these functions, possibly ignoring the diffusion of light as unnecessary, and, up to now, replacing the oxygen-producing function by tanks of oxygen, while wastes are stored. The Gemini successes have made this seem almost easy. However, for a very long flight, or a long-stay base on the moon or Mars, we would do well to consider creating, on our base, a microcosm of the oxygen–food cycle that occurs on earth.

The Oxygen–Food Cycle

The maintenance of our atmosphere on earth is done solely by means of the sun's energy. At the same time as the sun's energy liberates oxygen from plants, it causes the plant cells to build sugars and other food substances from carbon dioxide. We ingest these foods, extract the chemical energy as "work," and our bodies release chemicals of the type that first went into the plant. If these are "ploughed back" into the soil, the process can start all over again. It would be ideal if we could establish a cyclic process like this in a moon base.

We would not have to import new atmospheric chemicals but just keep the cyclic, or "regenerative," process under control, using the sun as a driving force. This, of course, is not a simple matter really, and the fully automatic control of such a process would represent an important engineering achievement.

As a basis for the cyclic process, therefore, our moon base must contain plant life. However, we cannot use all the immense variety of plants that do the work on earth. We must choose one or two hardy and adaptable ones to do the whole job. The problem is — which to choose?

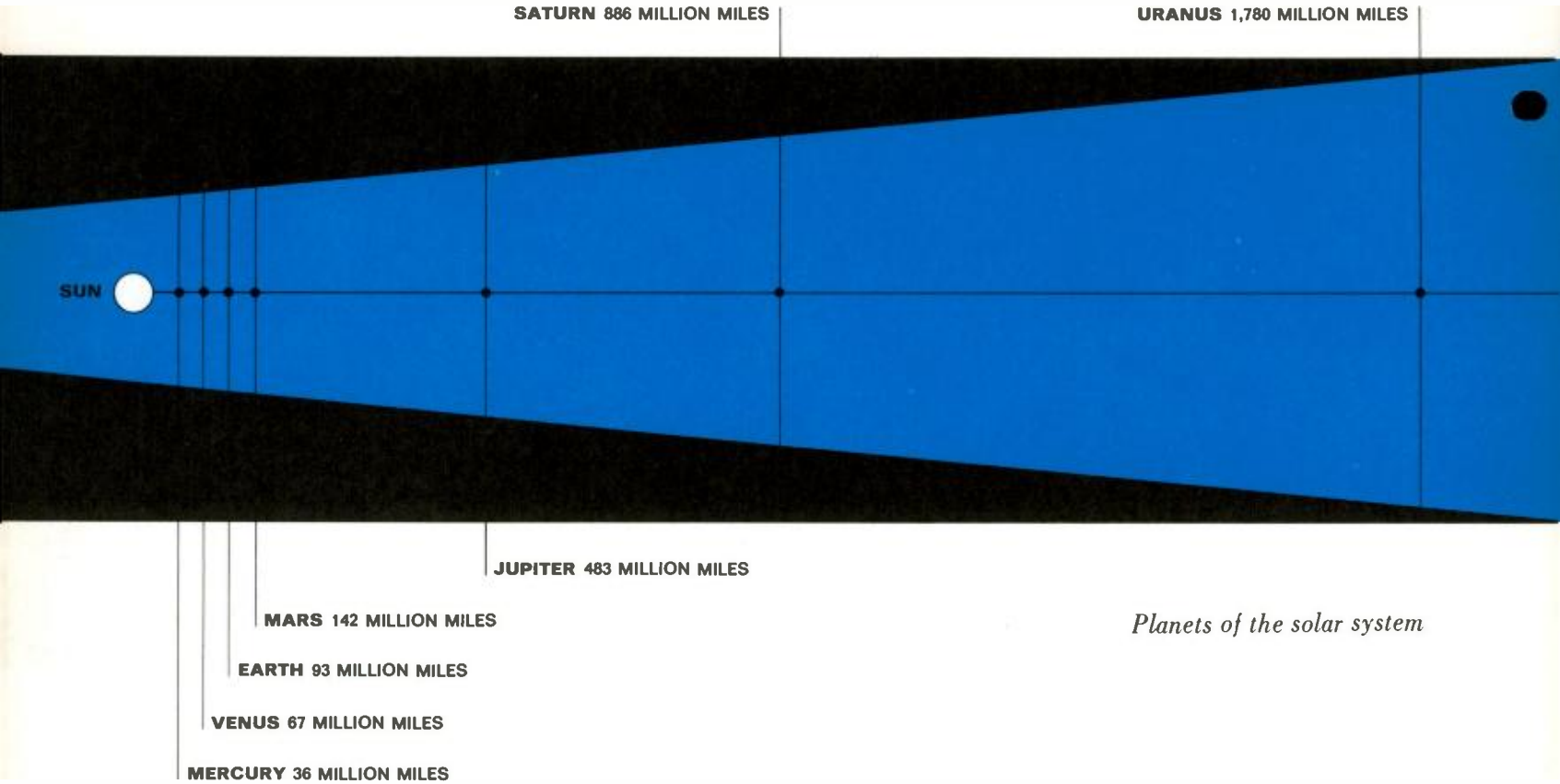
We might choose the tree on the basis that it is a hardy, powerful plant. It is, but it is not adaptable. A fairly large volume of tree is needed to keep one man supplied with oxygen; also, trees develop very slowly. For each man, a tree would have to be planted about 10 years before he came to the moon. And what to do with all the spare timber? It could not be used for construction; if it caught fire, it would suffocate the whole moon base.

"Green Slime" as Food

To give flexibility to our moon base, we want to choose a plant that packs closely, produces little inedible waste, tastes good, and is adaptable to "flow" production rather than "batch" handling. The best organism is to be found in the nearest fish bowl — the minute, simple "green slime" species Chlorella, one of the algae. The volume of chlorella culture needed to serve one man is about a thousand times smaller than that occupied by a tree. Furthermore, using stored sunlight (e.g., electricity, to light fluorescent tubes) as the energy source, a one-man supply of this plant can possibly be packaged in a container the size of a wastebasket.

The chlorella plants double their weight every day, contain most of the necessary vitamins and proteins, and are entirely edible. Here is the food that we need; unfortunately, it is not very palatable. After all, who would want to live exclusively on green slime? Hungry mice, given dried chlorella, sweep it aside and use it as bedding. It can, however, be used to fortify other foods, and "chlorella cookies" containing up to 20 per cent chlorella are edible. On the whole, though, it would be better if we could find, as on earth, an animal or a fish that would thrive on these useful little plants and then themselves provide us with better fare.

This approach, however, brings more problems. Most animals have a fair proportion of bone, gut, hide, or hair that we just cannot eat — one third in the case of cattle — and we at once have a real rubbish problem on the moon. We must seek an animal that is completely edible. The slug is one of the few nearly so, and it is eaten in parts of the world as slug jam; but perhaps we might prefer to forego this treat and compromise on shrimp, the edible insects, or, perhaps, just mushrooms. I am sure there are still many bright suggestions for a plant–animal combination that have not yet come to light, and the author is tempted to propose a prize for the best combination suggested. One animal suggested is the Tilapia fish, a South American species that



Planets of the solar system

enjoys algae, is hardy, tasty, and breeds fast. There should also be a prize for someone who invents slime with an attractive flavor.

Where to Find Life

We have seen, then, that life, as we know it, requires a protective atmosphere. Now we must consider where we should look for life. This can be reasoned out fairly well on the basis of temperature. There are reasons to say that life at all like that on earth can persist only if the temperature lies in quite a narrow part of the range between freezing and boiling points.

The only planets above freezing point would be those which, on our "Washington scale," lie in the downtown area. Those planets nearer than the Capitol would probably be hotter than the boiling point of water. Even in the "comfortable" zone, many sterile pieces of rock must exist, because they are too small or inert to hold an atmosphere. Earth, Mars, and Venus are the only three major bodies in the "comfortable" zone or "liquid water belt."

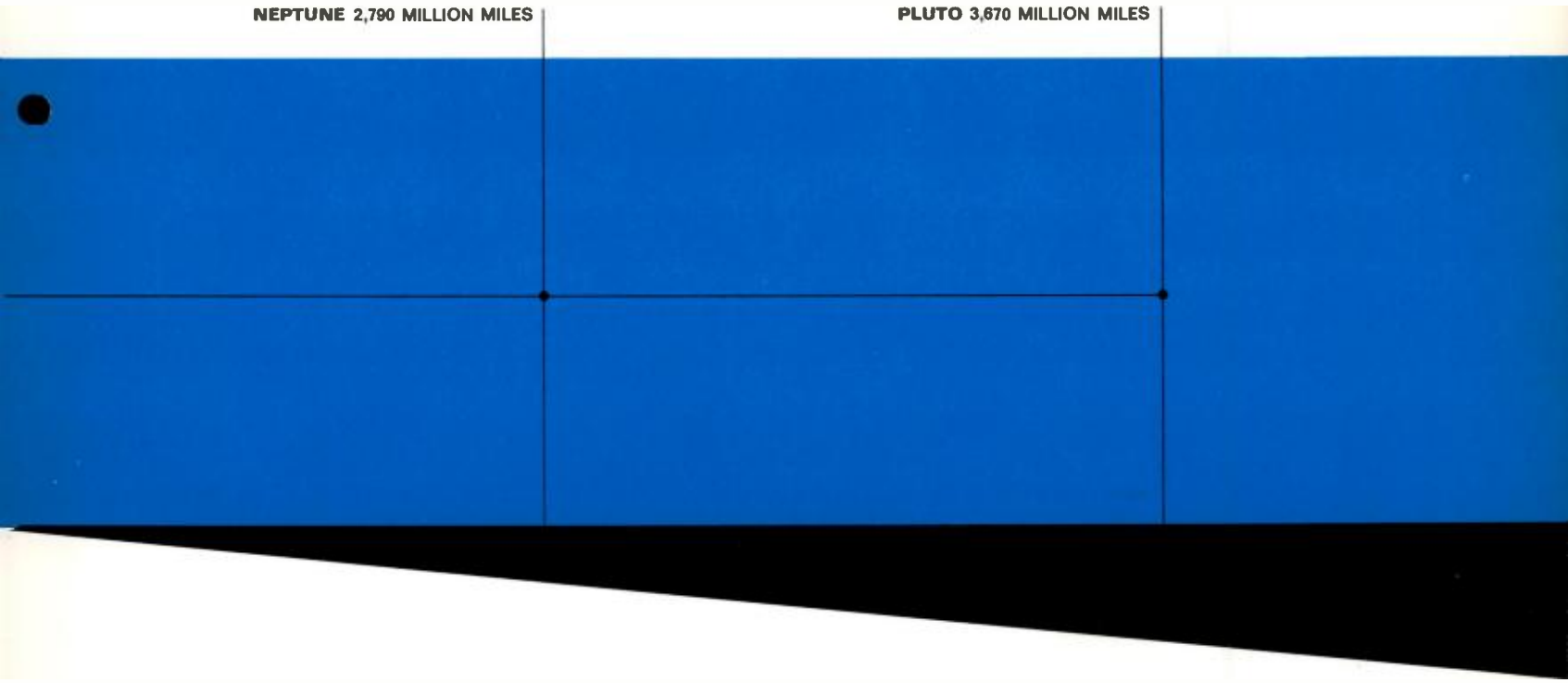
Let us not, however, be parochial. Mars and Venus apart, we must ask *could there be life around other stars?* Any star at any one time has a "comfortable" temperature zone around it. The answer is — there is no reason why there could not be life in this zone. There are many biologists who are prepared to say that, if there are any planets in the "comfortable" zone of other stars, life is nearly certain to have started on some of them; that the evolution of self-reproducing organisms is almost inevitable given the right mixture of minerals, the right physical conditions, and many millions of years for "chance" to produce the right chemical reactions.

Rules for Life

Earth-based biology provides us with some general rules as to what is needed for life. At least three chemical conditions appear to be completely indispensable: (1) a liquid solvent (life must be "wet"), (2) a system of polymers (the thing must hold together), and (3) polymers having the ability to *reproduce* themselves out of raw materials (reproduction is always in fashion).

In the case of the earth, it is not too difficult to propose a model of how self-reproduction of molecules could occur in a warm, sunlit "soup" of amino acids and sugars on a shallow sea bed. Clay could act as a template and allow the laying down of a complex chemical structure. The supported chemical molecule could then act as a "factory" for "zipping up" other simple molecules into replicas of itself. The result would be a blob of thickened "soup." If a crust hardens on the blob, we have a primitive biological cell; that is, an array of self-reproducing chemicals protected by a "wall" from being easily dispersed.

We have not, however, so easily solved thereby the secret of life's start; this crude model does not tell us how the primitive "cell" could learn how to divide, as true living cells do, and further, in the process, retain the right geometry and size. This problem is no more than nibbled at in contemporary biochemistry or "molecular biology."



The conditions found on Mars and Venus by our Mariner spacecraft do not look favorable to the kind of processes we have outlined, especially with regard to development of *higher* life forms. However, we cannot possibly yet pronounce these planets sterile. Even if they finally prove so, it will still be of great interest to discover whether Mars is *colonizable* at all levels of organism. As world population grows, the possibility of some temperate real estate on Mars may become very attractive. Mars, in any case, is of intense scientific interest because it is near and provides us with a relatively unobscured view of its cloudless surface. Dark patterns and frosty-looking patches come and go annually on the surface, while morning and evening mists can be seen even from the earth.

Looking to Mars

Balloon and satellite telescopes should shortly produce a better view of the Martian surface all year round. We have already had the one brief, incredible look by Mariner along a thin strip of surface, which, through no fault of the experimenters, missed some of the more intriguing features. Later, about 1971, automatic biological laboratories will be launched from earth and will settle on the surface of Mars. These will be electronics systems of a complexity to haunt the designer's dreams. They will have to detect phenomena that are at present only discernible to the trained human eye, such as viewing, under high magnification, the growth of fine molds on a dish of prepared culture broth.

Detecting Life

One cannot help feeling that some great issues and decisions may rest on some quite fallible test such as that mentioned. It is so difficult to design a machine that detects them all — elephants, flies, and viruses. For example, from the start, there is no way of knowing the culinary likes and dislikes of the Martian germ. If he is like his earth brother, he has to have his broth just right — not too salty, not too sour. He may well prefer arsenic to sugar. Perhaps only the TV microscope or telescope will provide us with enough "feel" to recognize highly foreign forms of life, or possibly the discovery will wait upon a man's arrival.

The aim of this brief account has been to make three points. Although we can detect life and examine it readily on earth, the engineers have to give us more advanced sensors before we can decide, by machine, at a distance, whether a certain observed phenomenon constitutes "life"; although we have demonstrated short-term life support outside the atmosphere, our present "Model T" system for support will have to be revolutionized before we can establish a colony on the moon or Mars. Finally, while we have several good handles on the problem of the origin of life, we have to do a lot of research before we arrive at a good set of principles to explain it. It might be said that the wish to discover these principles is one of the motives of the whole space effort. If we look closely on other planets, we may find out not only *if* life exists there but *how*, under different conditions, the vital transmutation was made. There, perhaps, will be the key to our own origin. ■

Graphics Through Electronics

New electronic devices and techniques are revolutionizing the world of the printed word.

by Ken Kizer

It has been a long time since reporters dashed through police lines or burst into a city hall meeting with a "PRESS" card stuck in their hatbands. Equally rare on the news scene today is the leather-lunged city editor who rules the city room by decibels; the "boomer" printer who uses his union card as a passport and meal ticket; or a "morgue" attendant who does not have a college degree in library science.

Old-time news hawks may regret these passings, but have accepted journalists and printers as journeymen sometimes despite the fact that they hold advanced degrees, go straight home at night, become interested in the PTA, and do all sorts of legitimate things any self-respecting newsman would have disdained only a few years ago.

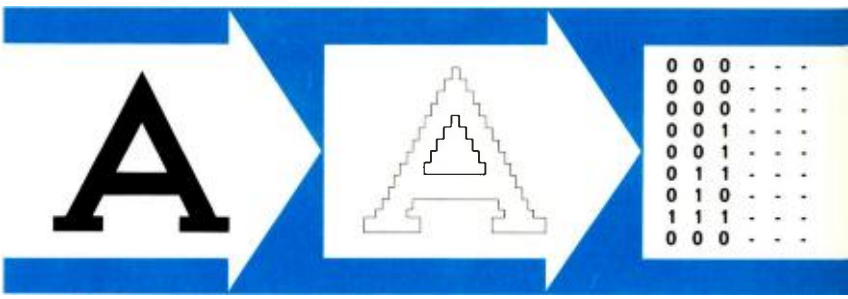
There is one thing newspaper traditionalists can always count on, however: A fast-breaking story will always be with us, with the reporter dashing to the nearest phone to dictate the facts to a rewrite man who bats the story out on a typewriter — probably typing just as fast with two or three fingers as most persons can with 10. The story is dispatched, paragraph by paragraph, to the copy desk and on to a linecasting machine while Page One is being held to make room for at least a bulletin on the hot story.

It will be quite a while before Hollywood will have to rewrite this portion of the city room script. Today, however, the writers are facing up to a situation in keeping with recent developments in printing and publishing — the use of electronics in graphics. For example, the Radio Corporation of America, a pioneer in these developments — which include the application of the computer to the tedium of keyboard typesetting — recently formed a Graphic Systems Division in recognition of the new electronic developments taking place in the printing industry.

The past few years have already seen the conventional flow of news copy undergo changes as an increasing number of newspaper publishers acquire computers. Where a news story once reached the back shop on the paper snatched from the reporter's typewriter, it is becoming a more common practice to tear paper tape from a computer-directed punch device, position it on a reader affixed to a linecaster, and have lines of type, hyphenated and justified, automatically drop into the galley. The reporter's copy is still used as the basis for headlines and to insert corrections and inadvertent omission of pertinent information, but nearly 100 daily newspapers today have already put aside the old ways and have "gone the computer route."

Even though computers are in use (mainly for justification and hyphenation), much of the manual routine to get the printed word to the presses and onto newsprint remains the same: Lines of type are set by a linecaster, and are picked up along with headlines, rules, and photos etched in metal and placed into a form; a damp papier-mâché matte is pressed under pressure to make a mold, then baked; hot metal is poured into this mold in the form of a half-cylinder, cooled, and sent to the presses. The news — at least that edition — is out on the streets.

Display advertising is something else again, typically following the "no computer" steps. The advertisement is brought into the ad office by a space salesman, approved by the advertising manager's staff, and sent to the "ad



alley" in the back shop to be composed manually with the necessary borders, rules, illustrations, and typefaces.

When it was noted that the application of the computer to typesetting was going to be accepted, electronic engineers at the David Sarnoff Research Center took a second long look at printing and publishing. From this searching study came what is now called an "integrated electronic composing room" based upon the combination of television, photography, and electronic data processing technologies.

This new concept in reproducing the printed word hinges on a technique called "electronic symbol generation," made to order for a general-purpose digital computer. Any symbol can be broken down into binary information (the "ink, no ink" decision elements) much the same as an optical scanner operates. For example, a capital "A" is reduced to "0"s and "1"s simply by overlaying a matrix or grid that tells the computer "this square is white, this square is black." By this method, any printed alphabetical language can be stored, retrieved, and reproduced.

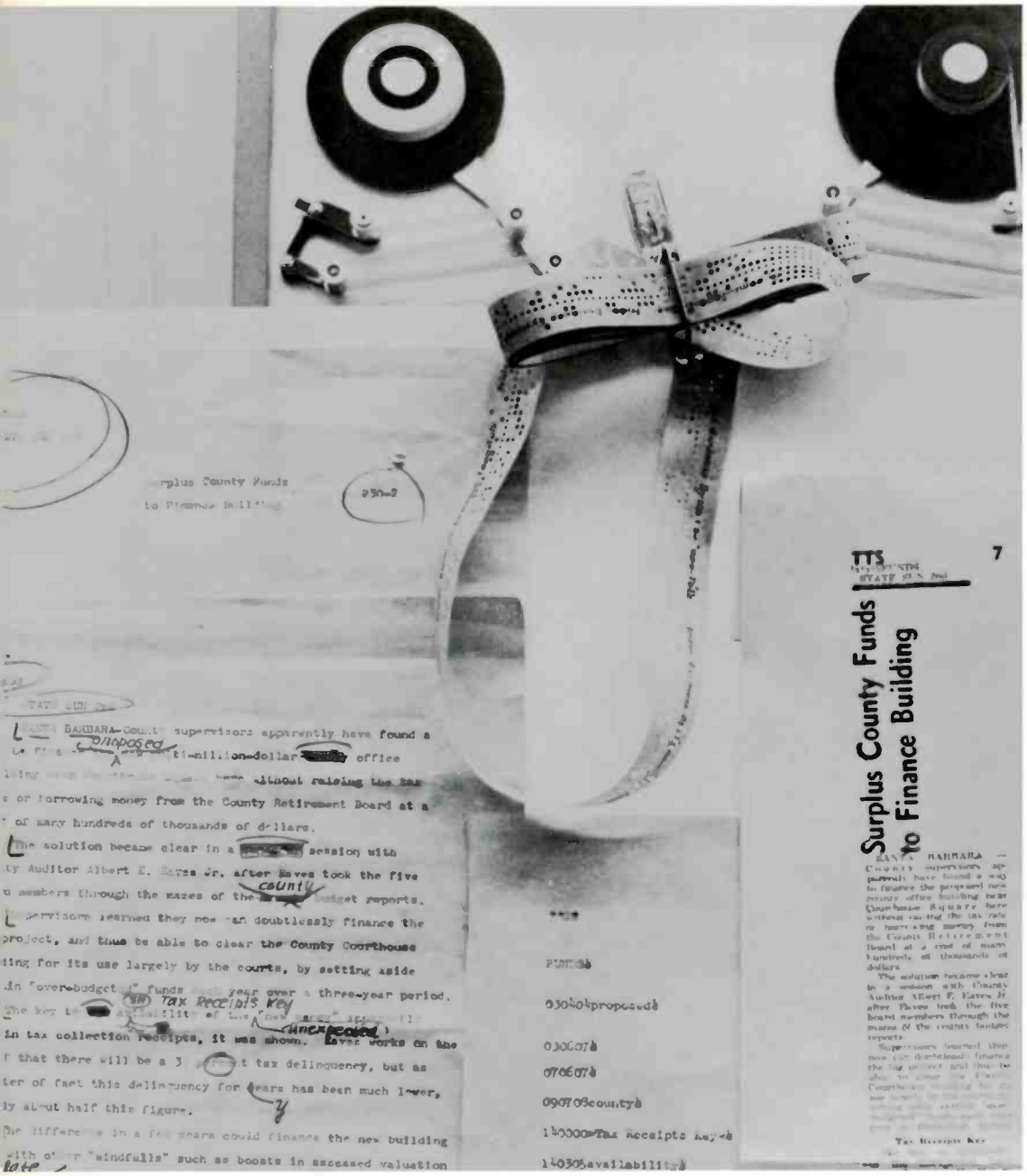
Electronic streams of digital information are stored and recalled to activate a light source to expose or not expose film or photographic paper. The computer stores this information as an "A" — not as an "A" in a particular typeface you see on this page but as a symbol of the first character in the alphabet. This symbol can be drawn out and exposed on film or photographic paper as Bodoni, Cheltenham, Century, Gothic, or whatever typeface the user wants to store and use. The parameter message preceding the taped text material simply tells the computer in what typeface the copy will be set.

Since alphabetical characters can be generated in this fashion, any symbol — for example, a ligature or a logotype — can be reduced to digital signals. These are stored in external memory and retrieved when needed.

The elements necessary to comprise an electronic composing room include a keyboard device to punch tape acceptable to a computer, a graphic material scanner to reduce pictorial material into binary code, a proof printer to furnish a printout of information stored within the computer system, and a photocopy generator to produce a complete news page. These devices are in existence or in the design stage, and it is at this point that a major change is coming in the publishing business.

The old proof press will be one of the things to go. Once entirely manual, a column or less of metal type was placed on the press bed, inked, paper was placed on the type, and a roller was pulled across to make an impression or proof of the inked type on the paper. The proof press has become somewhat mechanized, but it remains, at best, a manual-mechanical operation.

Soon, an electronic proof printer will provide a readout of the news text stored in the computer in the specific typeface, size, and format called for in the final form. The printer may run at the rate of some 6,000 characters (20 column inches) per second, in widths of up to a full news page in size. It operates with a cathode ray tube, printing out in black characters on office copier type paper. It provides not only a correction copy for the editor but also serves as a guide in page layout, indicating to the editor that more copy must be committed to the page, that the



< Computer composition of newspaper editorial copy is graphically portrayed in various stages of processing. Reporter composes his copy (left) on typewriter that simultaneously cuts a punched paper tape (above center). Additions, deletions, and other changes are made by reporter and his editors in pencil on original manuscript. A "correction tape" (center) is made by a typist in the computer room indicating each change, line for line. Correction tape and story tape are both fed into the RCA computer at 1,000 characters per minute via the tape reader (background). The computer then incorporates all changes in original story and creates coding for a final tape that divides each line into column widths and even decides where split words are to be hyphenated. Final tape is used to actuate automatic typesetting equipment. It is estimated that the computer composition system will result in time savings of 40 per cent in typesetting.

The seven 1,000-foot reels of punched > paper tape in this photo have been coded by an RCA computer to justify type that will be set by one of the several linecasting devices in general use. The seven reels are equivalent to 65 columns of classified ads, which would represent an average day's typesetting requirements for a standard size newspaper, exclusive of wire service copy and display advertising.

page is already filled and ready for closing, or that the page is overset and copy must be relocated to fit in other available spaces.

Another new device is the graphic material scanner to convert all graphics into digital signals. Input into the scanner are photographs, line drawings, unusual typefaces, and special symbols, contained on either transparent or opaque material. The scanner converts the pictures into digital representation for input to the computer. Continuous-tone pictures are converted electronically into their halftone representations. Input to the photocopy generator is a film or photographic paper, either in negative or positive form, computed in dots to the inch (halftones) in the case of photographs, or in solid lines such as used in maps and symbols. This image is exposed on a photosensitive metal plate, then etched to obtain a surface from which an impression can be made.

In an electronic composing room, the photocopy generator is the final computer peripheral to be used. Upon completion of corrections in text and graphics and the location of the editorial and advertising matter in the proper position on the page, the computer relays this information to the photocopy generator on signal from the computer operator.

Utilizing electron beam techniques, the generator provides a full news page of all text, line drawings, photographs, headlines, borders, and rules. Pages can be generated in approximately one minute, including automatic

film handling and processing. The operator receives a dry film for further processing — such as opaquing for typographical excellence and stripping in of any material not handled by the system.

The aim of the integrated electronic composing room is to perform all of the routine tasks in a composing room, including hyphenation and justification of lines of type, text corrections, original proofs, page makeup, and full-page ad composition. In addition to generating columnar matter, the computer system can also perform page mapping, vertical and horizontal justification of the page, and location of the material on the page.

The system will accomplish the manual and mechanical work attendant to advertising layout and makeup done in the back shop, create proofs of text and graphics, commit both editorial and advertising matter to the photocomposition machine, and produce a full page of words and artwork ready for the platemaker.

The system is designed to operate as well on books, magazines, directories, manuals, or any other multicopy publishing application, as it does on newspapers. In addition to shortening the time between the news event and the distribution of the newspaper on the street, the electronic system will not only enhance the appearance of the news pages to the reader but also give the publisher broader capabilities within his own shop.

Already, computers are directing the counting and bundling of newspapers, computing truck routing and scheduling maintenance, handling subscriptions for newspapers and periodicals, and printing mailing labels, as well as performing such relatively prosaic tasks as invoicing, billing, and payroll preparation.

The electronic data processing community is already looking ahead to the not too distant future when the graphic arts industry will be utilizing a full-page optical scanner, enabling the computer to store a complete newspaper in its memory. This would be linked with a video composition display unit where full pages could be displayed with headlines, text, and advertising. The man on page makeup could see instantaneously the progress of the layout, and could manipulate elements on the page electronically to give a new dimension in flexibility.

A little further off, perhaps, is the electronic printing press. Under computer control, electromagnetic fields will direct powdered ink to paper. This type of process would allow images to be changed while the paper on which they are to be printed is in motion. The old clarion call of "Stop the presses!" will be silenced because there will be no need to change plates.

Other than a subject for nostalgia, what does all this mean?

The integrated electronic composing room has two advantages over the conventional printing plant as it is known today. Linked together, the advantages could be called "economic product enhancement." A publisher will have the capability of increasing productivity with a given labor force (economic), and be able to do it better (product enhancement) than heretofore.

As an example, magnetic tape permits easy and rapid updating of textbooks and encyclopedias simply by specifying to the computer the changes to be made and allowing the computer to insert the corrections in the right locations. The speed of the electronic system may appreciably reduce the time cycle for updating as well as the time needed to produce the initial product. The time saved can be used in editing, makeup, and data collection. In any case, the consumer benefits.

It all adds up to the evolution in printing that has been going on since Gutenberg invented printing from movable type more than five centuries ago. At that time, it took five years to print the twin volume of the Bible. Some 400 years later, the typesetting machine was perfected. Today, the computer has been added; tomorrow, integrated electronic systems. ■

The Sonic Electron

The interaction of phonons—ultrahigh-frequency sound waves—with electrons is opening the way to new products being developed by the electronics industry.

by Bruce Shore

A potential cache of new and versatile electronic products based on the interactions that occur between electrons and sound waves propagating through solids has been uncovered and may soon be exploited by the nation's electronics industry. Included in this expected treasure are:

- Acousto-electric oscillators, detectors, mixers, and amplifiers that may spawn a new breed of radio communications equipment.
- Acousto-electric computer memories that may store 50 million bits of information on a handful of quartz rods.
- Solid-state microwave transmitters and receivers that do away with the bulky wave guides, hot electron tubes, and clumsy coaxial cables in modern radar and television installations.
- Sonic masers that generate sound waves so intense they may cut or pulverize metals.
- Acousto-electric photomultipliers that may one day employ sound to amplify light.

At the very least, it appears, mastery of these acousto-electric interactions can be used to improve the quality and performance of present electronic materials and devices. These exciting possibilities stem from the fact that, when an electric field is applied to a hunk of solid matter, free electrons floating aimlessly therein begin to drift purposefully downfield at a rate fixed by the pressure of the field (voltage) and the drag exerted by the sea of atoms around them.

This drag, arising from tiny vibrations of the atoms in the solid, is really a manifestation of sound energy oscillating constantly through the material at frequencies too high to be heard.

Ordinarily, such vibrations are a nuisance in electronic circuits because they cause heating and electrical resistance in various components. Recently, however, scientists have

Superconductive tunnel diode fixed to quartz rod is prepared for insertion into microwave cavity. Device generates and detects sound waves oscillating at 70 billion cycles per second when immersed in liquid helium.

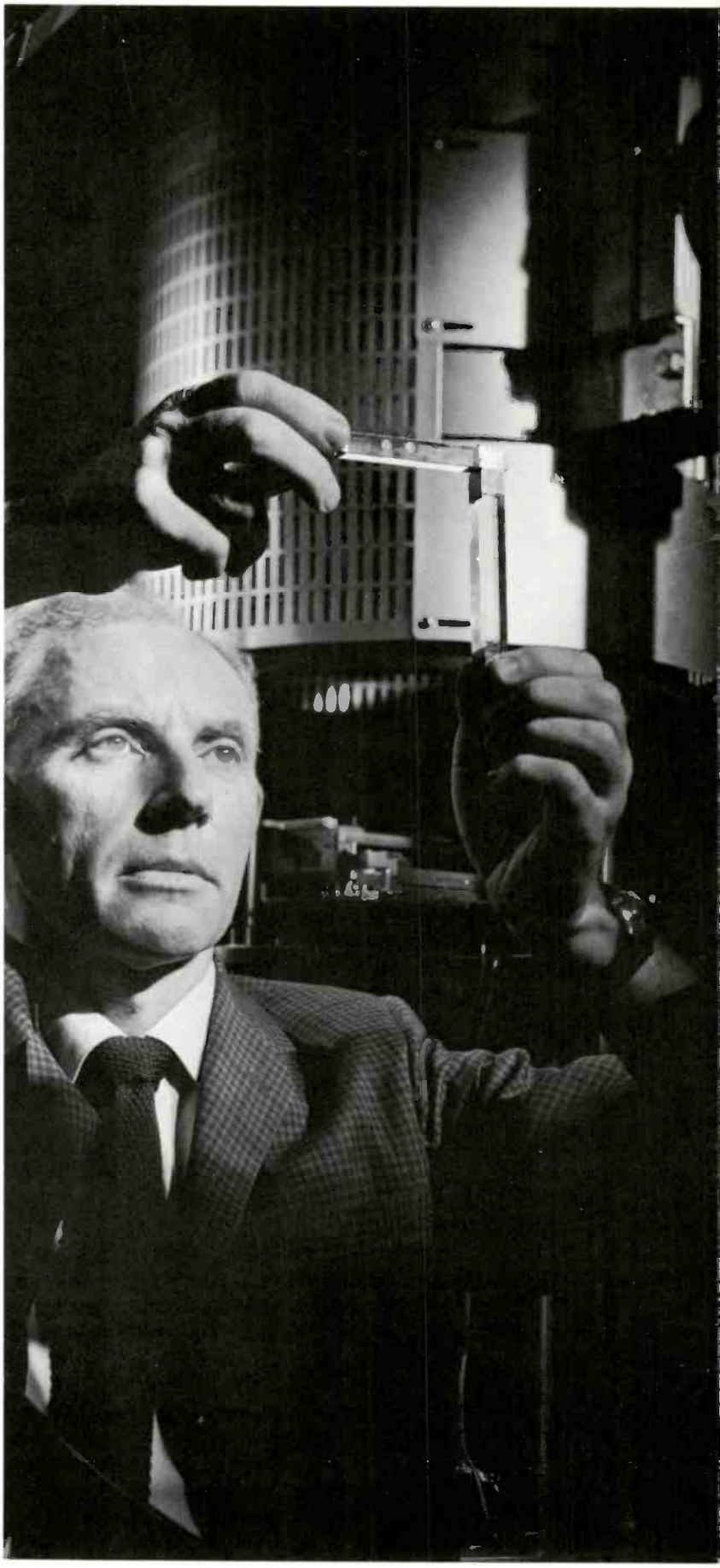
discovered that in semiconductors such as cadmium sulfide, and in superconductors such as niobium tin, these ultrasonic vibrations can have profound effects on free electrons adrift inside.

In cadmium sulfide, for example, they may form an invisible sound barrier that effectively limits the speed of free electrons moving through the material to the speed of sound. The phenomenon is reminiscent of that encountered by the aircraft industry 20 years ago when its airplanes were temporarily denied higher speeds by the sound barrier in the atmosphere.

There are significant differences, however. Whereas the atmospheric sound barrier was viewed as an obstacle to progress by aircraft manufacturers, its counterpart in solids (together with other acousto-electric phenomena) is viewed by electronics manufacturers as promising a new source of ways to amplify, switch, and otherwise control electric currents in solids.

A portion of what lies in store has already been realized through the phenomenon of superconductivity — one form of acousto-electric effect produced in certain metals when they are submerged in frigid baths of liquid helium. This phenomenon has been harnessed successfully to create crushing magnetic fields, to store computer data, to amplify microwaves, and has even been enlisted to track ultrasonic sound waves speeding through certain crystals.

Now, other acousto-electric effects have been unearthed and used experimentally in materials at normal temperatures to amplify sound directly without transforming it first to electric currents, to tune and modulate the intense



Scientist at the David Sarnoff Research Center, Princeton, N.J., holds specially processed quartz rods that may one day lead to the development of a computer memory employing sound as well as electric currents to store millions of bits of information.

light beams of lasers, to stimulate the emission of massive laser-like sound waves from certain crystals, and to probe the atomic structures and energy exchanges that occur in solids generally.

In a superficial sense, of course, acoustics and electronics have been teamed more or less from the inception of the electronics industry. The invention of the microphone, the speaker, and the ultrasonic transducer — and their subsequent application to radio, the telephone, the public address system, movie sound tracks, the stereophonic phonograph, and sonar — testify to that. But, this relationship has always had a brute-force aspect. The sound waves acting on the diaphragm of a microphone or the electromagnetic forces acting on the cone of a speaker trigger sonic vibrations that disturb the whole atomic structure of these devices. In neither of these cases do specific acoustic waves interact with specific electrons in any meaningful way. Sound at these frequencies (10 to 20,000 cycles per second) is a bulk phenomenon like ocean tides.

Even at ultrasonic frequencies up to hundreds of millions of cycles per second, sound is still a bulk phenomenon. But, when its frequencies soar into the billions-of-cycles-per-second range — and especially above 10 billion — its vibrational character acquires a radically new dimension. At these levels, the crests and troughs in the sound waves vibrating along the atomic networks that make up the solid state are so tiny and intense that they begin to interact with individual atoms in the networks and even individual electrons.

In fact, it becomes increasingly difficult to think of these perturbations as sound waves at all. Rather, they begin to assume the character of elementary particles. Accordingly, they have come to be called *phonons* in the same way that light waves are now said to consist of elementary particles called *photons*.

Recognition that such sonic waves, or phonons, can oscillate at these high frequencies may be traced to the work of Einstein, Peter Debye, and others in the early 1920s. In studies of atomic vibrations in crystals, these men noted that sound waves can have frequencies as high as 100 trillion cycles per second, or the equivalent, in electromagnetic terms, of infrared light.

There was no inkling at that time that the passage of phonons through a material was invariably associated with an electrical disturbance, however. That connection was not made until 1953 when Dr. Robert Parmenter, then at the Massachusetts Institute of Technology and now a theorist working on the riddle of superconductivity at RCA Laboratories, jolted scientific circles by suggesting the existence of such a disturbance traveling at the same speed and in the same direction as the sound wave causing it. It resulted, he hypothesized, from tiny electrical imbalances in the atomic structure of the solid occasioned by the bunching and thinning of the atoms in response to the rhythmic undulations of the sound energy.

Dubbed "the acousto-electric effect," its existence was confirmed in 1959 by Dr. Gabriel Weinreich, of Bell Laboratories in Murray Hill, N.J., during experiments on germanium, the raw material of the first transistors.

Two years prior to that, in 1957, the phonon concept came into its own when it was cited by Drs. John Bardeen, Leon N. Cooper, and J. Robert Schrieffer, then at the University of Illinois, as the key factor in producing superconductivity. According to their theory, now widely accepted, superconductivity occurs when electrons fall to such low energies in a material that they join together and travel in pairs. The force that binds them, despite their strong electrical antipathy, derives from the constant exchange of a phonon between them. In other words, superconductive electrons exist as partners locked in a kind of ultrasonic embrace.

A more concrete demonstration of phonon-electron interaction occurred in 1961 when Drs. Andrew Hutson, James McFee, and David White, also of Bell Laboratories, directly amplified sound waves in a crystal of cadmium sulfide by applying an electric field to the crystal. What they got, it turned out, was an ultrasonic microphone-amplifier-speaker all in one.

The following year, Roland Smith, an experimentalist working at RCA Laboratories, discovered further that the mechanism producing this unusual effect also restricts the velocity of free electrons streaming through the crystal to the speed of sound whenever their numbers approach a certain critical density. In 1962, a related effect was seen to occur in the semimetal bismuth by Dr. Leo Esaki of International Business Machines.

As a result of these experiments and the conclusions drawn from them, the following picture has begun to emerge regarding some of the interactions that occur in solids between electrons and high-frequency sound waves.

When an electron slides down the voltage ways, so to speak, of an electrical circuit and splashes into a solid component, it sends shock waves ahead of it just as a ship does when it slides into water. The pressure it exerts as it bumps against the atoms composing the device creates phonon waves (ultrasonic vibrations) forward of its "bow" and a well-defined phonon wake astern. These are in addition to the sonic ripples already naturally present in the material due to internal heat.

In certain instances, the bow waves may reinforce and amplify the sound waves naturally present or some others introduced from outside. In the one case, such amplified waves may be used by scientists to study the physics of the substance or, in the other, to produce the ultrasonic microphone-amplifier-speaker reported by Bell Laboratories.

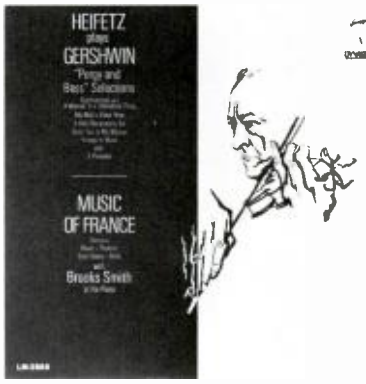
With regard to superconductors, it is not the bow waves but the phonon wake that is of interest. What seems to happen is that the two electrons in each superconductive pair whirl round a common center while floating in each other's wake. They achieve their whirling motion by "surfing" on these wakes, as Hawaiian surfboard riders scudding along the brow of a rolling surge.

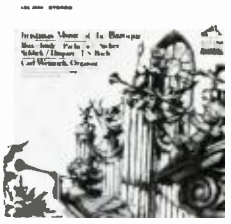
Though intensive investigation of the sound waves known as phonons has scarcely begun, research has already uncovered the sonic electron for amplifying them and the supersonic electron twosomes that use them to produce superconductivity. With still more such effects sure to be found, the conclusion seems inescapable that electrons, unlike children, are often better behaved when they are "heard" and not seen. ■

"THE GREAT RACE": *Music from the film score composed and conducted by Henry Mancini (RCA Victor LPM/LSP 3402).* One of the important motion pictures of the year is the subject of this latest composition by Henry Mancini. The film comedy provides him with opportunity to display a wide variety of invention, and the score abounds in melodies of the sort that made him famous, including "The Sweetheart Tree," a tune that suggests the mood of Mancini's earlier hits, "Moon River" and "Days of Wine and Roses."

"JOHN GARY SINGS YOUR ALL-TIME FAVORITE SONGS": *(RCA Victor LPM/LSP 3411).* In the two short years since his first recording with RCA Victor, the name John Gary has become one of the most popular in the entertainment world, and his albums are instant best sellers. In this very special collection of romantic favorites, Gary sings "All the Things You Are," "Night and Day," "Autumn Leaves," "Some Enchanted Evening," "Deep Purple," and others, giving each song his own unique and haunting treatment.

"HEIFETZ PLAYS GERSHWIN" and "MUSIC OF FRANCE": *Jascha Heifetz, Violinist, with Brooks Smith, Pianist (RCA Victor LM/LSC 2856).* In this album, Jascha Heifetz performs his own transcriptions, first of the lovely melodies in the George Gershwin opera "Porgy and Bess" as well as three Gershwin preludes, then of short pieces from such French Masters as Debussy, Ravel, Poulenc, Saint-Saëns, and Ibert. In each, one finds a delightful revelation of the diversity of Heifetz's talent as the foremost violinist of this era.





For the Records...

NEWS OF RECENT OUTSTANDING RCA VICTOR RECORDINGS

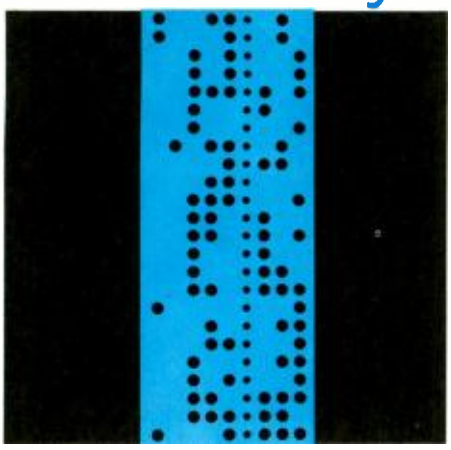
"CAROUSEL": *Original cast recording of the Lincoln Center production, starring John Raitt (RCA Victor LOC/LSO 1114).* When this famous Rodgers and Hammerstein musical was revived by the Music Theater of Lincoln Center last summer, critics acclaimed the production as being superior to the original one of 20 years ago. Mr. Raitt starred in both productions as the ill-fated Billy Bigelow. Eileen Christy, in her first New York appearance, plays the sweet and gentle Julie Jordan. Under the musical direction of Franz Allers, this recording captures the magic of "Carousel" and its top-rate songs. Among them are "If I Loved You," "June Is Bustin' Out All Over," and "You'll Never Walk Alone."

VERDI: LUISA MILLER: *Anna Moffo, Soprano (RCA Victor LM/LSC 6168).* This is the first stereo recording and the only version now available of "Luisa Miller," based on the Schiller play "Love and Intrigue," and composed during the transitional period of Verdi's operatic works. Miss Moffo gives a brilliant performance as Luisa, with the celebrated tenor Carlo Bergonzi as Rodolfo; baritone Cornell MacNeil, mezzo-soprano Shirley Verrett, and bassos Giorgio Tozzi and Ezio Flagello make a splendid supporting cast. Fausto Cleva conducts the RCA Italiana Opera Orchestra and Chorus on this Dynagroove album, which was produced in RCA's Rome studios by Richard Mohr.

BACH: GOLDBERG VARIATIONS: *Peter Serkin, Pianist (RCA Victor LM/LSC 2851).* Probably no other pianist of this generation has created exactly the same kind of excitement as has 17-year-old Peter Serkin. The son of the world-famous pianist Rudolf Serkin, Peter has an enviable musical background, but at the outset of his career he has established that he needs to lean on no one. This is young Serkin's debut solo recital album and his first for RCA Victor. His insight into the music of Bach as well as his technical virtuosity result in a performance that clearly indicates Peter Serkin, an extremely sensitive and gifted musician, is on the threshold of a most important musical career.

OTHER CURRENT RELEASES

Electronically Speaking...



ARTIFICIAL SUNS

Solar simulators, man-made suns, may soon be employed on a wide scale in industry to accelerate development of new and better products for the consumer market and may prove to be of great value in increasing world food production.

The artificial suns may save consumers millions of dollars a year by helping industry improve paints, plastics, fabrics, dyes, and other materials that are constantly exposed to the sun's rays.

Solar simulators accurately reproduce the sun's spectrum over long periods of operation. Scientists are hopeful that these man-made suns will enable them to perform accelerated tests to determine how materials will weather. Such tests are particularly important in developing products that will be exposed to the atmosphere. There the sun performs a Jekyll–Hyde role, being one of man's best friends and worst enemies. The sun sustains life, but its ultraviolet rays cause damage to paints, plastics, and other materials.

The artificial suns have already proved valuable in space research, where every subassembly of a satellite or spacecraft must be thoroughly tested to determine how it will react to conditions existing in space.

TEST CHAMBER DUPLICATES SPACE CONDITIONS

A space environmental test chamber that will permit experiments not now possible with any other facility in operation has been delivered to the National Aeronautics and Space Administration by the RCA Service Company. The chamber, which duplicates the extreme cold and high-vacuum conditions found in outer space, will be used by NASA at its Langley Research Center, Hampton, Va., to test components and future space systems.

The test facility is unique in that its design utilizes a chamber wall that is held below minus 450 degrees F. by circulated liquid helium. This temperature can be maintained even when receiving heat from a test object of up to 1,400 watts.

The chamber proved its excellent vacuum capability by exceeding by approximately 10 times the vacuum specified for it.

LASER RANGE FINDER

The first high-powered laser range finder for use in a missile-tracking system has been delivered to the U.S. Navy. It will provide an accuracy of plus or minus two feet at ranges up to 10 miles, a capability well beyond that of radar.

The new laser will emit 50-million-watt peak power pulses of light at a rate of 10 per second and will provide high-rate digital range data to a Navy computer for computation of missile trajectory. Built by RCA's Aerospace Systems Division, the laser range finder will be used to furnish highly accurate range information on missile flights.

Like radar, the laser range finder determines the distance to an object by measuring the time taken by its pulses of energy to travel to the object and back.

"DIAL-A-LESSON" EDUCATIONAL SYSTEM

An electronic system that will in effect provide "homework via television" is being installed at Oral Roberts University, Tulsa, Okla. The "dial-a-lesson" system will permit students to utilize televised playback of prerecorded study material. The student, seated in a booth equipped for study by electronics, may wish to review one of the prerecorded lectures listed in a numerical directory. To do so, he will dial the appropriate number to trigger a playback device, and the lesson will be reproduced pictorially on a viewing screen or as sound in earphones or both.

Dr. Paul McClendon, Director of Learning Resources for the university, said the system initially would have 130 study carrels — 100 equipped for both audio and video reception and 30 for audio only. He foresees extension of the system in the future to include dormitory rooms — perhaps as many as 1,000 — so that the recorded lessons would be available on a 24-hour basis.

The RCA electronic learning system at Oral Roberts University will have one TV production studio, and there will be at least six other locations to which mobile TV cameras and other equipment could be rolled for TV recording assignments.

Dr. McClendon noted that TV equipment would be put to a novel use in a "performance analysis studio." Students studying public speaking, acting, and similar courses would be able to record on video tape their appearances before TV cameras. Since the tape can be played back immediately, the student could evaluate his performance on the spot.

The electronic education program also calls for a mobile television unit to serve the science labs. Television cameras will be used with light microscopes, enabling an entire class to share the magnified view of a specimen.

NEW ELECTRON MICROSCOPE

A new electron microscope, capable of regularly distinguishing objects as small as 1/30 millionth of an inch in diameter, has been introduced by RCA. The new model — the EMU-4 — is the first electron microscope to make extensive use of solid-state circuits, a design feature that accounts for its reliability. Like its predecessor model, the new electron microscope can magnify objects to as many as 200,000 times their size. If an aspirin tablet were seen in its entirety at this magnification, it would appear as a powdery hill a mile in diameter.

Building-block construction, another innovation, permits the use of plug-in modules with the new instrument. These modules, which perform a single function or several related functions, can easily be removed and replaced.

A new photographic facility in the EMU-4 holds 18 photographic plates, partial loads of which can be removed without breaking the instrument's vacuum. This gives the microscopist immediate access to exposed plates and improves the microscope's productivity.

ABOUT OUR WRITERS

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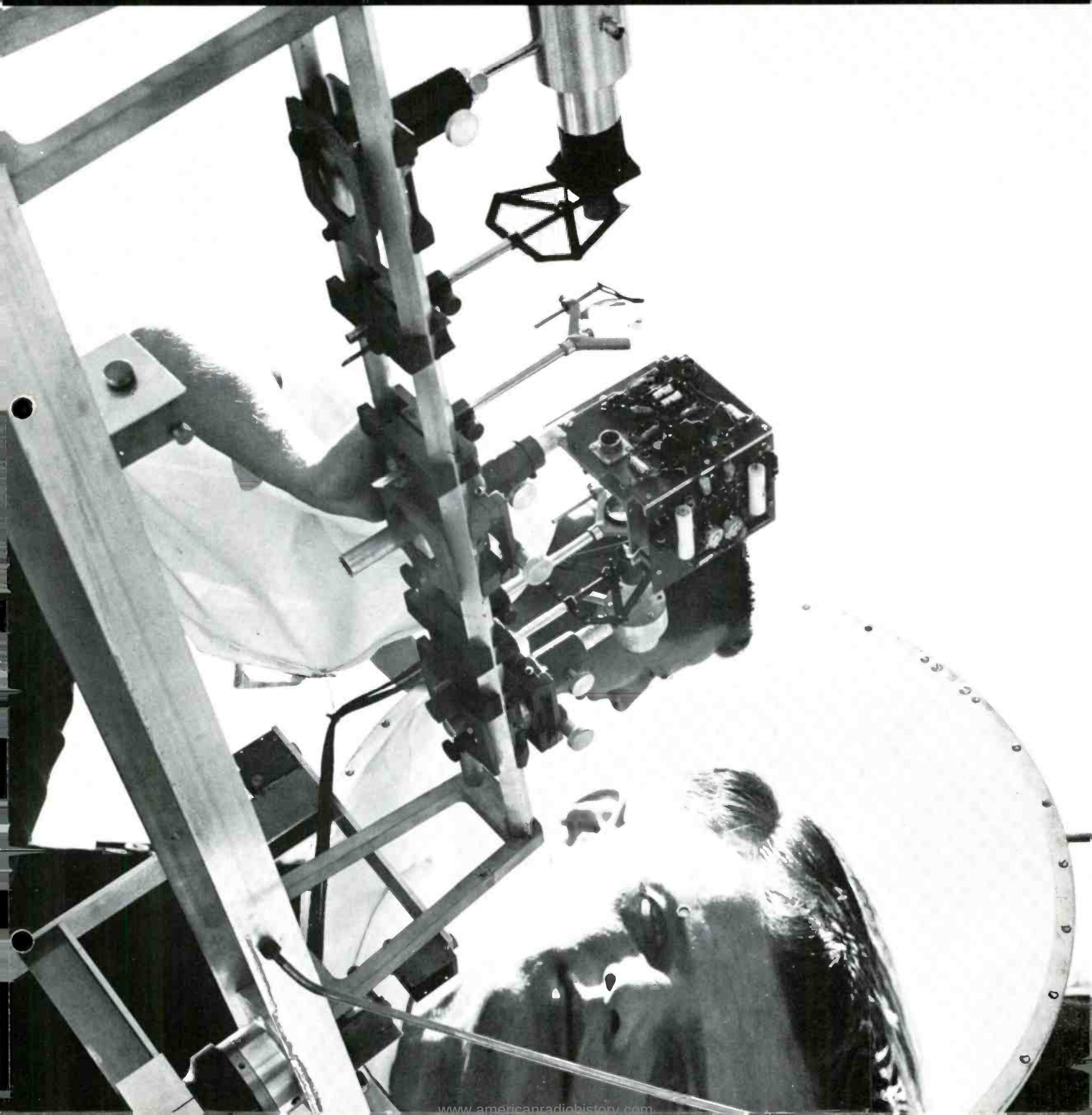
Mars communications is the purpose of this RCA experimental laser device. Called a "sun-pumped" laser because it is powered by the sun's rays collected in the parabolic mirror, the device was developed by RCA's Applied Research organization, Camden, N.J., for NASA's Manned Spacecraft Center, Houston, Tex., as the first step in a 50-million-mile communications link between spacecraft near Mars and Earth. The device is believed to be the first to transmit television pictures over a light beam from a laser powered by sunlight.



ELECTRONIC AGE

RCA *Autumn 1965*

The Boston Symphony Orchestra recording "Lohengrin" for RCA Victor