Introduction

RCA today is among the nation's largest industrial corporations, and one of the most broadly based enterprises in the field of electronics. In achieving this position, it has pioneered in the development of an art and industry which has compressed within a brief span of years a degree of business growth and technical progress that seldom is achieved in less than a century.

The history of RCA, related in the articles that follow, is an account of dynamic industrial growth. Among the forces responsible for this achievement have been the leadership and vision of David Sarnoff, Honorary Chairman of the Board of RCA, and the outstanding array of research, engineering, production, and marketing talents which have thrived in the technical and business environment which he and his colleagues have done so much to foster and maintain through the years.

The first of these articles was written more than 25 years ago. So rapid has been the evolution of both RCA and the electronics industry that many of the events described read like ancient history. Even the trade names familiar to a large public in the 1920's have vanished almost beyond recollection today. Very few will recall, for example, the Graphanola, a popular phonograph produced by the Columbia Talking Machine Company around 1922. When this article was written in 1938, television was still a daring experiment, the ultra-high frequencies were in their infancy, and the vast area of solid-state electronics was yet to be opened.

The author, John Chester Warner, was himself an intimate part of the scene which he describes. He was Vice President of the Radiotron Division, RCA Manufacturing Company—and in the same year in which the article was written he met a tragic and untimely death in an automobile accident at the age of 42. Through the 1920's, Warner had been associated closely with receiving tube research at the General Electric Company in Schenectady. In 1932, following the separation of RCA from the General Electric and Westinghouse companies, he was appointed Manager of research and development at the RCA Radiotron Company in Harrison, N.J. He was named Vice President of Radiotron in 1934, a year before the organization became the Radiotron Division of the new RCA Manufacturing Company.

The author of the three subsequent articles was uniquely qualified to chronicle the further development of RCA. Before his retirement in 1969 after more than 45 years as an RCA employee, Dr. Elmer William Engstrom held several important executive assignments, and directed most of RCA's principal research and engineering programs through three decades to the early 1960's.

During the 1930's, Dr. Engstrom directed the research and development program which transformed television from a series of experiments into a practical service. In 1942, he became Director of General Research and subsequently Director of Research at the newly organized RCA Laboratories in Princeton, N.J., where he led an outstanding program of RCA wartime research. Elevated to a Vice Presidency in 1945, he entered upon a series of increasingly responsible executive assignments extending to all of the technical activities of the corporation, becoming, successively, Executive Vice President, Research and Engineering, and Senior Executive Vice President of RCA. On December 1, 1961, Dr. Engstrom was named President of RCA, serving until January 1, 1966, when he was appointed Chairman of the Executive Committee of the Board. He was succeeded by Robert W. Sarnoff who is now Chairman of the Board and Chief Executive Officer.

Dr. James Hillier, author of the latest installment, is likewise an intimate part of the scene he describes. As Executive Vice President, Research and Engineering, he is responsible for research and development throughout the corporation.

Dr. Hillier first came into prominence for his contributions to the development of the electron microscope and for his subsequent role in encouraging the growth of electron microscopy as a research technique.

He joined RCA in 1940 as a research physicist at Camden, N.J. Working with a group under the direction of Dr. V. K. Zworykin, television and electronics pioneer, Dr. Hillier designed the first commercial electron microscope to be made available in the United States.

In 1953, he was appointed Director of the Research Department of Melpar, Inc., returning to RCA a year later to become Administrative Engineer, Research and Engineering. In 1955, he was appointed Chief Engineer, RCA Industrial Electronic Products, with responsibility for directing the corporation's engineering activities related to industrial systems, broadcast equipment, communications systems, and other major nonmilitary electronics.

In 1957, he returned to RCA Laboratories as General Manager, and a year later was elected Vice President. He was named Vice President, RCA Research and Engineering, in 1968, and in 1969 he was appointed to his present position.

The Editors

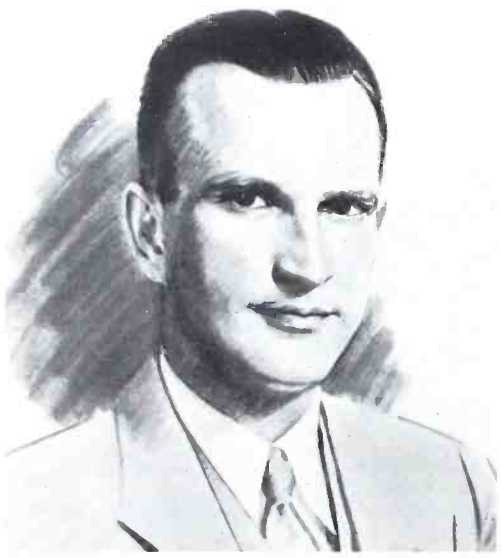
RADIO CORPORATION OF AMERICA

PART I—THE YEARS TO 1938

*By **J. C. WARNER**

Vice President (1934-1938), Radiotron Division,
RCA Manufacturing Company, Inc.

*Article written in 1938



J. C. Warner

IT WOULD BE misleading for me to imply that anything approaching a complete history of the Radio Corporation of America could be covered in the brief time which we can spend together. While the company is only a little over 18 years old several volumes would be required to do a really thorough job. However, I shall try to review some of the high points in the history of the company, and to cite the progressive changes in organization and their relation to the progress of the company in radio and allied fields.

It has often been said that "the story of the Radio Corporation of America outlines the larger story of the radio era," i.e. the era of radio broadcasting. Peculiarly enough the company was not organized with radio broadcasting in mind, although it is significant that the man whose name is so closely associated with the history of RCA and who has for many years been its active head, had clearly visualized the possibilities of radio broadcasting service and even "electric tuning" long before broadcasting made its first appearance. I refer, of course, to Mr. David Sarnoff.

RADIO—A NEW COMMUNICATIONS SERVICE

At the close of the war the only company in a position to handle commercial transatlantic radio communications was the Marconi Wireless Telegraph Company of America, although the stations which it had operated before the war were in the hands of the Government who had taken over all such stations for wartime purposes. This company was an offshoot of the British Marconi Co. and was largely owned by English interests.

At this time the best known means of long distance transmission was the Alexanderson high frequency alternator, the patents on which were owned by the General Electric Company. Negotiations between General Electric and the American Marconi Company, which had started several years previous, but had been interrupted by the war were resumed in 1919 for the purpose of transferring patent rights as well as alternators to the Marconi Company which was anxious to expand its transatlantic services.

Certain high officials of the Government learned of these negotiations and were unwilling to see a growing communications service under foreign control, particularly since the transatlantic cables were in the hands of foreign, though friendly, nations. Consequently they suggested to the General Electric Company that negotiations be suspended until after discussion with the Navy Department. This was in April 1919 and it is interesting to note that the letter to the General Electric Company was written by Mr. Franklin D. Roosevelt, then Acting Secretary of the Navy.

FORMATION OF RCA

As a result of conferences with the Navy a plan was developed for forming a new American company to take over the assets of the American Marconi Company. So, on October 17, 1919, the Radio Corporation of America was incorporated, and on November 20, 1919 the entire business of the Marconi Company was taken over.

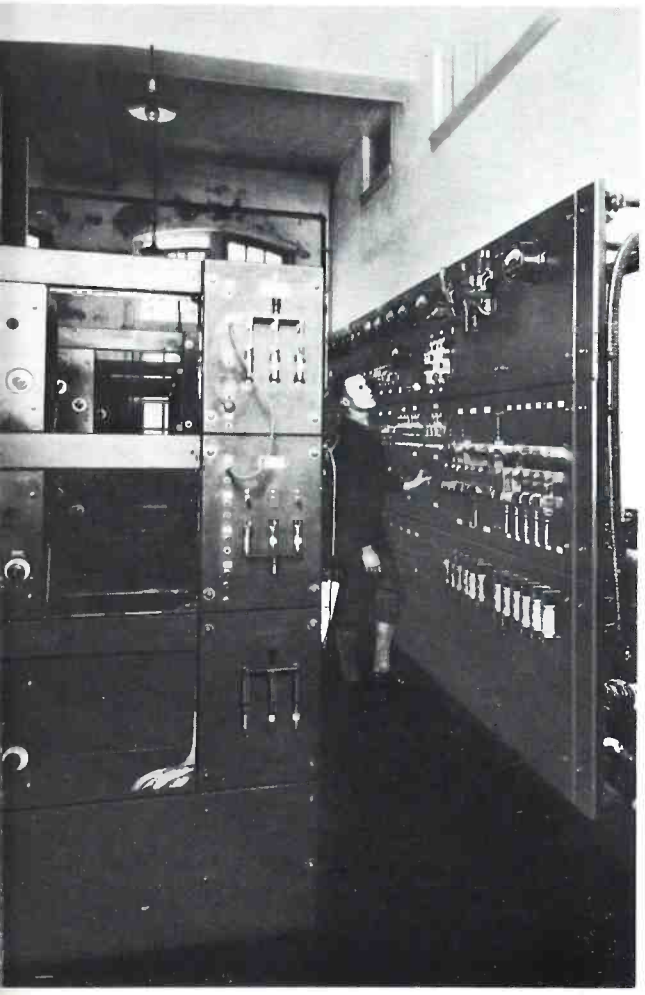
GE held a substantial interest in the new company, and immediate arrangements were made between RCA and GE to cross-license each other to use the radio patents of the GE Company and the patents RCA had just acquired from Marconi. Work was started at once on new high power alternator stations in California, Massachusetts and Hawaii.

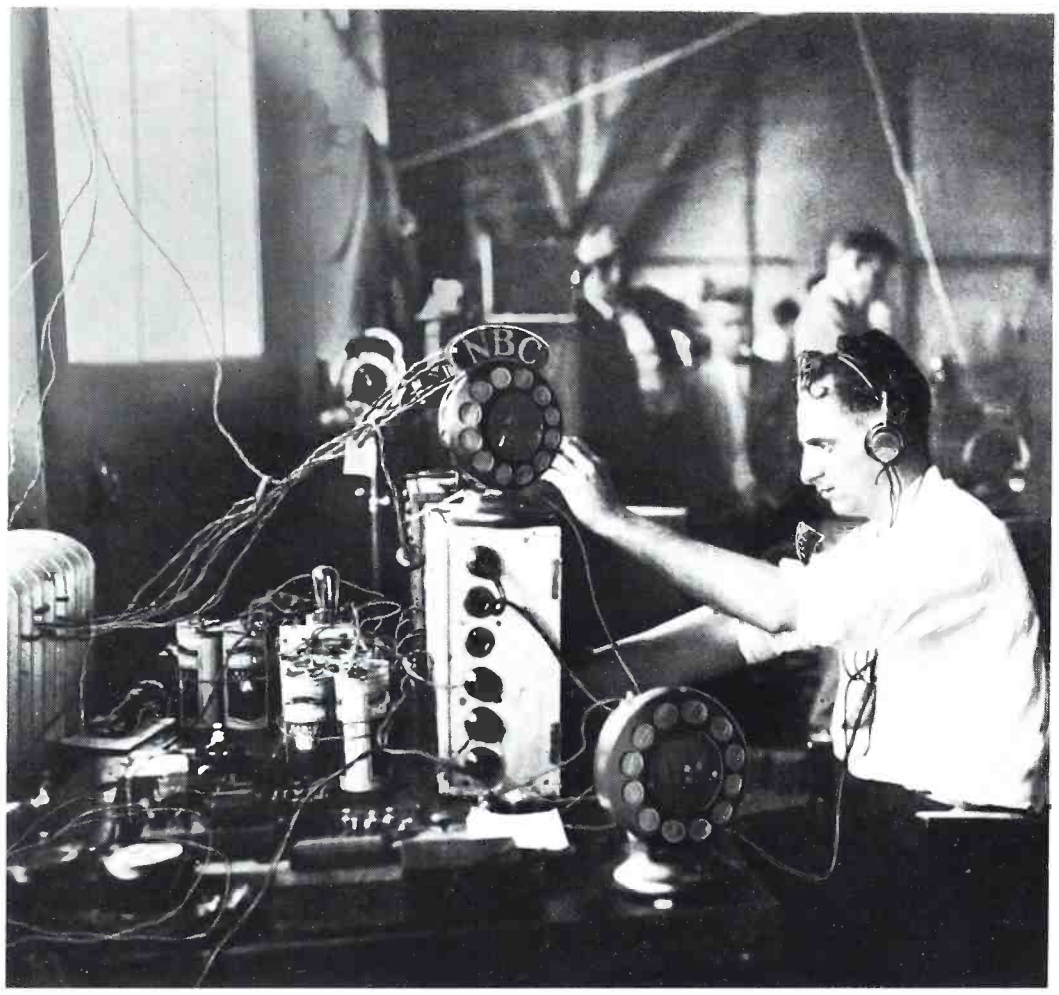
But another patent deadlock soon appeared particularly with respect to vacuum tubes. The possibilities of long distance shortwave communications were unknown at this time. In fact, wavelengths under 200 meters were relegated to the supposedly unimportant use of amateurs. But, tube transmitters were needed for medium power services and, of course, tube receivers were essential.

Strong patents on vacuum tubes were held by both GE and the Western Electric Company, but neither could make effective use of its own patents without infringement of the other's. Again the Navy lent a hand and persuaded the GE Company and AT&T Company to come to an understanding "For the good of the public." This was in January 1920.

TRANSOCEANIC SERVICE BEGINS

In February 1920, the stations which had been taken over from the Marconi Company by the Government during the war were turned back to the new RCA, and a foreign communications service were inaugurated. One of the principal stations was in New Brunswick, N. J., and the long-wave antenna there has no doubt been seen by a great many of you. During that year,





Two scenes of early communicatians and braadcasting activities.

foreign service was established with England, Germany, France, Norway, Japan and Hawaii.

In July 1920 an agreement was reached between RCA, GE, and AT&T which permitted RCA to proceed with the use of all radio patents of these companies.

BEGINNING OF BROADCASTING

During the first year of the RCA attention was directed almost exclusively on communications, but in 1921 the first rumblings of what soon was to become a broadcasting boom began to be heard. A number of experimenters had been playing with the idea of transmitting phonograph music over somewhat crude telephone transmitters.

WESTINGHOUSE JOINS RADIO GROUP

Westinghouse had done a certain amount of radio experimentation in its laboratories, and shortly after the formation of RCA began to consider going into the radio field. A subsidiary company was set up known as The International Radio Telegraph Company which had acquired a large group of Fessenden patents from the old National Electric Signaling Company. Consideration was given to going into the communications business, but difficulties were encountered in that the important European stations were all tied in with the stations of the Marconi Co. now held by RCA.

To strengthen their position Westinghouse acquired a group of Armstrong and Pupin patents, among which was the Armstrong "feed-back" patent later to become quite famous. Finally, in 1921, a cross-license agreement was made between RCA, GE and Westinghouse, and Westinghouse now became a member of the radio group.

BROADCASTING BEGINS

Meanwhile, strenuous efforts were being made to get broadcasting started. The pioneer licensed station of the United States, and of the world, was KDKA, of the Westinghouse Company, in Pittsburgh, licensed by the Department of Commerce on October 27, 1920. This station broadcast election returns in November of that year. RCA first entered this field on July 2, 1921, when a one-day broadcast was made from a temporary station at Hoboken, N. J., on the occasion of the Dempsey-Carpentier fight. Soon after, RCA opened station WDY at Roselle Park, N. J., which continued for some months, when it was shut down on account of interference with station WJZ of the Westinghouse Company in nearby Newark. RCA then went in as halfpartner with Westinghouse in the management of WJZ. Broadcasting was really on its way.

WIRELESS SPECIALTY COMPANY

Another corporate element entered the picture in 1921, the Wireless Specialty Apparatus Company. This was a Massachusetts concern largely occupied in making apparatus for the Tropical Radio Company, which in turn was a subsidiary of the United Fruit Company, and which operated coast and ship service for the large United Fruit fleet. GE bought into Wireless Specialty, and again made license arrangements which cleared up a few more of the patent obstacles to RCA's progress.

A FORMATIVE PERIOD

These first two years cover what might be called the formative period of RCA. It was a period during which all of the important American companies which could play a part in the development of the radio field of that time were brought into a workable relationship.

It was a fortunate coincidence that the end of this two year period came just at the threshold of the development of the new broadcasting industry. In fact it is a fair statement that without the removal of the many previous obstacles, broadcasting itself would never have developed on a national scale in such a short time.

RCA ENTERS MERCHANDISING FIELD

Just prior to the start of broadcasting RCA had given thought to furnishing apparatus to radio amateurs both for reception and transmission. As broadcasting appeared, the line of amateur apparatus was expanded as quickly as possible to include home broadcast receiving equipment, and RCA now entered the merchandising field with GE and Westinghouse as manufacturers son with the present. For that reason I shall digress for a few moments to describe some of the things which where offered for sale. The catalogue was entitled "Radio Enters the Home," and since in this period every man had to be his own serviceman all the accessories imaginable were included as well as many parts for the experimenter to make his own set.

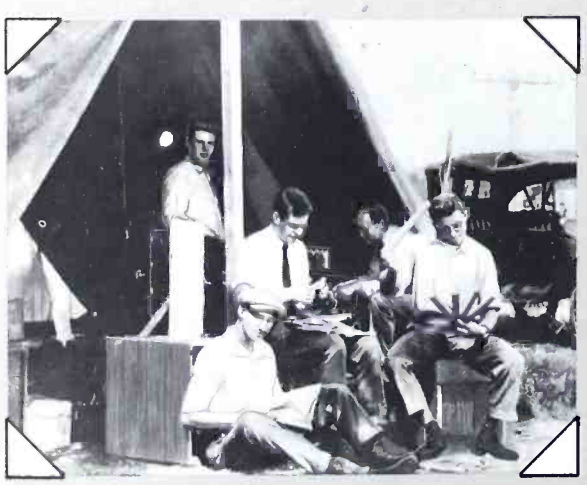
The cheapest receiver listed was a steel box containing a single-circuit tuner and crystal. This sold for $25.50 with headphones, antenna equipment and "full instructions." More elaborate crystal sets were available at $32.50 and $47.50. The cheapest tube set was the one-tube "Aeriola Senior" made by Westinghouse—it used a WD-11 tube in a regenerative circuit and sold for $75.90 with batteries and antenna, and for $65.00 without the accessories. This was a very popular set in its day and it is quite likely that a few of them are still in use.

GE supplied a set made in steel boxes. The two units comprised a tuning system in one box and a three-tube were four ballast tubes to avoid use of a filament rheostat. No emphasis was placed on the number of tubes since the practice of stressing this had not yet appeared. This set sold for $401 with all accessories.

The only loudspeaker shown was similar to a brass automobile horn with a telephone receiver on the end—which sold for $30.00. It is interesting to note that a phonograph attachment was available at $18.00 which consisted of a telephone receiver element to be attached to the tone arm of the phonograph so as to get the equivalent of a loudspeaker. There were two models—one for Victrolas and the other for Graphanolas.

FIRST RADIO TUBES

At this time RCA sold four types of receiving tubes. Two were made by Westinghouse and two by GE. The Westinghouse tubes were designed and manufactured in East Pittsburgh and the GE tubes were designed in their Research Laboratory at Schenectady and manufactured in two of the GE lamp factories, one at Nela Park,



First RCA labaratory (1919) was located at Riverhead, Long Island

Broadcast stations in the farmative years were crude by present standards

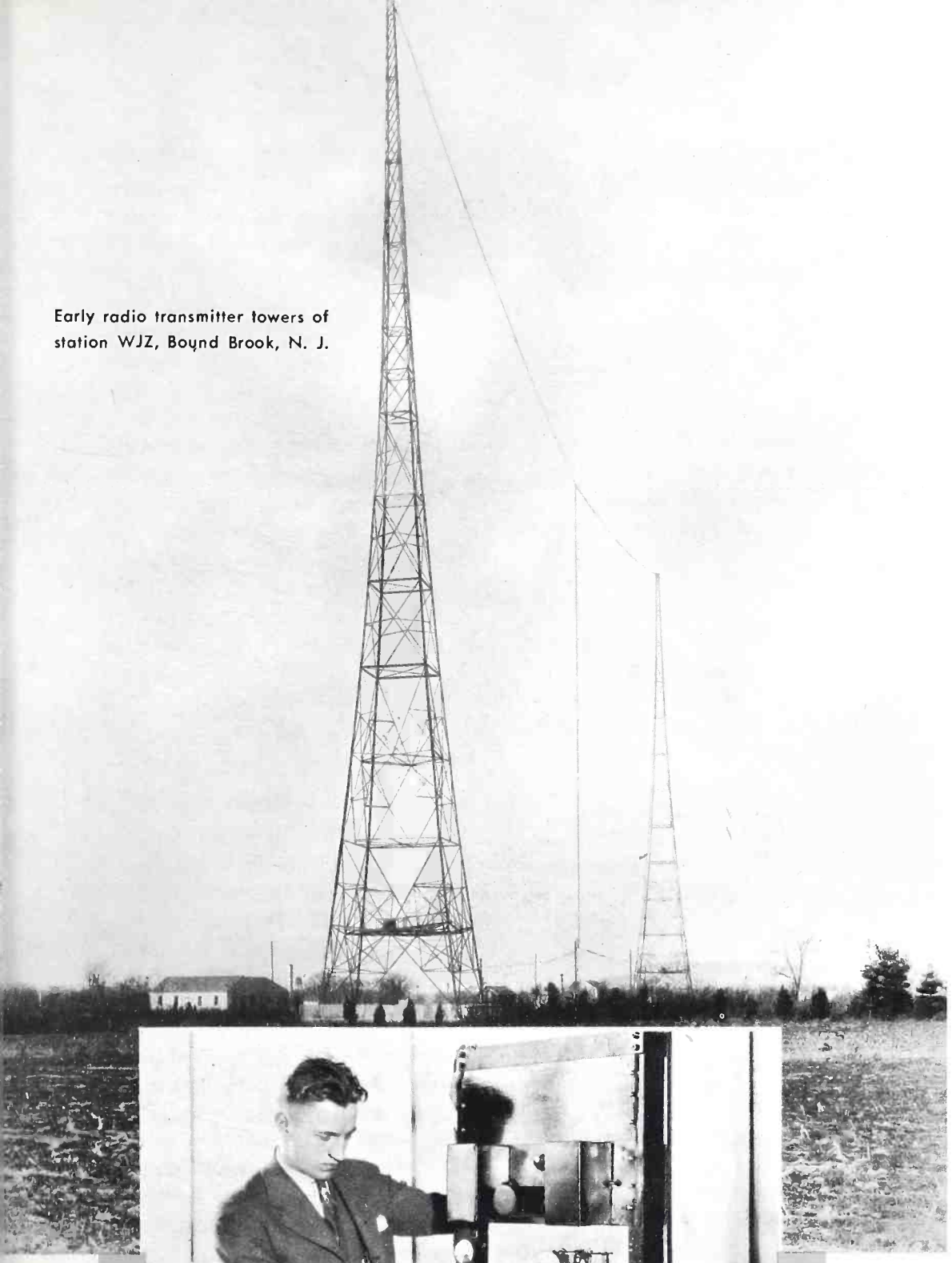
Early recording sessions were waxed without electronic processing methods

(Wireless Specialty also furnished a small amount of apparatus for a time). As later developed, this arrangement had many disadvantages but remember that at the time it was probably the only way in which the RCA could get started. It was, so to speak, a condition of RCA's birth.

In 1922, RCA got out a catalogue of radio equipment which well illustrates the conditions of that day in comparidetector-amplifier in the other box, and sold complete for $250.00. Westinghouse supplied a somewhat similar receiver in a wooden box at $261.75. This also comprised two elements, one of which was a single circuit tuner, the other a detector-amplifier.

The most elaborate set was the "Aeriola Grand" made by Westinghouse. This had four tubes, a regenerative detector and, in addition, there Cleveland, and the other in the Edison Lamp Works at Harrison, the same plant which is now the Radiotron Works of our own company.

Tubes were also sold by E. T. Cunningham, Inc., first on the West Coast, and later throughout the country. Mr. Cunningham for some years had been making tubes for amateurs on the West Coast, and seeing the possibilities of merchandising tubes on a large

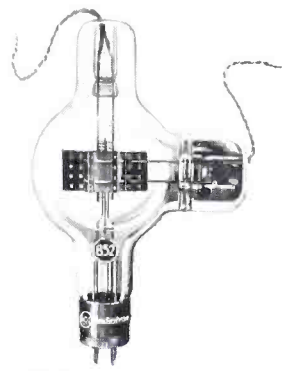


Early radio transmitter towers of station WJZ, Bound Brook, N. J.

Lester J. Wolf is shown with a developmental quartz crystal frequency standard at Westinghouse, 1928-29.

Original studio and operating room, station WBZ, Springfield, Mass., in 1921.

WD-11 Detector Amplifier—1920



852 Transmitting triode—1927

scale he entered into an arrangement with RCA in 1920 which gave him the right to sell tubes under his own name. They were the same as RCA tubes but had different type numbers.

RCA PROGRESSES IN ALL FIELDS

The years 1923, 1924 and 1925 brought numerous advances in the RCA fields. To mention only a few—in 1923 two broadcasting stations were opened by RCA in New York and one in Washington. In 1925 the first WJZ transmitter was installed at Bound Brook, N. J. Short-waves came into use for long distance communications, first to supplement the high power long-wave transmitters, and later to take over practically all of the long distance service. Trans-oceanic communications were extended to additional European and South American countries. The first superheterodyne receiver was brought out in 1924. In 1925 a receiver was sold with accessories permitting it to be operated from alternating current. In the same year the electrodynamic loud speaker was brought out. Apparatus was developed for recording and reproducing records electrically. Improvements were made in tubes greatly reducing the power consumption.

In 1925, RCA furnished certain components to the Victor Talking Machine Company which were built into a radio-phonograph combination employing a single speaker. This is significant as the first step in very important later developments.

RCA ONLY A SELLING AGENCY

Remember, that during this period and for several years after, in the merchandising field RCA itself was only a selling agency. The manufacturing was done entirely by the electric companies. Receivers were made at Schenectady by GE and at East Pittsburgh by Westinghouse. Receiving tubes were engineered at East Pittsburgh and Schenectady, and were made in GE lamp factories at Cleve-

UX-222 Sharp-Cutoff Tetrode—1927

247 Power Pentode 1931

land, Harrison, and later at Newark—also in Westinghouse factories, at East Pittsburgh, Bloomfield, N. J., and later at Indianapolis (in what is now our Indianapolis Plant).

It must already be evident that the problems of coordination began to be tremendous. RCA first utilized the electrical laboratory of the City College of New York, which was in charge of Dr. Alfred N. Goldsmith, to test new models of apparatus. This was quickly outgrown and the Technical and Test Department of RCA was established in its own building at the edge of Van Cortlandt Park in New York. Here samples of apparatus were submitted independently by GE and Westinghouse, tested and reported back to the manufacturing companies, with approval or suggested changes.

It soon became necessary for RCA to have the same apparatus regardless of which company made it. In the case of tubes it was particularly essential to have uniform designs from all factories so they could be interchangeable in any receiver. Of course, this was long before the time tubes were shipped in sets.

EFFORTS ON COORDINATION

In an attempt to accomplish this necessary coordination, "design" or "standardization" committees were set up separately for receivers and tubes, comprising representatives of GE and Westinghouse. The tube committee which started in 1924 perhaps best serves to illustrate the unwieldiness of such an arrangement, which I will describe in some detail.

This committee was known as the Radiotron Standardization Committee. It was made up of representatives from East Pittsburgh, Cleveland, Schenectady, Bloomfield, and Harrison—two and sometimes three from each. It met once a month around the circle and attempted to arrive at agreements on tube designs, ratings, characteristics, and even some production problems. It had no direct representation from the receiver divisions so the coordination with them was supposedly handled by the East Pittsburgh and Schenectady tube representatives, and the ideas and needs of the receiver engineers carried to the tube meetings. The main committee carried with it a train of sub-committees and coordination groups intended to handle specific technical items. Needless to say this kind of an arrangement was in many ways unsatisfactory, yet it is difficult to visualize any better method under the then existing company relationships.

The "Design" committee on receivers operated in much the same way as the tube committee, but with some advantage in having only two groups involved. It finally became necessary to set up an additional receiver coordination committee which included RCA representation. One of their first subjects of discussion in 1927 was the "Radiola 16," and another model which became the "Radiola 17," which was the first real a-c receiver using a-c tubes.

The loss of time inherent in the inter-company committee method of coordination was a major handicap to progress in engineering, manufacturing, and sales, but it remained until new major changes in organization came to pass, as we shall see later.

FORMATION OF NATIONAL BROADCASTING COMPANY

Going back to 1924, the AT&T was actively developing the use of wire lines for furnishing programs to broadcast stations and they set up WEAF as the source of these programs. In 1926 RCA and its associates took steps to integrate a complete broadcasting service and formed the National Broadcasting Company. This was a recognition by RCA officials that this new service had the possibilities of an important industry and that a specialized organization was necessary to develop programs, to install new stations and to maintain a satisfactory continuous service to their own as well as other stations.

The new company acquired station WEAF from the AT&T, and also took over the stations owned by RCA and thereby created the real beginning of the network broadcasting industry.

RCA LICENSES OTHER RADIO COMPANIES

In 1927, a major step was taken in a new direction, the licensing of other manufacturers under RCA patents. It was inevitable that the demand for broadcast receivers would lead other companies into the business, and a large number had by this time become established. The granting of licenses to these companies strengthened their position, but at the same time gave RCA a rightful return for its huge investment in patents obtained through the research and engineering of the radio group and also by purchases from other inventors.

At first the superheterodyne patents were not included in the licenses. Also it was not until two years later that tube licenses were granted, although a number of lamp and other manufacturers were actively making tubes.

RADIOMARINE COMPANY FORMED

Late in 1927, the ship-to-shore telegraph business of the RCA, which had been growing steadily, was segregated into a new subsidiary company—the Radiomarine Corporation of America.

RCA PHOTOPHONE ORGANIZED

In 1928 a new offshoot of the radio business appeared. For several years work had been going on in the GE laboratories to perfect a system of recording sound on film. This was now ready for commercial exploitation in the motion picture industry and RCA Photophone Company was organized to handle this business.

RCA PURCHASES VICTOR COMPANY

1929 was a year of far-reaching changes in the organization of the RCA group which constituted the first major step towards integration of the company into a self-contained, self-controlled radio business.

I have mentioned already some of the handicaps inherent in the arrangements whereby RCA did the selling while the other companies manufactured. This method was wholly inadequate to meet the quick moves of the independent competitor. Furthermore, the electric companies naturally wanted to make a profit and so did RCA. This seriously handicapped the coordination of sales and production which is so essential to the success of an entire operation. RCA needed its own manufacturing facilities.

The "Radiola II", an early radio marketed by RCA at the start of the '20's. The word "Radiola" was cained by Dr. Alfred N. Galdsmith in a note to General Sarnoff supporting his concept of a "Radio Music Box" for home entertainment.

The Victor Talking Machine Company at Camden had been seriously affected by the growth of radio and had not been particularly successful in its attempts to enter the radio field. In order to obtain manufacturing facilities RCA purchased the Victor Company including the manufacturing plant, what was left of the phonograph business, and the Victor dog trademark. Arrangements were also made whereby RCA took over tube manufacturing from GE and Westinghouse. RCA acquired the entire Edison Lamp Works property of the GE at Harrison, and also the Westinghouse factory at Indianapolis, and at the end of the year the RCA Victor Company and the RCA Radiotron Company were organized.

RCA COMMUNICATIONS FORMED

In this same year the RCA Communications Company was formed to take over all of the business in transoceanic communications.

CONSOLIDATED RESEARCH, ENGINEERING, MANUFACTURING AND SALES

In 1930 RCA completed the consolidation in the RCA Victor and Radiotron companies of all facilities of research, engineering, manufacturing, and sales of RCA products which now for the first time included phonographs and records. Somewhat later, in 1932, the Photophone business also was taken over by the RCA Victor Company.

Licenses were now being granted to tube manufacturers and the superheterodyne patents were included in the set licenses. Agreements had also been made with a number of foreign radio manufacturers giving RCA rights under their patents and in some cases access to their laboratories.

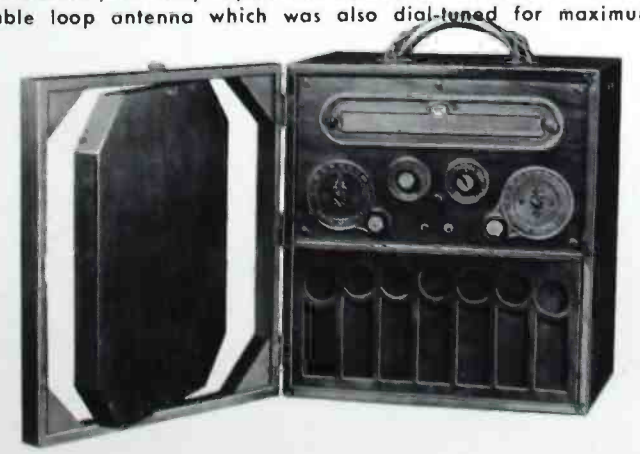
CUNNINGHAM COMPANY BOUGHT

In 1931 the E. T. Cunningham Company was taken over by RCA and consolidated with the RCA Radiotron Company, giving RCA rights to the use of the Cunningham brand and bringing Mr. Cunningham into the RCA organization.

ELECTRIC COMPANIES WITHDRAW

The second and final step toward an independent RCA took place in 1932. In 1930 the Government had brought suit against RCA attacking certain exclusive features of the inter-company agreements, and as the result of a consent decree all the stock interest of GE and Westinghouse in RCA was disposed of by those companies. AT&T had disposed of its stock interest in RCA some years before. Modified cross-license patent agreements were entered into with the approval of the Attorney General and the sanction of the Court. RCA now became a completely self-contained organization with wholly owned subsidiary companies operating a broadcasting business, a communications business, a marine radio business, a radio school, and a manufacturing and merchandising business.

The "Radiola 26", an early superheterodyne portable receiver. The lid contained a rotatable loop antenna which was also dial-tuned for maximum sensitivity.



DE FOREST COMPANY PURCHASED

In 1934 the tube business was augmented by the purchase of certain patents from the defunct De Forest Radio Company. This brought about the beginning of transmitting tube manufacturing by RCA Radiotron.

RCA VICTOR AND RCA RADIOTRON MERGE

In 1935, the manufacturing and merchandising business was further consolidated by the merger of the RCA Radiotron and RCA Victor Companies which now became the RCA Mfg. Co.

IMPORTANCE OF DIVERSIFICATION

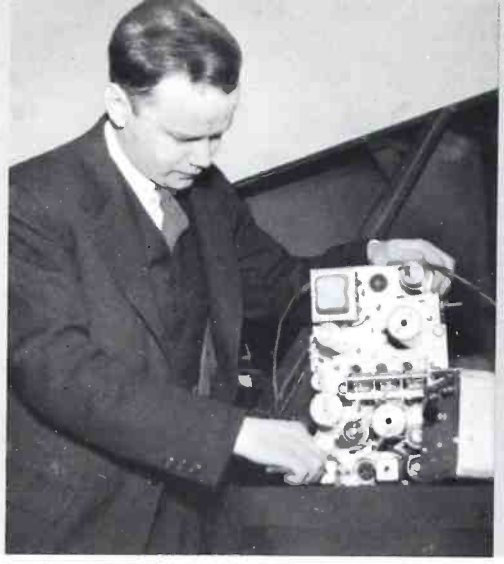
Before concluding I want to emphasize one phase of the history of RCA which so far I have mentioned only indirectly, yet which stands out with clearness and significance in the whole course of the 18 years of RCA's life. I refer to product diversification. A study of the history of RCA is well worth while if it does no more than demonstrate the value of diversification, and its paramount importance to us in looking toward the future.

The corporate history is a sort of family tree in which certain elements contributed at the start, but which were later separated from the new growth. I shall use another horticultural analogy to illustrate product diversification.

Certain varieties of trees are responsive to wide differences of training. Two plants may sprout from the ground exactly alike, side by side. One of them may be trained to grow perfectly straight with a central trunk and beautiful symmetry. The other may be trained into a large bush-like growth with many branches.

Two companies may also start in

John B. Coleman inspecting a transmitter in Camden, ca. 1936.



Dr. Elmer W. Engstrom working on a radio receiver in a Camden research laboratory in 1934

Clarence A. Gunther is shown making receiver tests in a Camden laboratory, ca. 1935.

the same way from small beginnings. One may be concerned with a single product or a narrow field while the other grows many branches, large and small. We may have a great admiration for the tall straight tree, but if a storm comes along and breaks off the top it may be years before it recovers its original form. The same storm has little effect on the other tree. It may pass over without harm or even if a few branches are broken they may be trimmed off without showing.

The one-product company may do admirably in times of prosperity and we may envy its simple operation. But if it meets with changing conditions or times of depression the "one product" may no longer be in demand and the company has nowhere to turn.

Suppose that back in 1921 RCA had said "No, we aren't interested in radio entertainment, we are in the commercial communications business." Again suppose RCA had looked at talking pictures and said "No, we aren't interested, we are in the radio business." Again, after acquiring the Victor Company suppose RCA Victor had said "We will let the phonograph business die. It doesn't amount to much and we want to sell radio receivers." There are several obvious answers to these suppositions, but the uppermost in our minds probably is that if these things had happened most of us wouldn't have our jobs.

PUBLIC SERVICE IS PARAMOUNT

The strength of a company is in a large measure proportional to its service to the public. The RCA has grown as it has extended its fields of public service. It will continue to grow just so long as it utilizes its variety of resources to give the public new or better services, or new or better products.

It should never be forgotten that a by-product often becomes a main product. Again, the limitations of a product or service today may turn into advantages of tomorrow. The often alleged lack of secrecy in radio communication was once talked of as a handicap, but broadcasting, as its name implies, made good use of this so called handicap.

RESEARCH INSURES PROGRESS

Research has played a major part in the evolution of the RCA and must continue to do so. I use the term not alone in a technical sense but broadly —research in sales methods, in advertising, in relations with the public, in better understanding and organization of our personnel, as well as in engineering and manufacturing of our products.

Research provides the new food which the tree needs when the old is exhausted or no longer suitable. The tree must grow or it will die and a company must go ahead or back. It never stands still. RCA has made good use of its resources to expand its fields of activity. But it is a safe prediction that if we live up to our opportunities we will some day look back at 1938 and see that we have now only started to scratch the surface. Facsimile is barely started. Television is still ahead of us. Commercial Sound applications are getting under way. A multitude of ultra-high frequency applications are certain. And outside the radio or entertainment fields the field of electronic devices is in its early infancy.

I hope that this brief story of the RCA has served to show something of how far we have come but more important, how much farther we can go in the future.

The "Radiola 17"—the first a-c radio. The receiver contained six tubes plus rectifier and operated on a tuned radio-frequency principle

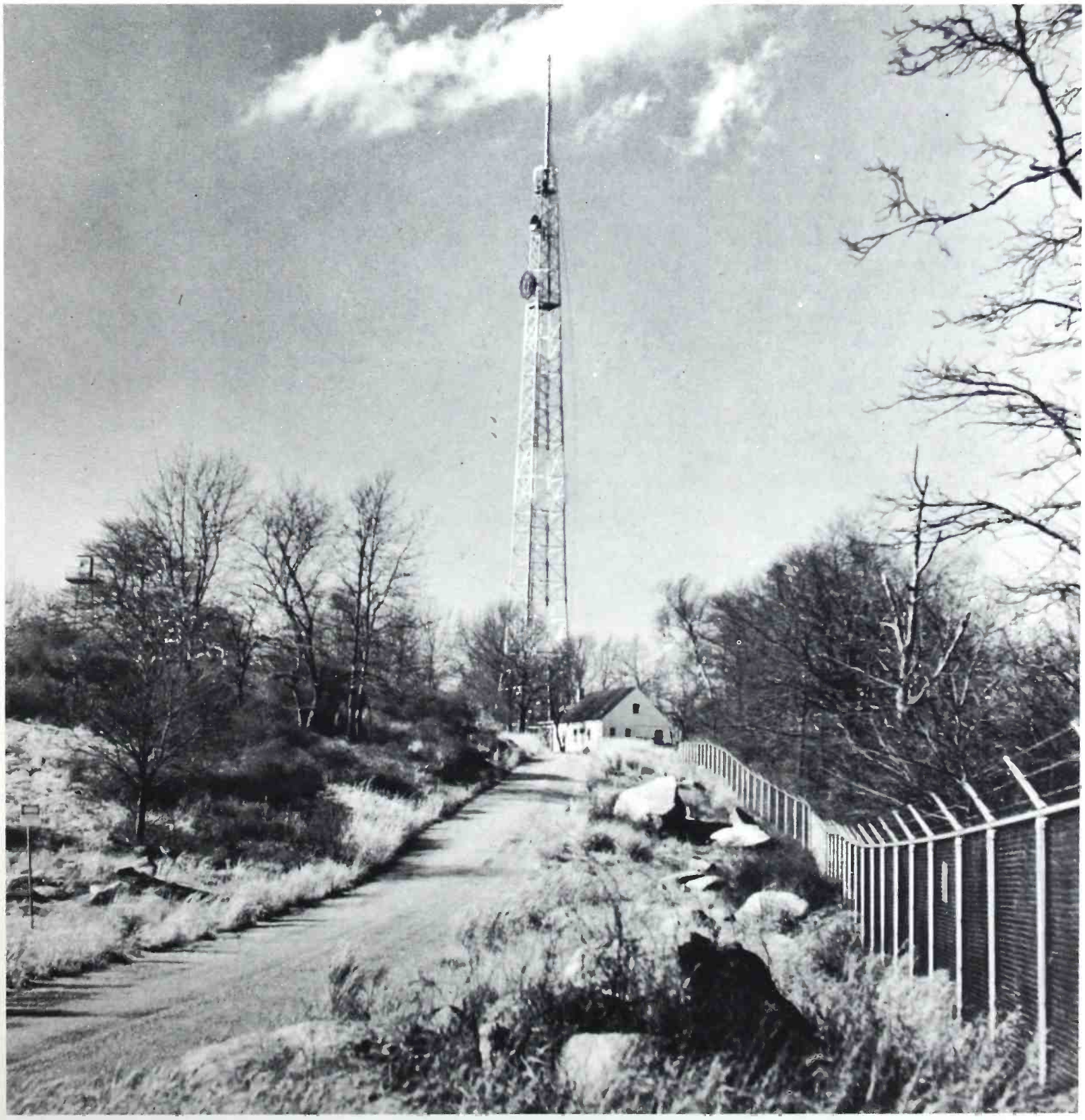
RADIO CORPORATION OF AMERICA

PART II—THE YEARS 1938—1958

* *by* **DR. ELMER W. ENGSTROM**
Senior Executive Vice-President
Radio Corporation of America

** Since this article was written in 1958, Dr. Engstrom was made President, RCA, and then Chairman of the Executive Committee of the Board. He is now retired.*

Pioneering efforts by RCA contributed much to the expansion of television service into the UHF spectrum. Shown is RCA's tower and transmitter building of KC2XAK, the first licensed experimental UHF station at Bridgeport, Conn. After the experiments were completed, the tower and antenna were shipped to Portland, Ore. to be put on the air as part of KPTV, the first commercial UHF television station in the world.



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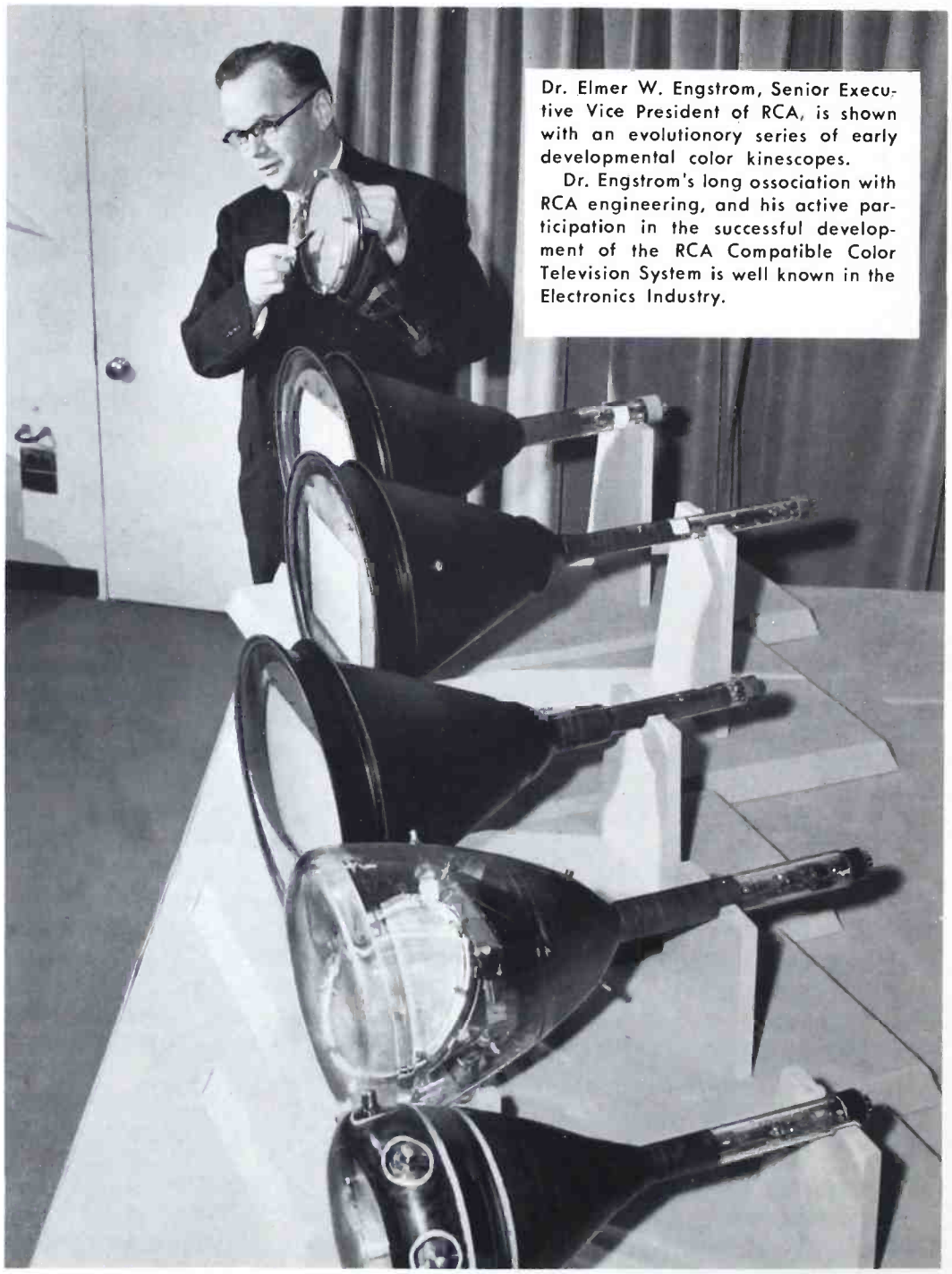
*by **DR. ELMER W. ENGSTROM***
Senior Executive Vice-President
Radio Corporation of America

AS A HISTORIAN writing in 1938, the late J. C. Warner, then Vice President, Radiotron Division, of the RCA Manufacturing Company, undertook to review the first 18 years of RCA's corporate life. His concluding words at the time were: ". . . if we live up to our opportunities we will some day look back at 1938 and see that we have only started to scratch the surface."

None of us associated with Warner in 1938 would have disagreed with this estimate. At the same time, it is doubtful that anyone could have foreseen the phenomenal growth that has marked the second 18 years of RCA's existence. From a $100 million corporation in 1938, RCA soared to the billion dollar corporate rank in 1955, a position it maintained in 1956 and 1957. In 18 years, its plant and equipment multiplied six times in value and the total number of employees quadrupled, to some 80,000 persons.

More significant than this impressive growth was the basic change in the nature of the Corporation itself. In 1938, RCA was in transition from a radio communications concern to a broadly diversified electronics organization with a growing interest in such new fields as radar, television, and airborne electronics. Today it has become an outstanding research, engineering and manufacturing enterprise, holding a position of leadership. The second 18 years of RCA not only have lived up to the opportunities which Warner referred to in 1938 but have created a host of new and exciting opportunities for the future.

Shortly after Warner had published his review, two events occurred which were to influence profoundly the future of the Corporation. In April, 1939, seven years of intensive research, engineering development and field testing by RCA culminated in the introduction, at the New York World's Fair, of the first public television service. Four months later, Hitler's assault on Poland and the declarations of war by England and France opened the Second World War.



Dr. Elmer W. Engstrom, Senior Executive Vice President of RCA, is shown with an evolutionory series of early developmental color kinescopes.

Dr. Engstrom's long ossociation with RCA engineering, and his active participation in the successful development of the RCA Compatible Color Television System is well known in the Electronics Industry.

The official inauguration of television service was the harbinger of a new era in mass communications, but it required a keen eye to see in the actual event the shape of the nation-wide television service we know today. It was an extremely limited service, covering only the New York metropolitan area, and operating on the "experimental" basis authorized by the Federal Communications Commission. Programs emanating from the NBC transmitter atop the Empire State Building were viewed on a relative handful of 9-inch direct view and 12-inch reflection-type receivers produced at Camden for sale in the New York area.

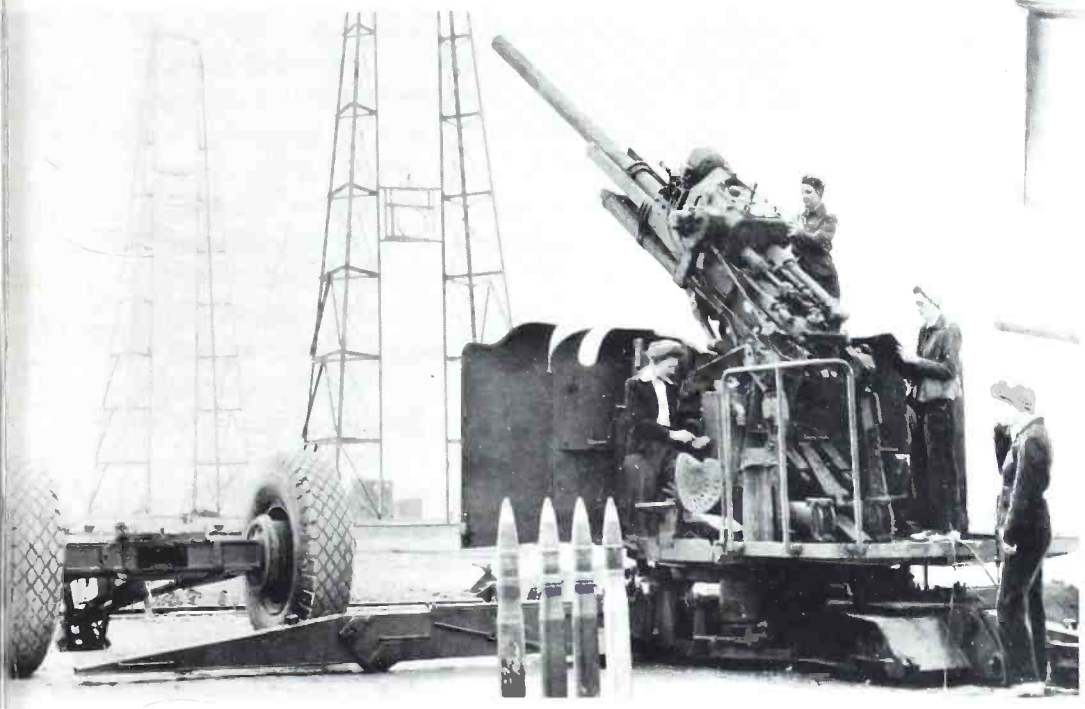
Standing before the Iconoscope cameras in front of the RCA Building at the World's Fair on April 20, David Sarnoff announced the beginning of regular television service by NBC. And he added:

> "Now we add sight to sound. It is with a feeling of humbleness that I come to this moment of announcing the birth in this country of a new art so important in its implications that it is bound to affect all society . . . This miracle of engineering skill which one day will bring the world to the home, also brings a new American industry to serve man's material welfare . . ."

RCA IN WAR

The outbreak of World War II effectively halted the further progress of commercial television. The clear need

Described as second only to the A-bomb as the most effective weapon to come out of World War II, the Variable-Time fuse for artillery and naval projectiles consisted of a 5-tube transceiver which detonated the shell at its moment of maximum effectiveness. RCA manufactured over half the total production of V-T fuses.



During World War II, RCA electronic equipment was used in testing muzzle velocities of large-coliber guns ot Aberdeen Proving Grounds. A magnetized shell wos fired through two detecting coils, and the time difference was converted into muzzle velocity.

for military preparedness led to increasingly heavy demands through 1940 and 1941 on industrial research, engineering and production facilities both for American forces at home and for Britain and France through the Lend Lease program. RCA, with long experience in communications and with a pre-war record of major contributions in the important military areas of radar, underwater sound and airborne electronics, was in the forefront of this program from the start. By the time of the Japanese attack on Pearl Harbor in December, 1941, virtually all of the Corporation's facilities were devoted to military requirements for radio equipment, radar, special tubes, acoustical devices and navigation systems.

The increasing demand for military electronic equipment led, early in the war, to several important changes in RCA's organization and facilities to expedite research, engineering and production. The first of these related to the RCA research organization.

During the 1930's RCA's research facilities had been concentrated largely at the manufacturing plants in Camden and Harrison in addition to the communications research groups on Long Island. By late 1940, the growth of defense activities had generated a need for increased staff and facilities, both for research and manufacturing. At the same time it was recognized that the research program could benefit from a separate environment in which the laboratories might physically be brought together to obtain better coordination and direction. Thus, in March, 1941, the research staffs were incorporated as a new department called RCA Laboratories. Concurrently, work was started on a new research center at Princeton, New Jersey, approximately mid-way between the Camden and Harrison operations.

Dedicated in September, 1942, the new building—the present David Sarnoff Research Center—provided the RCA research staff for the first time with complete modern facilities in an environment fully conducive to creative research. Further, it provided a physical as well as an administrative unity impossible under previous conditions.

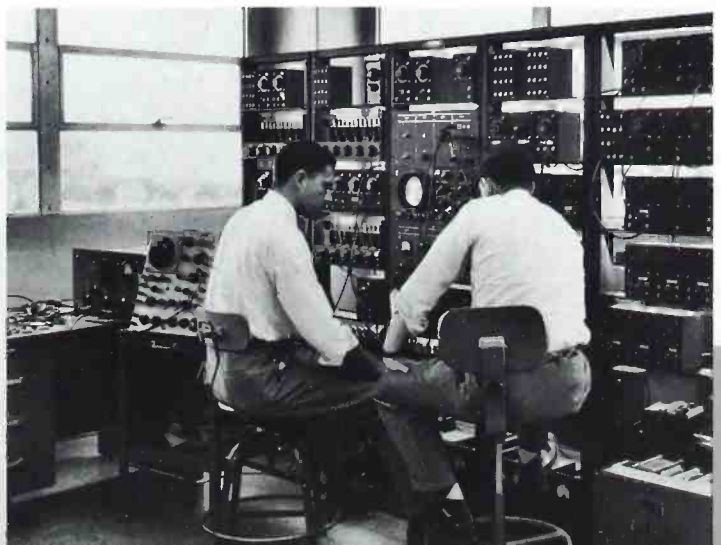
In addition to the new research center at Princeton, expansion early in the war included new facilities for production. Advances in military electronics, particularly in such high-frequency applications as radar and microwave communications, led to a greatly increased demand for special purpose radio and electron tubes. To meet this need, the U. S. Navy undertook construction of a large new plant at Lancaster, Pennsylvania, to be operated by RCA. Completed in 1942, the plant operated at full capacity through the war to produce hundreds of thousands of tubes for military applications. At the war's end, it was purchased from the Navy by RCA.

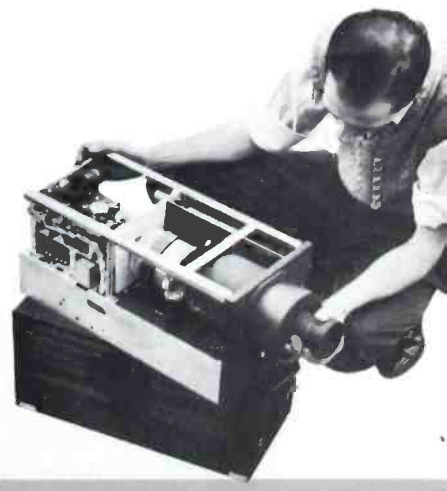
A further organizational change of significance was made in December, 1942, to achieve closer coordination of all RCA manufacturing activities. The RCA Manufacturing Company, established in 1935 as a wholly owned subsidiary of RCA, was consolidated with the parent Corporation to become the RCA Victor Division, comprising all of the Corporation's tube and electronic equipment production facilities.

CONTRIBUTIONS TO VICTORY

The contributions to victory of the divisions and services of RCA, in research, engineering, production and

RCA has continued its active participation in military electronics in post-war years. Engineers are shown here with computer equipment at the Moorestown Missile and Surface Radar Engineering Plant.





Experimental RCA "Block" television equipment was developed and tested during World War II for various airborne applications. This compact equipment was the forerunner of modern miniature television systems.

service were extensive, varied and distinguished. Although the list is too long for more than brief mention, it includes the following:

RCA Laboratories: New devices, systems and techniques including the Shoran navigation and blind-bombing system, airborne radar equipment, electronic fire control, and airborne television equipment for aircraft, and guided missiles.

RCA Victor Division: Design and quantity production of tubes and electronic equipment including 200 types of electron tubes and 350 types of electronic apparatus. Among the large-quantity items were some 20 million miniature tubes and five million proximity fuses. Outstanding among types of equipment were radar altimeters, sound-powered telephones, battle announce equipment and R/F power generators.

RCA Communications: Initially providing the only means of communication with the war zone, RCA Communications worked closely with the Government to keep vital networks in operation.

Radiomarine Corporation: Produced more than 40,000 major units of marine radio equipment, comprising 42 different types of radio and radar apparatus for installation on merchant and supply vessels.

RCA Institutes: Trained thousands of Army, Navy and Marine servicemen in radio and electronic techniques.

National Broadcasting Company: Provided world-wide coverage of military operations for broadcast to the public and developed many special morale programs. Television facilities, more limited than radio, were turned to morale and instruction purposes.

The outstanding performance of the various RCA divisions through the war was recognized by seven Army-Navy "E" pennants, two U. S. Navy Bureau of Ordnance Flags, the U. S. Maritime Pennant, the Victory Fleet Flag and 27 stars for continued excellence in operations.

RETURN TO PEACE

With the return of peace in 1945, RCA found itself, with all other electronics manufacturers, in a vastly changed environment. World War II had triggered a swift transformation in electronic technology. Research and engineering led to major advances in high-frequency techniques, in electronic systems development, in electron optics and in other fields of future peace-time importance.

The post-war environment for the industry was characterized by two totally novel features—a far more versatile and sophisticated technology than in the pre-war years, and a substantial increase in the number of participating and competing companies. Moreover, this greatly expanded art and industry faced a tremendous demand for its products and services from a public recently released from war-time austerity.

Plans for converting its research, engineering and production facilities to a peace-time basis were undertaken by RCA during the late stages of the war, when it had become apparent that victory was at hand. As a result, the process of conversion was rapidly carried out after V-J Day. Within eight weeks, RCA Victor plants at Bloomington, Indiana, and Camden were producing radios for the civilian market. Before the end of 1945, commercial tube production had been resumed at Harrison. By mid-1946, production of television picture tubes and tubes for broadcast transmitters and industrial uses was under way at the newly acquired Lancaster plant.

One organizational development of importance in the conversion pattern was the establishment, in February, 1945, of the RCA International Division. In anticipation of an expanded foreign market for electronic equipment, the new division was given responsibility for distribution of products manufactured by RCA, the operation of foreign subsidiaries, and coordination of all RCA international activities.

POST-WAR TELEVISION

Full attention could now be given to the expansion of a civilian television system which literally had been nipped in the bud by World War II. The pre-war sharing with other manufacturers of RCA's television research and engineering experience and the availability of important technical developments to RCA licensees had made possible a broad manufacturing base for home receivers. By 1941, standards for the present television system also had been worked out by the National Television System Committee, an industry group, and approved by the FCC.

Thus, by the end of the war, television not only was ready for commercial application; it also was a better system, because of research and engi-

Early NBC experiments with televising on-the-spot news events provided invaluable technical and artistic experience which paved the way for the post-war television boom.

An overall view of the record-changer and amplifier assembly lines at RCA Victor's factory at Cambridge, Ohio. The plant, world's largest producer of packaged hi-fi instruments, has fifteen assembly lines capable of turning out 6,000 sets in an eight-hour shift.

neering advances achieved for military purposes. Among these were a more sensitive camera tube — the Image Orthicon; more powerful transmitting equipment operating over the full bandwidth allocated to commercial service; improved picture display techniques based on radar developments during the war, and effective network relay techniques.

Television activities resumed on a large scale during 1946, when the first network was opened, linking NBC facilities in New York and Washington by co-axial cable, and including Philadelphia and Schenectady.

It also was during 1946 that the RCA Victor Division placed the first post-war television sets on the market. The basic model was the famed 630TS, with a ten-inch picture tube. Marketed at a price of $375, the 630TS' economy, reliability and high quality swept it into immediate popularity. The nation's first quantity produced and marketed receiver, it was television's equivalent of the "Model T." As much as any other single factor, the 630TS was responsible for the swift appearance of television in American homes during the early post-war years.

The pre-war practice of sharing with other manufacturers the results of RCA television research and engineering experience also was resumed vigorously. Engineering data relating to the 630TS was made available to other manufacturers in conjunction with industry symposia held at Camden. The result was a rapid growth of television production by many organizations in the industry.

Another factor in television growth was the initiation of large scale picture tube production at the Lancaster plant during 1946. By 1948, nonetheless, receiver sales had expanded so rapidly that a shortage in picture tubes threatened to develop. This was minimized by RCA's ability to supply tubes from the surplus accumulated at Lancaster during the previous two years in anticipation of just such an emergency.

Further expansion of RCA manufacturing facilities, extension of the NBC network, and improvements in the television system itself characterized the years after 1946. A new plant for tube manufacture was acquired at Marion, Indiana, and placed in operation during 1949. In February, 1950, the RCA Victor Division produced its one-millionth home television receiver. At the same time, the size of the picture tube steadily grew larger, expanding in 1949 to the 16-inch metal cone, to 19 inches in 1950, to the popular 21-inch size by 1952. The NBC network, keeping pace with the growth of home television, reached rapidly across the nation to link principal cities in all of the 48 states. From the four-station network of 1946, it has grown today to more than 200 network affiliates.

COLOR TELEVISION

As the commercial television system expanded, RCA undertook an energetic post-war program of color television research and development. Although mechanical techniques offered promise in terms of early commercial advantage, RCA decided, soon after the war, to strive for an all-electronic color system fully compatible with black-and-white. Outstanding progress was achieved at RCA Laboratories during 1947 and 1948. Several demonstrations were held, showing a color system employing three kinescopes and combined with an optical system to present a composite color picture.

In 1949, the FCC scheduled a series of hearings to consider, among other matters, the establishment of standards for color television transmission. At issue were two competing systems—a non-compatible mechanical system of color, and the all-electronic compatible color system advocated by RCA.

As the hearings progressed, the research staff of RCA Laboratories, supported by engineering groups at the tube plants at Harrison and Lancaster, moved with full speed to the development of the final basic element in the compatible system—a single tube capable of producing pictures in full color. The result of this extraordinary effort, demonstrated publicly in March, 1950, was the tri-color kinescope, one of the outstanding achievements in early post-war electronics. In the words of General Sarnoff: "Measured in comparison with every major development in radio and television over the past fifty years, this color tube will take its place in the annals of television as a revolutionary and epoch-making device . . . As the master key to practical color television, it is an outstanding development of our time."

Despite the basic technical superiority of all-electronic color transmission, the FCC gave its approval to the mechanical, non-compatible system. In effect, this banned the compatible system from the market place.

Through court actions, RCA vigorously sought reversal of the FCC decision. Meanwhile, it proceeded with further refinements in compatible color transmission. In December, 1953, the FCC finally approved new and compatible standards recommended by the NTSC.

While receiver and tube production forged ahead, color broadcasting equipment was speeded to television stations. By October, 1955, 111 stations of the NBC network alone were equipped to broadcast in the new medium. Today the compatible color system embraces roughly half the stations in America and is capable of reaching 96 per cent of the nation's television homes.

In 1949, television, now firmly established as a national broadcast service, moved in a new and significant direction. Development by RCA scientists of the small and highly sensitive Vidicon pick-up tube opened vast opportunities for closed-circuit television for industry and education.

OTHER DEVELOPMENTS

If television, in all its aspects, was perhaps the most spectacular of the early post-war electronic developments, by no means was it the only one. A dramatic transformation in which RCA played a dominant role, was under way in the phonograph and recording fields. In 1949, the Corporation introduced its 45-rpm system of recorded music, including the fastest automatic record changer ever devised.

By the end of the year, 45-rpm records of unbreakable vinyl plastic were being produced at the rate of more than 25,000,000 annually and the number doubled in 1950. That year also saw the introduction, by RCA, of a three-speed record instrument.

The growth of popular interest in high-fidelity music reproduction spurred a number of other RCA contributions to the new form of home entertainment. Among these was the LC1A duo-cone speaker, placed in

RCA's all-electronic compatible color television was a Corporation-wide cooperative engineering development. Shown here is Loren R. Kirkwood (Manager of the Television Division's Color Receiver Engineering at Cherry Hill) with a line of developmental color receivers.

production a year after its debut, in 1947, at the Berkshire Music Festival. In 1953, RCA introduced two high-fidelity "Victrola" phonographs designed for the mass market. At the same time it began to market a complete line of high quality "intermatched" components for home assembly.

NATIONAL SECURITY

World War II, which saw the development of jet aircraft, radar, sonar, the V-2 rocket and other weapons of high complexity and growing effectiveness, presaged a new era of military technology in which electronics would play a determining role. Any doubts as to the need to maintain a strong military posture, supported by the latest technology, moreover, were dispelled by the militant agressiveness of the Soviet Union.

Thus RCA, which emerged from the war as one of the nation's foremost contributors to military progress, continued to devote a significant proportion of its research and development to problems of advanced military technology.

Its work for the Government included a variety of development and production projects in such fields as sonar, advanced radar apparatus and fire control. In 1950, for example, RCA Laboratories completed for the U. S. Navy the development and construction of the world's largest and most accurate electronic analogue computor to evaluate the performance of guided missiles, airplanes, ships and submarines.

When war in Korea erupted in 1950, RCA's activities in the fields of military electronics increased sharply. The Government field service activity of the RCA Service Company stepped up to such an extent that by the end of the year, approximately twice as many trained field engineers were assigned to military activities as at the peak of World War II. In manufacturing, new projects for the military included equipment in the fields of electronic sound, sonar, missiles, navigation and communications.

This, in turn, necessitated additional plant expansion, devoted wholly or in large part to defense purposes. Cincinnati; Los Angeles; Woodbridge and Moorestown, New Jersey; and a new engineering laboratory at Waltham, Massachusetts, were some of the sites for these new RCA facilities. In 1954, announcement was made of what was to become one of the most significant RCA contributions to national defense—the beginning of RCA Service Company maintenance and analysis of electronic guidance apparatus for missiles at the Air Force Missile Test Center at Cape Canaveral, Florida.

The extent and scope of RCA's military electronic activities may be gauged from some of the projects in which it was engaged during 1957, such as, instrumentation radar, the Talos Defense Unit, and the "Telemite" television camera, fitting the palm of a man's hand.

ORGANIZATIONAL CHANGES

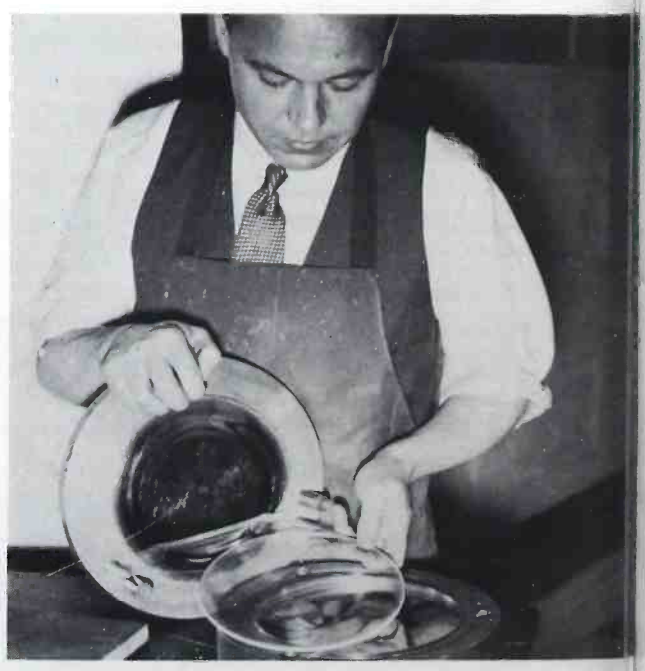
The expansion by RCA into these many areas of electronics was paced by a comparable realignment and extension of RCA executive and administrative functions.

In July, 1947, following the retirement of Lieut. General James G. Harbord, David Sarnoff was elected Chairman of the Board of Directors of RCA. The following year, Frank M. Folsom was elected President of RCA.

Keeping in step with the needs of a steadily expanding business in a constantly changing industry, 1954 saw a series of sweeping revisions of the Corporate structure. The RCA Victor Division, formerly responsible for all RCA manufactured products, became two separate groupings, RCA Consumer Products and RCA Electronic Products, each under the direction of an executive vice-president. RCA Sales and Service Subsidiaries formed a third grouping. The importance of RCA Laboratories to the progress of the Corporation was recognized by the elevation of its position in the Corporate structure. Behind these basic changes was the purpose of intensified research, expanded manufacturing capacity and greater diversity of output.

THE REVOLUTION IN MATERIALS

Underlying the Corporation's growth and change after 1950 was a revolutionary transformation in the nature of electronics itself, resulting from fundamental advances in the field of new materials and their application. These opened the way to new devices, techniques, and systems that previously were impossible of achievement, either technically or economically.



A major development which made projection television practical was the development of a molded-plastic aspherical correcting lens for the Schmidt-type optical system. Iaury G. Maloff (currently with the Television Division's Advanced Development Engineering at Cherry Hill) is shown removing a lens from a mold.

Throughout the 30's and 40's, basic research interest grew in the field of physics of the solid state. This was fundamental to the forthcoming rapid advance in the use of electronically-active solids—the semiconductors. RCA's effort blossomed first on photoconductors potentially useful in television camera tubes.

Bell Telephone Laboratories research in semiconductor materials led to development of the transistor. RCA research in this area moved at an early stage to an alloy junction type which soon became standard in receiving circuitry. Through the early and middle 1950's, the corporation's research and development work ranged ever more widely over the materials field, covering the various semiconductor materials, including photoconductors, thermoelectric materials, and materials exhibiting photovoltaic effect; and a wide variety of luminescent and magnetic materials. Among the outstanding results of this work were new types of transistors with greater power output and higher frequency performance.

Other major accomplishments have resulted from increasing application of systems engineering techniques in both military and commercial electronics. Through the early 1950's, RCA engaged in an intensive program of research and engineering related to electronic systems to compute, sort, file, and recall large quantities of data and to perform a variety of computing, clerical and other paperwork functions. Out of this program came Bizmac, RCA's electronic data-processing system. In 1955, a four-unit Bizmac system, the world's largest electronic "brain," was purchased by the U. S. Army for its Ordnance Tank-Automotive Command at Detroit, to keep track of more than 100 million tank and automotive spare parts in the Army's world-wide inventory. During 1957, major Bizmac installations were purchased by the New York Life Insurance Company and The Travelers Insurance Company, Hartford, Connecticut.

PROGRESS AND PROSPECTS

The quickened pace of electronic developments and the mounting importance of electronics to the national defense resulted in continued adaptation of the RCA organizational structure. In 1955, two new major operational units were created, Defense Electronic Products and Commercial Electronic Products. In 1957, CEP was reorganized into RCA Industrial Electronic Products, to provide still further impetus in this rapidly expanding area of electronic development. An indication of the rapid growth of RCA activities in the transistor field was the organization of the RCA Semiconductor Division.

In January, 1957, John L. Burns was elected President of the Radio Corporation of America. He succeeded Frank M. Folsom who was elected Chairman of the Executive Committee of the RCA Board of Directors.

Meeting the demands of the coming Age of Space, RCA established in early 1958 a new Astro-Electronic Products Division for the production of satellite and space vehicle systems.

What are these demands and what are the opportunities? As America enters the Space Age, electronics assumes a pivotal role in assuring continued national progress in the technologies of peace and security. As a leader in the industry, the Radio Corporation of America begins the third epoch of its existence with a flexibility in organization, a resourcefulness in research and a diversity of operations to meet the challenges of the years ahead.

A development of major importance to the field of science was the RCA Electron microscope. Shown with the device are Dr. V. K. Zworykin (seated) and Dr. James Hillier who contributed much to the development of the instrument.

In research, devices and systems now nearing final development point the way to new RCA opportunities for service to the consumer, to business and to industry. Participation by RCA in the cooperative nuclear reactor for industrial research in atomic energy at Plainsboro, New Jersey, will enable the Corporation to pursue fundamental electronics studies in the vital and closely related area of nucleonics. RCA research and engineering organizations are helping to explore methods for harnessing the power of the H-Bomb for peaceful uses.

In products and devices, color television, pioneered and developed by RCA, will dominate the broadcast scene as black-and-white television has done for the ten years past. On the basis of industry-wide projections, automation and electronic data processing undoubtedly will provide another great market for RCA systems, as will closed-circuit TV for industry. Out of today's research and development will come other products for the consumer, such as new forms of lighting, personal communications equipment, home television tape recording, and a variety of other novel electronic adjuncts to living.

If J. C. Warner could foresee the time when historians would look back to 1938 as a period when the surface had barely been scratched, what is there to say about the potentialities for RCA today? For all of RCA's tremendous past growth, not only is the surface of electronics still largely unscratched, but now there is the new challenge of the Space Age.

Writing in *Fortune* Magazine in 1955, General Sarnoff noted: "There is no element of material progress we know today . . . that will not seem, from the vantage point of 1980, a fumbling prelude." When that day finally comes, I am certain that some future historian will begin his review of RCA with exactly those words.

RADIO CORPORATION OF AMERICA

PART III—THE YEARS 1958-1962

Dr. ELMER W. ENGSTROM, President*

Radio Corporation of America

**Since this article was written in 1963, Dr. Engstrom was appointed Chairman of the Executive Committee of the Board. He is now retired.*

DR. E. W. ENGSTROM, received the BSEE at the University of Minnesota in 1923. In the early thirties, Dr. Engstrom directed RCA's television research toward a practical service. He was responsible for development and construction of apparatus used in field tests, and in the early planning and coordination of black-and-white television. Dr. Engstrom was a member of the NTSC at the time TV standards for broadcasting were established and a member of the Radio Technical Planning Board. He was a member of the NTSC which developed technical signal specifications for color television transmissions, adopted by F.C.C. Dec. 17, 1953. In 1942 when all research activities of RCA were brought together at Princeton, N.J., Dr. Engstrom became Director of General Research. On Dec. 7, 1945, he was elected Vice President in charge of research of the RCA Laboratories Division; on Sept. 7, 1951, he was elected Vice President in charge of RCA Laboratories Division; on Jan. 11, 1954, he was elected Executive Vice President, RCA Laboratories; and on June 4, 1954, he was elected Executive Vice President, Research and Engineering. In 1961, he was named President of RCA; he is a Director of RCA, of NBC, and of Radio Communications Company, Inc. The honorary degree of Doctor of Science was conferred on Dr. Engstrom in June, 1949, by New York University. In Aug. 1949, Dr. Engstrom received a silver plaquette from the Royal Swedish Academy of Engineering Research. In Oct. 1950 he received the Outstanding Achievement Award gold medal from the University of Minnesota. Dr. Engstrom is a member and past President of the Princeton Chapter of Sigma Xi, science research honor society; a Fellow of the IRE, of which he was a Director in 1949, and of the AIEE.

IN CONSIDERING events and developments from 1958 through 1962, the past five years of RCA history have been fully as meaningful as the two preceding time spans in terms of change, accomplishment, diversification, and growth. All of the expectations for electronics and for RCA have been more than amply fulfilled.

RCA continued to achieve conspicuous successes in its established lines of business. During the half decade, it ventured into fields where growth and profit, halting at first, began to manifest themselves with increasing strength. At the same time, it advanced importantly in new technologies whose potentialities for growth and service are as great as any of the areas in which it now operates. In brief, the five years reveal a constant progression of technological and commercial opportunities, ranging the electronics spectrum from microdevices to space systems.

These developments are measurable in many forms, and among the most readily recognizable are the traditional yardsticks of corporate accomplishment. Thus, RCA sales of goods and services rose during the half decade to an all-time high of $1.75 billion, *50 percent greater than at the end of 1957.* Profits increased to $51.5 million, 34 percent over 1957.

In ten years, 1948 through 1957, total products and services sold amounted to $7.78 billion. In the past *five* years, 1958 through 1962, the total was almost as large: $7.36 billion.

Year	*Sales* *$ billion*	*Fixed Assets* *$ million*
1938	0.1	31
1957	1.2	200
1962	1.75	264

At the close of 1962, space devoted to manufacturing was at a peak of 12 million square feet, comprising new, expanded, or renovated RCA plants in 12 of the nation's 50 states. RCA's activities reached into home instruments, electronic data processing, electron tubes and semiconductor devices, radar and microwave equipment, scientific instruments, weather and communications satellites, broadcasting, and technical services. In major part, its products and services were available throughout the Free World.

COLOR TV

The most important development by far to RCA in the past five years was the emergence of color TV as a new industry and public service of massive and mounting proportions.

Technologically, the record requires little updating, for the major research and engineering advances had been made prior to 1958. What gives color such transcendent importance to RCA is that the past five years witnessed its transformation from a $130 million investment to a major source of Corporate profits. *It vindicated the faith of one man — David Sarnoff — who staked his and the Corporation's prestige on the new medium while the rest of the industry stood aside or in opposition.*

In 1960, color TV earned a profit for RCA for the first time since its introduction in 1954, and color set profits alone were measurable in seven figures. By the following year, color TV — receivers, tubes, video tape, and other equipment —attained the status of a $100 million business, an achievement of no mean proportions in seven brief years.

By 1961, there occurred—finally—the long-awaited color breakthrough. One by one, TV receiver manufacturers abandoned the sidelines and entered the ranks. By the following year, nearly every major TV manufacturer was actively marketing color, and industry volume has reached $200 million. RCA's set sales for 1962 doubled over the year before; its profits from color manufacturing and services increased fivefold; and color sets and tubes became the *largest* single profit contributor of any products sold by the company.

It is pointless to debate which came first in color TV — the sets or the programming. In all certainty, the development was concurrent, with receiver purchases soaring because of increased color programming, and programming benefiting in turn from the increase in color set ownership. Thus, while there were 291 stations equipped for network color and a bare total of 700 hours of

network programming in 1958, five years later the number of stations equipped for network color came to 406 and network color broadcast hours had risen to some 2,000 for the year.

Of the many brightly illuminated pages in RCA's history there are few that gleam more brilliantly than those dealing with color. Indeed, there are few companies which can validly claim to have created virtually single-handed a new industry, and few which more richly merit the rewards of pioneering than RCA.

ELECTRONIC DATA PROCESSING

While RCA was mounting its major effort to make color television commercially viable, another decision had been made to enter in force a new, formidable, and costly area of business—electronic data processing.

The action entailed a bold and calculated risk: the entry fees were exceedingly heavy; returns were long delayed because of the large lease nature of the business; the competition was powerful and strongly entrenched.

As Board Chairman Sarnoff subsequently explained, the decision to go forward was made:

"First, because we have a technological background in electronics that gives us a capability in many computer areas which few, if any, other companies can rival. This is a young, fast-changing technology, and the research breakthroughs of today will shape the character of the industry tomorrow. We are well-positioned to make contributions of fundamental importance to this evolution.

"Second, because electronic data processing has become a vital element of most major defense and space contracts. The company with skills in this area has a decided competitive advantage.

Fig. 1—An RCA 601 Computer system plus four RCA 301 Computer systems process the toll records of 14 million phone calls handled monthly by the Teaneck, N.J., Office of the N. J. Bell Tel. Co.

"Third, because the commercial computer market is growing faster than the industry itself anticipated."

In 1958, RCA launched its major venture into the electronic data processing field with the introduction of the RCA 501, a medium-sized commercial business computer and the first fully transistorized system in the industry. By 1960, the Corporation had introduced the compact RCA 301 for medium-size and small businesses, and had announced a coming third entry, the RCA 601, for large enterprises and scientific computation.

One of the greatest of RCA's strengths lay in computer communications — backed by four decades of leadership, experience, and know-how in all types of communications systems and equipment.

In 1959, RCA introduced DaSpan, a computer-to-computer communications system which could span a continent, and gather and coordinate vital data from the many plants of a large industrial enterprise.

The same computer-communications know-how made RCA the supplier to Western Union, the prime contractor, of an automatic electronic data switching system for the Air Force Combat Logistics Network (ComLogNet) linking 350 bases and stations across the country in the world's most advanced communications system.

Rapid economic expansion in other industrial nations also gave RCA an unexcelled opportunity to extend its computer activities overseas. In 1961, it concluded a series of multimillion dollar export sales agreements with three of the world's leading data processing equipment manufacturers — in Great Britain, Japan, and France. By the end of 1962, 158 computer systems had been ordered by the three companies, and further orders placed for components and peripheral equipment.

Domestically, in addition to the rental or sales of its computer systems, RCA established data-processing service centers in New York, Washington, D.C., Chicago, Cherry Hill, N.J., and San Francisco. These centers provide computer service to small businesses as well as offering programming and training services to buyers or lessees of RCA systems.

Whatever the risks and costs involved, the decision to enter data processing was extremely sound. RCA not only staked out its share in one of the major electronics growth markets but, equally important, it acquired the basis for continuing preeminence in other electronics fields where computers and computer systems were indispensible to progress. Among these were the vital areas of space and national security.

Fig. 2—A GI utilizes a PRC-51 helmet field radio—a developmental type utilizing micromodules.

SPACE AND DEFENSE

On October 4, 1957, the first signals from a man-made object in the skies heralded the dawn of a new era — the Age of Space.

Swiftly, RCA realized that space was preeminently an electronics domain — for tracking, communications, computing and controls. Less than a year later, RCA set up a special division — Astro-Electronic Products—for the development and production of satellites, space-vehicle systems, and associated electronic ground equipment. (That organization is now called the Astro-Electronics Division.)

In December of the same year, the world's first successful satellite radio relay equipment, produced by RCA for the U.S. Army Signal Corps, lofted into orbit aboard an Atlas missile. It broadcast to the world a prerecorded Christmas message from President Eisenhower, and then performed a number of communications experiments never before attempted, looking to a new era in global communications.

Within the next four years, the Astro-Electronic Division had scored a series

Fig. 3—Looking down at the top of the Environmental Test Chamber at the Astro-Electronics Division, near Princeton, N.J. Satellites can be placed inside for extended exposure to simulated space environment.

of achievements which quickly catapulted RCA into the front rank of space organizations.

Chief among these was a systems development of the first magnitude — an integrated ground and space complex for the televised observation of the world's weather via satellites. Between 1960 and 1962, as major elements of the system, RCA developed for the National Aeronautics and Space Administration six TIROS weather observation satellites, all of which were launched and operated with optimum effectiveness. Up to the end of 1962, the TIROS series—ranking as the nation's *most successful* space venture—provided a total of more than 200,000 televised images of cloud formations and other global weather data for use by weather scientists and forecasters. The average useful life span of the satellites was more than double the operating life called for by the initial design specifications.

Another significant feat was the RELAY communications satellite, which after launching in December 1962, experienced initial operating difficulties. These subsequently were overcome, and by early 1963, RELAY was transmitting television pictures of remarkable clarity between the United States and Europe, and conducting radio communications with Latin America.

The Astro-Electronics Division has also provided the advanced television equipment for the RANGER lunar probes, television systems and solar-cell power supplies for the second-generation NIMBUS weather satellite, and was engaged in the design and construction of the SERT vehicle for the space testing of experimental electric propulsion systems.

Portending still greater growth in years to come, an environmental test facility, most advanced of its kind in the electronics industry, was put into full operation during 1962 at RCA's Space Center, near Princeton, N.J. Space concepts and systems now germinating in various RCA research areas may undertake their initial trials in this environmental center and so provide new episodes for future RCA historians to record.

The complexities manifested in computer and space electronics are fully matched in the area of defense. From the production of relatively simple hardware for communications, electronics for military purposes has burgeoned into vast and complicated systems — frequently global in scope, integrating multiple techniques and subsystems, and employing the resources of many varied organizations.

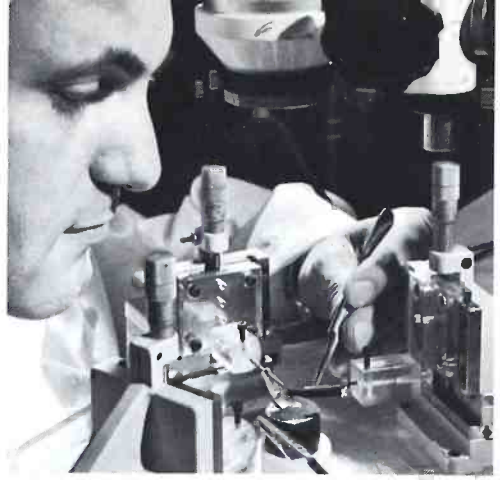


Fig. 4—An electrical probe is positioned over a silicon wafer containing 2,200 insulated-gate field-effect MOS (metal-oxide semiconductor) transistors. RCA Laboratories research produced this device which combines properties of a conventional transistor and an electron tube. It has promise for future microelectronic circuitry.

RCA's depth of experience in systems engineering and its military electronics background dating to the mid-thirties earned for it one of the lead positions among designers and constructors of such advanced systems for the armed services.

In 1958, RCA received one of the largest contracts ever awarded by the Department of Defense, to assume the project management of the Ballistic Missile Early Warning System (BMEWS) to provide advance warning of an enemy missile attack across the polar wastes. As manager of this vast undertaking, it employed 485 large companies and 2,415 smaller firms spread over 29 states to get the job done swiftly and efficiently. By the end of 1962, two installations (Thule, Greenland, and Clear, Alaska) were operative and the third was nearing completion in Yorkshire, England.

The need for virtually instantaneous warning against impending missile attack assumes similar readiness for counter-attack. In the past half decade, RCA contributed significantly to a greatly strengthened defense posture with the development of automatic programmed check-out equipment (the APCHE) and launch-control equipment for several series of the ATLAS ICBM.

Subsequently, major RCA work on the MINUTEMAN ICBM involved advanced concepts in command-and-control systems, including the sensitive-command and support-information networks, and checkout and test techniques. Especially challenging for both design and production were very high reliability goals for such sophisticated equipment—goals that pushed the state of the art.

By the end of 1962, RCA was deep into such diverse development and constructions as a flight-control system and checkout for the super-powerful SATURN booster, telemetry equipment for the two-man GEMINI space vehicle, miniaturized computers such as MICROPAC (built with micromodules) for military field use, and a variety of communications systems and test apparatus, including a lunar-landing simulator.

In 1962, RCA also could point to some 22,000 scientists, engineers, and production personnel—roughly a quarter of all RCA employees—working at eleven defense and space centers. In that year, the Corporation's total volume of government business exceeded $600 million, or more than a third of the Corporate total.

CIRCUITRY AND COMPONENTS

Basic to all RCA progress in both the old and new fields of electronics were the advances made in electronic circuitry and components.

RCA's Electron Tube Division, facing the growing competition of semiconductors, moved quickly and aggressively to sustain its position through intensified product and market development.

One decision was to concentrate production and sales in those areas where semiconductors could not yet compete. Conspicuous success was achieved in heavy-duty and special-purpose tubes. From 1958 through 1962, RCA developed some 800 new tubes of this variety.

Another decision was to compete directly with semiconductors through greatly improved low-cost vacuum tube products. In 1959, the Tube Division announced the revolutionary *Nuvistor*, a receiving tube as small as a thimble and incorporating high reliability and durability. This was followed the next year with a new line of metal-to-ceramic *Cermolox* power tubes for transmitter applications, one of which was aboard the famed PIONEER V Venus probe.

A third decision was to join the move toward semiconductors where this would blend with skills and technologies perfected in some three and a half decades of tube development. In 1960, for example, the Division began to manufacture solid-state photoconductors and silicon solar cells.

Finally, the Tube Division decided to diversify its product line and seek *wholly new products*. A new Business Development Department was set up for new items whose revenues could replace or even surpass those from older tube products. By the end of 1962, the first results were beginning to bear fruit —in thermoelectric power generation and cooling, thermionic energy conversion, superconductive magnets, electroluminescent materials, and high-speed reed switches for computer and telephone relay circuits.

Challenge and change also confronted RCA's Semiconductor and Materials Di-

vision. The challenge came in the form of intense competition where companies —old and new, large and small— thronged a market of supposedly unlimited profitability and growth. Change came in the rapid obsolescence of materials and devices under the stimulus of quickening research and development.

Organized in 1955 primarily to manufacture germanium transistor devices for consumer purposes, the Division swiftly expanded in size and scope. By 1962, for example, it had become the leading domestic producer of solid-state semiconductor devices for consumer products, and over 100 million of its germanium units were in use.

With the advent of high-power silicon devices, the semiconductor field grew to embrace industrial, computer, and military applications, and with this came corresponding growth in RCA activities. New manufacturing facilities were added, new devices developed, and new markets opened. Ultra-high-speed tunnel diodes, gallium arsenide rectifiers, and microferrites for computer memories were among the product developments of the period.

But the continuing solid-state revolution involved more than the geometric expansion of individual circuit devices and applications. Equally fundamental to the future of electronics was the emergence of materials and techniques leading from separate components to assemblies of components functioning as complete circuits and subsystems. In this, RCA played a leading role, with the U.S. Army Signal Corps, in the development of micromodules. With later developments—for example, thin-film active devices, and the insulated-gate MOS (metal-oxide-semiconductor) transistor—RCA reaffirmed its position as an industry leader in advanced integrated circuitry.

OLD AREAS—NEW OPPORTUNITIES

Change, diversification, and growth were readily evident in other divisions and services of the Corporation. New technologies, products and systems infused vigorous progress in both the older as well as the more recent RCA activities.

The RCA Victor Home Instruments Division, which in 1961 moved from Cherry Hill, N.J., to a consolidated operation in Indianapolis, Indiana, continued to advance in the design and marketing of home entertainment products. Particular emphasis during the past half decade was placed on stereophonic high-fidelity record and tape players for the growing high-fidelity music market, on transistorized pocket radios, and on black-and-white as well as color television.

One milestone was the production in 1958 of the ten millionth RCA Victor black-and-white television receiver. Another was the introduction, a year later, of the *first* miniature transistor radio to be produced entirely in the United States. By the end of 1962, Home Instruments could point to an over-all sales increase of 30 percent over the previous year, exceeding the earlier all-time record established in 1956.

The RCA Victor Record Division made significant progress in new sound-reproduction techniques at the same time that it advanced briskly into new marketing methods and areas. In 1961, Victor Records introduced a new electronic process for reproducing stereo recordings originally recorded in monaural sound. The year following, it opened the world's largest and most modern recording studio, in Rome, Italy.

Early in 1963, after two years of intensive research and development, Victor Records also announced a striking new process of music reproduction—*Dynagroove*—bringing recorded music more closely than ever before to live music.

In the five-year period, Victor Records aggressively expanded its Record Clubs around the nation, while developing new retail sales outlets such as supermarkets and drug chains. Overseas, RCA became the leading U.S. company in the international field, and by the end of 1962, Victor Records could report the largest sales volume in its history, with gains scored in all product lines.

For industry, for broadcasting and communications, RCA continued to develop new microwave systems, transistorized video tape recorders for both color and black-and-white broadcasting, and new color cameras. Among its pioneering advances were closed-circuit equipment for educational purposes.

In 1962, RCA also manufactured and delivered its 1,000th electron microscope, assembled on the same production line that completed the first commercial instrument nearly a quarter century earlier.

Fig. 5—A NUVISTOR tube production line at the Electron Tube Division, Harrison, N.J. July 1961 saw the production of the 1,000,000th NUVISTOR, a distinct RCA innovation in small ceramic-metal receiving tubes. Developmental work continued toward furthering the NUVISTOR concept in smaller and even more-reliable receiving tube products.

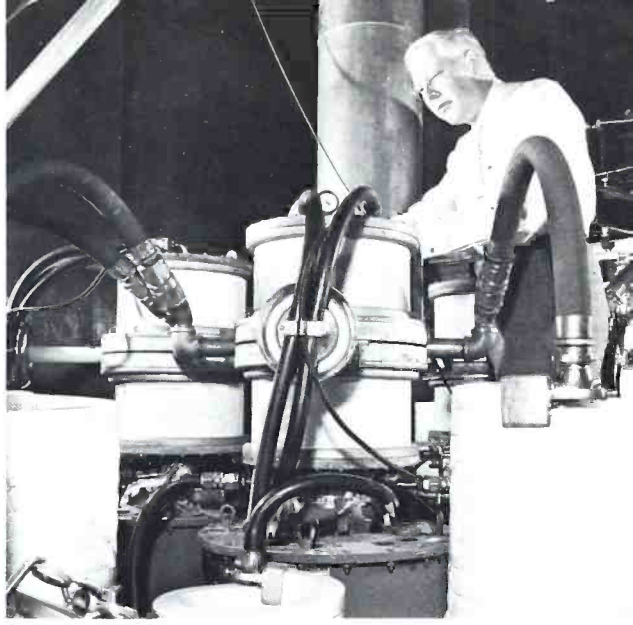


Fig. 6—RCA engineer Nils Oman and part of the largest electronic power supply of its type ever built—an assembly of 500-kw super-power tubes for the C Stellarator fusion-research facility. These tubes supply RF pulses to raise the deuterium in the Stellarator to some 1,000,000°C by ohmic heating process. During the period covered by this article, a joint RCA-Allis Chalmers project, called C Stellarator Associates, designed and constructed the massive C Stellarator facility for Princeton University, who will utilize it in major research on controlled thermonuclear fusion. Engineers and scientists from several RCA Divisions participated in this project.

Significant growth trends also manifested themselves at the National Broadcasting Company, which moved into commanding leadership in providing the public with a broad range of news and public affairs coverage. By 1962, 25 percent of *NBC-TV*'s schedule was in this category.

Earlier, NBC pioneered an educational experiment by presenting a college level course. "Continental Classroom," demonstrating that commercial broadcasting could perform a significant role in education. And its massive programming on behalf of color was as responsible as any single factor in hastening the ultimate mass-market breakthrough. These and other developments culminated, in 1962, with the highest sales and earnings in NBC's 36-year history.

As meaningful as any aspect of electronics' growth during the past five years was its expansion on a global scale. It was reflected in the RCA Service Company where, by the end of 1962, there were some 16,000 employees in the United States and 36 foreign countries. Its activities ranged from maintenance of the BMEWS emplacements in Alaska and Greenland to responsibility for the control and data gathering activities at the Cape Canaveral, Florida, space center. Here, incidentally, where RCA undertook its first technical assignment

10 years earlier with 26 technicians and engineers, there were approximately 4,000 RCA people in 1962.

By early 1963, the RCA Service Company was able to report that revenues for the year from installations and service on color-TV receivers could surpass for the first time revenues on black-and white sets. And with equal portent for the future, the Service Company moved into still another space activity—the design and construction of space chambers and solar simulators.

World economic expansion and the emergence of new nations were reflected by the growing demand, during the five-year period, for basic and advanced types of communications and broadcast equipment. RCA sales and installations extended to every continent—from broadcasting equipment and stations to entire national and international television and communications systems.

The same economic expansion found further expression in the global communications services of RCA Communications, Inc. By the end of 1962, it was providing more channels between this country and 100 others than any other U.S. international communications carrier. In early 1963, RCA Communications applied for permission to purchase shares in the new Satellite Communications Corporation, thus assuring for RCA still another role in the rapidly unfolding progress of electronics.

RESEARCH AND PROGRESS

Behind the extraordinary five-year record of RCA change, diversification, and growth stood the basic and applied achievements of the RCA Laboratories —ranging from revolutionary high-speed computer techniques to submarine communications to space telescope guidance.

The variety of RCA research activities may be gleaned from a few samplings of the past five years.

In 1958, RCA joined nine other companies in ownership and operation of a nuclear reactor, for the purpose of conducting radiation studies relating to RCA projects and areas of interest. That year too, RCA Laboratories joined in the design and construction of the C Stellarator, which may provide an answer to the control of thermonuclear fusion for peaceful purposes. The following year, it undertook two projects approaching the ultimate in geographic disparity. One was for the design and development of an advanced communications system for the POLARIS program; the other was to build the television guidance system for the STRATOSCOPE I and II balloon-borne telescopic observations of the sun and planets.

RCA scientists had the assignment of developing the key elements of a computer that would operate at speeds a thousand times faster than the swiftest computer yet built. On yet another tack, in 1960, they completed the "electronic highway" to demonstrate the feasability of electronics for the control and movement of road traffic.

Most significant for the long run, perhaps, were the RCA Laboratories' contributions in the areas of basic circuitry, energy conversion, superconductivity, and laser technology. These have led in the past five years to such research advances as thin-film transistors, superconductive magnets capable of generating enormous magnetic fields, superconductive thin-film memories, crystal lasers activated by natural sunlight, and new thermoelectric and thermionic generators.

To the breadth and depth of its scientific probings, RCA also added the element of greater speed in converting research to applied development. Most of the Corporation's principal operating divisions now maintain development groups of their own engineering specialists at the RCA Laboratories at Princeton. These development groups work directly with the laboratory research teams, adding a vital new perspective to many RCA scientific projects, and furnishing the link for the swift transmission of new materials, devices, and techniques to the divisions to transform them into new products and market opportunities.

LOOKING TO THE FUTURE

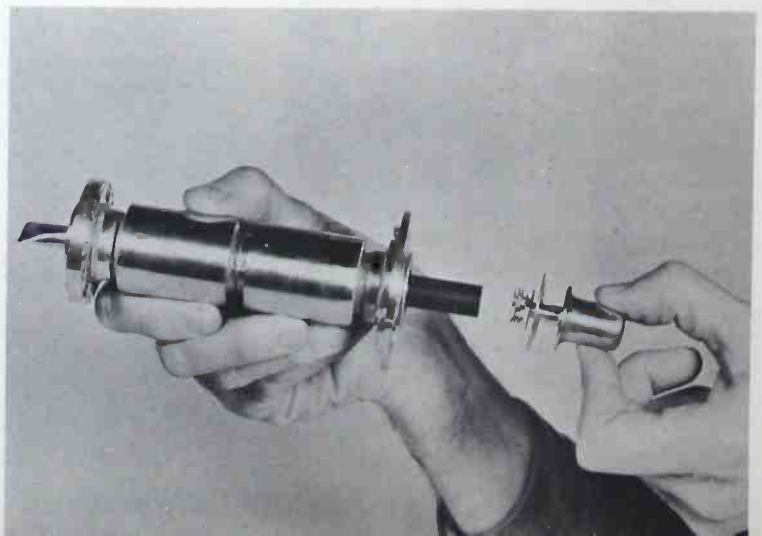
In reviewing the past, one's thoughts inevitably turn to the future of electronics and RCA, for it is there that the most interesting history will be written. For that future, it no longer seems sufficient to say, as in the first two segments of the RCA history, that the surface of electronics has barely been scratched. As electronics broadens its contributions to the nation and the individual, and as its influence extends around the globe and deep into space, new dimensions of service as well as new concepts of opportunity come into focus.

At the present point in time and historic development, electronics perhaps is *the single most important instrument at the disposal of mankind for the solution of present problems and the advance to new levels of well-being.* Electronics provides means of comprehension and action far beyond the capacity of the brain to grasp or the hand to move. In science, medicine, manufacturing and commerce, transportation, agriculture, education, energy, space exploration, and communications, *electronics* is the lever to still greater progress—directly or as the catalyst to other efforts. Its reach has extended far beyond the surface of technological growth to embrace virtually every activity, human or natural, affecting civilization.

In such a context of service and opportunity RCA is uniquely positioned to achieve the optimum. In these past five years, it has strengthened beyond measure its resources and capabilities for leadership in *any direction* which the science and industry of electronics may take.

Fig. 7—RCA Laboratories research produced the first practical amplifying device to be made entirely by evaporation techniques—the TFT (thin-film transistor), shown above in a test unit. The tiny device can be made so small that over 20,000 could fit in a square inch of surface. The process promises breakthroughs in the mass production of ultraminiature transistor circuits.

Fig. 8—Direct energy conversion came to the forefront as a major RCA effort as the 1957-62 period ended. Shown here is a thermionic convertor that converts heat (in this specific case, heat from a nuclear reactor) directly into electricity. Important advances at both RCA Laboratories and the Electron Tube Division in thermoelectric materials, methods, and production may lead to major RCA product lines in power generation.



RADIO CORPORATION OF AMERICA

Part IV—The Years 1962-1966

DR. ELMER W. ENGSTROM*

Chairman of the Executive Committee of the Board

Radio Corporation of America

*Since this article was written in 1966, Dr. Engstrom has retired.

For the Radio Corporation of America, the years from 1962 through 1966 were characterized by vigorous growth and an outward thrust that took the company into new areas of business.

By any measure, the rate of growth was impressive. Total annual sales increased from $1.75 billion in 1962 to $2.5 billion in 1966. During the same period, net profits more than doubled.

RCA's manufacturing capacity was vastly increased as more than $500 million was spent to build new plant facilities and expand existing ones. In 1966 alone, the company undertook the largest domestic capital expenditure in its history, allocating $198 million for the construction of new plants at 11 locations and substantial expansion at 15 other operating facilities. These additions involved such key activities as color television, home instruments, semiconductors, computers, and communications.

By early 1967, total employment had grown to exceed 120,000 people in the United States and abroad, up from approximately 93,000 five years earlier.

During the four-year period, RCA maintained a growth rate that consistently outpaced the average of all American manufacturing enterprises. In 1966, the percentage of sales increase over the previous year was double that of the average for all other manufacturers, and the company's profit increase of 28% contrasted with the average manufacturing rise of 11%.

This outstanding performance reflected many influences—a sustained period of strong consumer demand for RCA home entertainment products; a steady growth in other established areas of business, such as commercial and industrial electronic products, and a vigorous involvement in new ventures, such as publishing, the graphic arts, education, and medical electronics.

Coupled with these trends was a gradual change in the character of the

Final manuscript received May 1, 1967

DR. E. W. ENGSTROM, received the BSEE at the University of Minnesota in 1923. In the early thirties, Dr. Engstrom directed RCA's television research toward a practical service. He was responsible for development and construction of apparatus used in field tests, and in the early planning and coordination of black-and-white television. Dr. Engstrom was a member of the NTSC at the time TV standards for broadcasting were established and a member of the Radio Technical Planning Board. He was a member of the NTSC which developed technical signal specifications for color television transmission, adopted by F.C.C. Dec. 17, 1953. In 1942 when all research activities of RCA were brought together at Princeton, N.J., Dr. Engstrom became Director of General Research. On Dec. 7, 1945, he was elected Vice President in charge of research of the RCA Laboratories Division; on Sept. 7, 1951, he was elected Vice President, RCA Laboratories; and on June 4, 1954, he was elected Executive Vice President, Research and Engineering. In Oct. 1955, he was named senior executive Vice President. In 1961, he was elected President of RCA, and on Jan. 1, 1966, he became Chairman of the Executive Committee of the Board. He is a director of RCA, of NBC, of RCA Communications, Inc., and of Random House, Inc. He is also a member of the Board of Directors of the Prudential Insurance Co. of America. Dr. Engstrom has been awarded honorary degrees by 14 colleges and universities. In 1958, he was the recipient of the Industrial Research Institute Medal for distinguished leadership in Industrial Research; in 1962, he received the Medal of Honor of the Electronics Industry Agency; in 1965, he was awarded the Charles Proteus Steinmetz Centennial Medal at the first annual meeting of the National Association of Engineers of which he is a founding member. In 1966, he received the Founders Award of the IEEE and the William Procter Prize for scientific achievement from the Scientific Research Society of America. Dr. Engstrom also is a member of the Royal Services Academy of Engineers and Scientists, and in 1965 the King of Sweden conferred upon him the rank of Commander of Vasa.

electronics industry. From its initial concern with communications and entertainment, electronics was steadily evolving into the role of a basic industry whose products and services are vital to virtually every other industrial activity. This provided a broader base than ever before for the company's growth.

COLOR TV AND THE CONSUMER MARKET

While all these factors contributed materially, the force that gave the greatest impetus to RCA's performance between 1962 and 1966 was unquestionably color television. The pioneering days of the late fifties and early sixties were over, and in five short years, color television mushroomed from an annual retail sales level of $200 million to more than $3 billion. This latter figure was achieved in 1966, when consumers spent more money to purchase color television sets than they did for all other home instruments, including black-and-white television, radio, phonographs, and tape recorders.

Beyond the manufacture and sale of sets and tubes, the color television industry embraces the production of studio and transmitting equipment, such as color cameras and video tape machines. It includes broadcasting, programming, service, and the production of the many electronic components that go into the final assembly of a set.

Because of its decision to blaze a trail in color, RCA had long before developed its own capabilities in all these areas. It was recognized that if color television were to succeed, it had to be presented to the public as a total system. As a result, many divisions of RCA experienced major gains in sales as public opinion on color television changed from the cautious interest of 1962 to the unrestrained eagerness of 1966.

RCA was in a position to take full advantage of the new opportunities presented by the rapid expansion of the market and to take the lead in many new developments. Slimmer cabinet styling replaced the earlier, bulkier models as the 90-degree rectangular color television picture tube gradually replaced the 21-inch round tube which had been the industry standard for nearly a decade. By the end of 1966, production of this older model was entirely phased out, and RCA was manufacturing four different color picture tube sizes—15″, 19″, 22″, and 25″—for a diverse line of portable, tabletop and console model receivers. (When used in sets, these tube sizes are now designated as 14″, 18″, 20″, and 23″ picture diagonal.)

The addition of rare earth phosphors from materials research added greater brightness and clarity to the color picture. In 1966, integrated circuits were introduced for the first time into home instruments when RCA employed them in the audio stage of its color and black-and-white television sets.

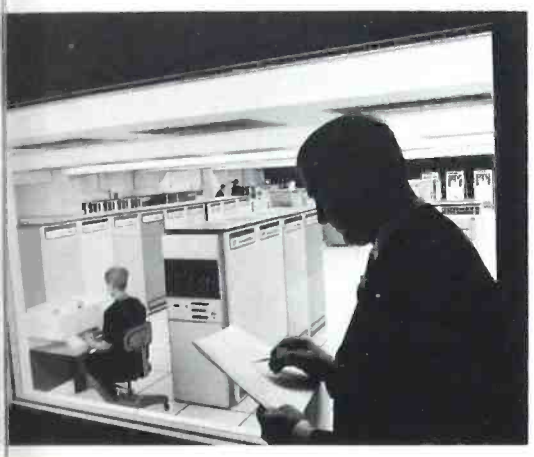
The RCA engineers in the background discuss integrated-circuit applications in the 12-inch, portable, black-and-white, TV receiver while those in the foreground examine the complex deflection yoke for the 90° color picture tube. The chassis in the foreground shows the trend toward more compact color receivers using shorter rectangular picture tubes.

The versatile, battery-powered tape recorder found new uses in the home and in school lecture halls.

Standing among the more than 50 different loudspeakers used in Home Instruments Division products is W. E. Davis of Radio "Victrola" Engineering in Indianapolis. H. D. Ward of the Record Engineering Laboratory shows a tape cartridge from the Record Division and the YGG45 reel-to-reel stereo tape recorder produced by Home Instruments.

Portable television sets being readied for shipment at RCA's Memphis, Tennessee, plant.

This advanced RCA Spectra 70/45 data processing system at the new RCA computer center Cherry Hill, N. J. is one of a family of data processing systems which employ "third generation" monolithic integrated circuitry.



RCA Communications' Electronic Telegraph System (ETS) processes message telegrams to and from overseas points in fractions of a second at RCA's Global Communications headquarters in New York. In 1966, RCA's ETS processed more than 10 million overseas telegrams via the 100 full-duplex input and output buffers associated with the computers.

The years 1962 through 1966 also saw steady advances in the manufacture of color transmission equipment. A new, all-transistorized tape recorder for both color and black-and-white television, the TR-22, found a ready market among broadcasters and closed-circuit television operators both in the United States and abroad.

In 1964, as the result of a major engineering development effort, RCA's Broadcast and Communications Products Division presented an entirely new look in broadcasting equipment. The new line featured sweeping changes in design, appearance, and function, and employed the use of solid-state components wherever possible.

By the end of 1966, 450 out of approximately 650 commercial television stations in the country were equipped to originate color programs from film. About 150 stations could originate live color programs.

Leading the way towards full conversion to color was the National Broadcasting Company. In the autumn of 1962, about 68% of NBC's total nighttime programming was in color. By the end of 1966, the entire network schedule was broadcast in color, with the occasional exception of feature films originally photographed in black-and-white.

The spectacular growth of color television was the principal feature of a generally thriving consumer market for electronics.

In 1965, for example, RCA sold more black-and-white television sets than in any year since 1955. By the end of 1966, industry sales of both imported and domestic radios were approximately 44 million units, up from a little over 33 million units sold five years earlier.

Stereophonic sound was firmly rooted in the home instruments market, and industry sales of phonographs increased each year from 1962 to 1966, with RCA "Victrola" phonographs leading the way. Music on tape gained in popularity during the period, and the company responded by marketing a full line of reel-to-reel and cartridge tape recorders.

As phonograph and tape recorder sales increased, the RCA Victor Record Division also enjoyed a succession of peak years. In 1966 the Division completed three successive years in which all-time sales volume levels were reached. A significant development in 1965 added a new force to this aspect of the home entertainment market. This was the introduction of prerecorded Stereo 8 tape cartridge and player for use in automobiles and homes. RCA Victor Records pioneered in the production of musical selections on Stereo 8 cartridges, and a home player for the tapes was introduced in the 1966 home instruments line.

The Stereo 8 cartridge and player typified the growing trend to more casual electronic entertainment equipment, designed for use anywhere. The television set and the phonograph were no longer regarded only as items of furniture for the home, and demand grew for personalized, portable entertainment indoors, outdoors, and on the road.

COMPUTERS AND INDUSTRIAL ELECTRONICS

The expansion of the consumer electronics market in the five-year period had its counterpart in commercial and industrial markets. RCA served this market with a wide variety of products and services ranging from data processing installations to radar equipment for the aircraft industry.

Electronic data processing equipment was the most dynamic element on the commercial and industrial scene, both in technology and in business growth. In hardware alone, the sales volume of the computer industry rose from about $1.8 billion in 1962 to more than $3 billion in 1966.

The period brought significant advances for RCA in system design and programming concepts, and the company further solidified its position for the long run in the computer market.

At the end of 1962, the product line consisted largely of the 301 system for medium and small business enterprises, and the larger RCA 601 for industrial and scientific use. In 1963, a versatile new unit, the 3301 Realcom, was added to the line as the first computer designed to span the full range of data handling capabilities in a single system —business data processing, high-speed communications, real time management control, and scientific computation.

In the same year, a significant adjunct to these systems was introduced in the RCA 3488 mass memory, designed to hold several billion characters and to operate with either the 3301 or the 301.

Progress in circuit design and system concepts led in 1964 to a major step forward. RCA introduced the Spectra 70 series, the first in the industry of a new third generation of computers. The group initially included four compatible general-purpose computers—two of them employing the first monolithic integrated circuits to be used in commercial equipment. A fifth model was added in 1965.

Singly or in multiples, these systems were ordered by insurance companies, manufacturing industries, airlines, railroads, government agencies, and many other users in the United States and abroad.

As the 1960's progressed, computer systems were put to increasingly sophisticated use in a wide range of business and public functions. At their inception a decade and a half ago, electronic data processing equipment was regarded principally as immensely powerful tools for use in the repetitive and clerical tasks of commerce and industry. Through the past few years, progress in programming techniques as well as hardware has led to increasing application of the systems in more complex tasks of information processing, from management simulation to the analysis of physical, social, and other problems with many variables.

Within RCA, for example, computers were employed on a growing scale for management information. In this func-

tion, systems at various operating divisions and at corporate headquarters were programmed to supply current information on all aspects of the company's operations and to aid in planning and decision-making by indicating trends in the wide range of factors affecting production and marketing.

Another significant trend was the growing relationship between computers and communications—both in the development of computer-to-computer links and in the use of computers to increase the speed and flexibility of communications.

RCA introduced several advanced terminal devices during the 1962-1966 period for communication between computers and users. Among them were a voice response unit that provided spoken replies to inquiries telephoned directly to a computer, and a self-contained video display unit employing integrated circuitry.

The greater use of computers as tools in communication systems was evident in the operations and services of RCA Communications, Inc. In 1964, an Electronic Telegraph System (ETS), employing RCA computers of special design, was put into operation at the RCA Communications, Inc. facilities in New York to route, process, and transmit overseas messages electronically, in great volume at high speed. The innovation came at a time when communications satellites were on the verge of multiplying international channel capacity. The combination of expanded channels and electronic message switching promised, by the end of 1966, to revolutionize international communications in terms of volume and scope of services.

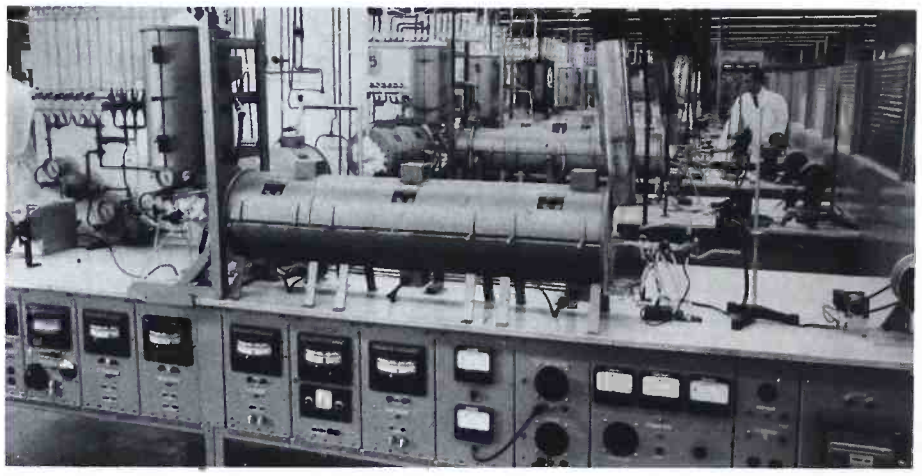
There were indications of this in two new services introduced by RCA Communications. In 1965, the company announced DATEL, a service for overseas data transmission from punched tape or cards, or magnetic tape, at speeds up to 1,200 words a minute. In 1966, it introduced a new service concept incorporating computer techniques in an Automated Information and Reservations Computer Operated Network (AIRCON) for message processing and reservations.

In addition to its activities in computers and data processing, RCA played a significant part during the period in supplying new products and services for other business needs. Among the notable contributions were airborne weather radar systems for commercial and business aircraft, and at the end of 1966, RCA was one of the largest suppliers of such equipment. Two-way mobile radio communications systems were developed and installed in trucking fleets and public transportation bus systems, including those of the New York City Transit Authority. In the fall of 1964, the Western Union transcontinental microwave network, the longest single microwave project ever undertaken at one time, went into operation with RCA equipment in its 267 relay and terminal stations.

ELECTRONIC COMPONENTS

In 1963, RCA's Semiconductor and Materials Division was consolidated with the Electron Tube Division to form a new operating unit known as Electronic Components and Devices. The blending of the newer technology with the older in an organizational sense can be said to symbolize the coming of age of solid state electronics as a business. The move enabled all of RCA's talents in the field of electronic components and circuitry to be employed on a more closely coordinated basis. The results of the union have since demonstrated both the potential of the young solid state art, and the continuing vigor of electron tube technology.

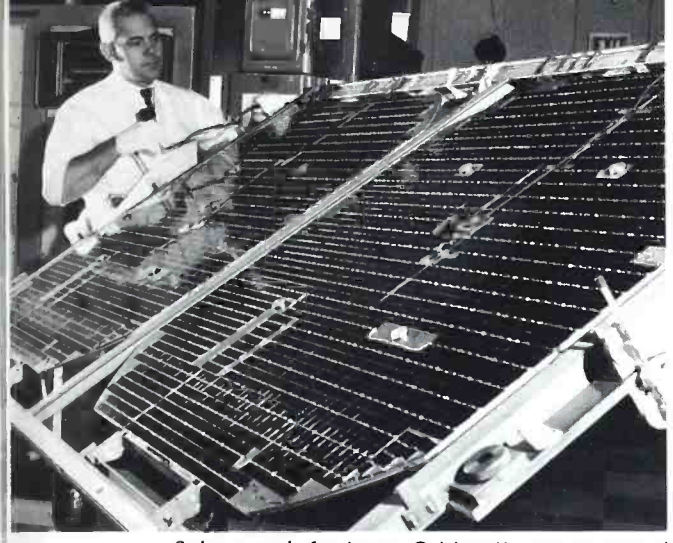
Electron tubes remained unchallenged in many areas. In the fall of 1964, RCA produced its three millionth color television picture tube, a short time



Vapor-deposition equipment in RCA's Harrison, New Jersey, plant produce "VAPODEP" superconductive ribbon. These superconductive ribbons, released in January 1966, provided outstanding performance, increased current capability, improved economies of application, and superior mechanical strength in the construction of commercial high-field-intensity magnets up to 100 kilogauss.

In November 1965, these high-temperature furnaces were added to RCA's integrated circuit production facility in Somerville, N.J. At the same time, RCA announced its entry into the integrated circuits market with a broad line of 17 new digital and linear integrated circuits.

One of the final steps in the manufacture of integrated circuits is performed by this probing equipment at RCA's plant in Somerville, N. J., where production facilities were expanded to meet growing demand in 1966.



Solar panels for Lunar Orbiter II were prepared for final testing at RCA's Space Center, Princeton, N.J., before joining the spacecraft that mapped the moon for possible manned landing sites. The spacecraft carried four solar panels (only two are shown) to convert sunlight directly into electricity to power the spacecraft and recharge its batteries for nighttime operation. Each of the four panels contains 2,714 individual solar cells.

Weather pictures from the RCA APT camera system on the Nimbus II satellite are automatically transmitted to small ground stations where they are reproduced on a facsimile machine as shown. Storage of the weather picture on the APT camera vidicon tube permits transmission to simple ground stations located in any area of the world. The APT system is one of two advanced RCA television systems aboard the experimental Nimbus II satellite.

after it had turned out its 25 millionth monochrome tube. Significant innovations were made in television pickup tubes, including improved vidicons for studio cameras and a number of special purpose types. Among the latter were several built for use in the Ranger lunar vehicle, and one employed for underwater television equipment used by the Navy to recover missiles and torpedoes.

Many other special tube types were provided by the new division, including a high-efficiency traveling-wave tube for microwave systems, high-efficiency thermionic converters, and special klystron power tubes employed in the 2-mile accelerator at Stanford University in 1966.

The application of new solid state technology and materials research led to significant contributions during the period in new and improved components and devices for a variety of uses. In 1964 and 1965, for example, RCA introduced the new "overlay" transistors and a promising line of silicon power transistors for use in public address and home sound equipment. The company also continued as a leader in the production of transistors for use in automobile radios.

A major new activity was launched in 1963 to engineer, develop and produce integrated circuits for general use. Two years later, RCA made its full scale entry into this new market with an initial line of 17 types for application in communications, instrumentation, and industrial and military equipment, as well as computers. By mid-1966, the family of new circuits had been increased to 25, and integrated circuit sales had become a significant factor in RCA's total components business.

The new Electronic Components and Devices activity launched other vigorous programs to develop new business. An outstanding example, based on pioneering work at RCA Laboratories, was the company's entrance into commercial production and sale of superconductive magnets, principally for use in nuclear research.

SPACE AND MILITARY ELECTRONICS

The most dramatic achievement for RCA in space between 1962 and 1966 occurred in 1964 when NASA's RANGER 7, with a six-camera payload designed and built by RCA's Astro-Electronics Division, reached the moon and sent back the most detailed photographs ever taken of the lunar surface. This was followed in 1965 with the successful launch of the RANGER 8 and 9 spacecraft, which together obtained and transmitted to earth nearly 13,000 close-up views of the moon.

The TIROS television weather satellite program continued an unbroken series of successes. In 1962, three TIROS satellites, developed by RCA, were placed into orbit, providing television pictures for world-wide weather forecasting.

The following year, two more TIROS satellites were launched, and RELAY I, a communications satellite built by RCA for NASA, completed its scheduled year-long mission. Among RELAY's achievements were the first space transmission of a color telecast, simultaneous voice relays between the United States and Brazil, and the first trans-Pacific transmission from the United States to Japan.

RCA in 1963 was assigned major roles in the APOLLO program, this country's attempt to land astronauts on the moon. The company was selected to develop communications and control systems for the LUNAR EXCURSION MODULE, which was scheduled to perform the actual landing. In addition, RCA contracted to build the power and communications equipment for the LUNAR ORBITER, designed to transmit pictures from an orbit around the moon in search of a suitable landing site. During 1965 and 1966, spacecraft in the orbiter series returned remarkable pictures of selected areas from altitudes as low as 28 miles above the moon.

The major RCA contributions to the nation's space program in the 1962-1966 period included the picture-taking systems for NASA's experimental NIMBUS satellite to map global weather conditions; a second successful RELAY communications satellite; three more TIROS weather satellites; and a continuation of the TIROS program under the name of ESSA (Environmental Science Services Administration) which established the first operational weather satellite system.

In other aspects of the space effort, RCA delivered tracking radars for the APOLLO Radar Instrumentation Ships and the APOLLO Recovery Ships. It provided communications links between NASA headquarters in the United States and various overseas tracking lo-

In 1966 an RCA mobile two-way radio network was provided to the Singapore Police Department.

Students from more than 60 countries throughout the world have received training in electronics in courses conducted by the RCA Institutes.

RCA's Graphic 70 Videocomp was designed to set type electronically for the printing industry.

cations, including voice and teletypewriter circuits to tracking vessels at sea, alternate voice/data and teletypewriter circuits to Europe, Africa, the Caribbean, Australia, and several points in the Pacific. RCA computers were developed for test and checkout of the SATURN launch vehicle in the APOLLO program.

In 1964, the RCA Service Company was awarded a contract for the planning, installation, operation, and maintenance of communications for NASA's Spaceport at Merritt Island, Florida.

The company's military support activities were highlighted by operation and maintenance of the Ballistic Missile Early Warning System, the electronic systems used on the Air Force Eastern Test Range at Cape Kennedy, and the White Alice communications system of the Air Force in Alaska. The company began delivery of communications equipment for the Department of Defense AUTODIN data communications network in 1964. Delivery continued throughout 1966, and when the project is completed, the continental portion of AUTODIN will be the most advanced data communications system in the world, with individual switching stations capable of handling 6 million messages a month.

As one of the leading industrial contractors to the Department of Defense, RCA continued to supply a wide range of military electronic devices and systems. Among them were microelectronic receiving equipment, various types of radar, secure communications systems, laser range finders and related equipment, and mobile radio relay units.

In 1966, RCA became extensively involved in the challenging new area of underwater technology through a three-year contract awarded by the U. S. Navy to manage, operate, maintain, and support the Atlantic Undersea Test and Evaluation Center (AUTEC) in the Bahamas. AUTEC is a naval facility employing weapons, acoustic, and sonar ranges located in the deep-ocean areas south of Nassau.

THE INTERNATIONAL MARKET

Technological progress and rising aspirations in most parts of the world between 1962 and 1966 created new international markets for electronic products and services. This was especially evident in the spread of color television abroad.

In 1964, RCA Victor Company, Ltd., of Montreal, began the assembly of color picture tubes. In the same year, RCA sent a specially built mobile unit on a six-month tour to demonstrate the United States color television system to European governmental authorities. By 1966, RCA's Canadian subsidiary had substantially expanded its color picture tube facility, and had started construction of a new cabinet plant in Ontario.

In anticipation of regular color broadcasting in Europe, a new company, RCA Colour Tubes, Ltd., was formed in England in association with the British firm of Radio Rentals, Ltd., to produce RCA color picture tubes for the British and European markets.

On the other side of the world, the Philippines became the second Far Eastern nation after Japan to begin color broadcasting, employing RCA color studio and transmitting equipment.

In addition to supplying color and black-and-white television equipment to nations in Asia, Africa, and the Middle East, many other RCA products were in use throughout the world.

In 1963, RCA's Canadian subsidiary received a contract from the Canadian government for the design and construction of an advanced satellite communications ground station in Newfoundland. The station began operations in 1966. RCA Communications, Inc., was selected by the government of Thailand in 1966 to install Southeast Asia's first communications satellite earth station.

During the five-year period, RCA subsidiaries were active in the Latin American Free Trade Area, exporting electron tubes to this expanding market. The recording operations of RCA Italiana, conducted in Rome at Europe's most modern recording facilities, increased substantially. Two-way mobile radio units were supplied to the Hong Kong Ambulance and Fire Service, and to the Singapore Police Department, and NBC reached audiences in 93 countries through the sale of television films to government broadcasting authorities.

The continued growth of new opportunities abroad led at the end of 1966 to a realignment of RCA's organizational structure to capitalize upon its

special skills for foreign markets. The change was designed to draw the domestic operating divisions more directly into RCA's overseas businesses in order to make the most effective use of the company's resources in an expanding world market.

NEW BUSINESS AREAS

Major diversification moves were made during the four-year period to develop positions of leadership in new technology and new markets, ranging over wide areas of information processing and education.

In 1965, RCA organized a Graphic Systems Divison to apply computer and electronic technology to processes used in the printing industry. The following year the Division marketed its first two products—the Graphic 70 Videocomp electronic typesetter, and the Graphic 70 Color Scanner, which electronically produced the four basic color separations needed in full-color printing. At the same time, a vigorous applied research and development program was launched to supply a flow of new products.

The company expanded into publishing and took major steps into new areas of education. In 1966, Random House, Inc., became a wholly-owned subsidiary of RCA.

The educational facilities of the RCA Institutes, Inc., were expanded substantially. In 1966, the RCA Service Company received multi-million-dollar contracts to operate two Job Corps Training Centers for the Office of Economic Opportunity.

In order to coordinate the sale of TV systems, cameras, learning laboratories, and other equipment to the educational market, RCA formed an Instructional Electronics Department in 1966. That same year, the nation's largest educational TV system, installed by RCA for the Catholic Archdiocese of New York, was put into operation, and a similar system serving the Miami Diocese was extended.

Other new opportunities explored in 1966 included an agreement with Hoffmann-LaRoche, a leading pharmaceutical firm, to collaborate in the development of new medical electronic equipment.

Also in 1966, the company established the Magnetic Products Division to speed the growth of RCA's business in computer and other tapes for use in industry and the home.

Finally, late in the year, the Boards of Directors of RCA and The Hertz Corporation approved an agreement for the acquisition of Hertz by RCA.

RESEARCH

Many of the products that so radically changed the character of the electronics industry between 1962 and 1966 represented the successful application of research performed in earlier years in the laboratories of RCA.

The company's research and development activities during the period were scattered widely through the principal operating divisions, spearheaded by theoretical and applied research at the David Sarnoff Research Center of RCA Laboratories at Princeton, N.J.

In 1963, and again in 1965, major expansion programs were undertaken at the research center to increase laboratory facilities and to accommodate new research activities associated directly with specific product divisions of the company.

The research program itself penetrated increasingly into new areas of basic materials and phenomena, and it produced a number of significant advances leading to new devices and technology applicable to present and future businesses for RCA.

Extensive research efforts relating to lasers led to a number of new laser devices and techniques for employing lasers in possible future communications systems. A highlight of the program was the development in 1965 of an argon laser producing the highest power of any visible light laser yet known. The device was translated into a new commercial product and placed on the market by RCA in 1966. RCA's scientists also achieved in 1965 the first injection laser to emit visible light at room temperature.

Continued research in computer memories led to a number of new concepts and techniques of considerable promise for the future. The program followed several different lines, including new types of ferrite devices, thin film techniques, and superconductive memories. The latter effort achieved in 1966 a new technology for making high-capacity superconductive arrays that promised to out-perform present mass storage electromechanical memory systems and to compete economically with them.

Experiments in thin-film techniques employing improved photosensitive materials resulted in an experimental tubeless television camera. This device employed networks of thin films of photoconductors and other semiconductor materials, and digital scanning techniques, to perform the functions of a pickup tube and picture processing elements in a conventional camera.

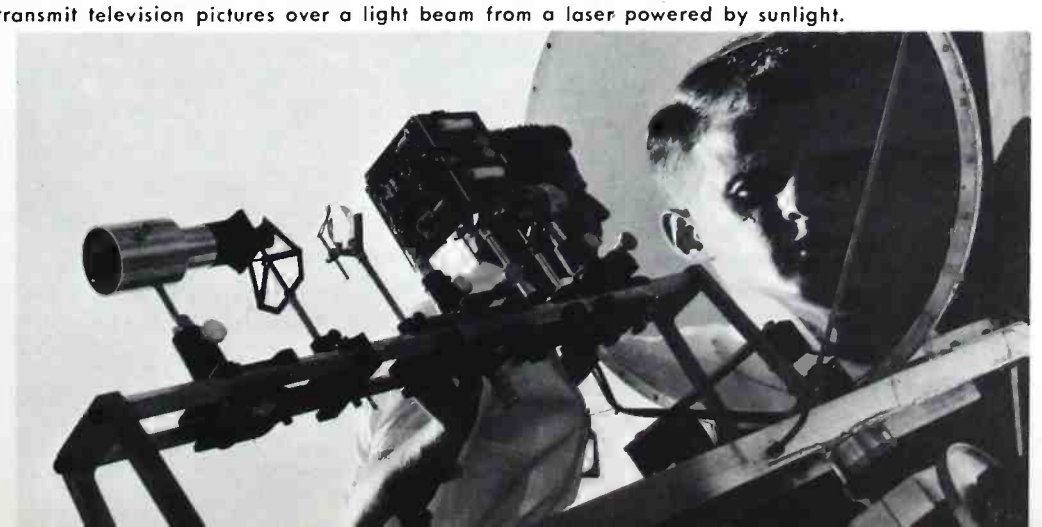
These are highlights of a wide-ranging effort that also produced new understanding of basic phenomena, explored new materials for a multitude of device applications, and developed new technologies for manufacturing microminiature devices in large arrays. The results promise to carry RCA forward in many existing and new areas of business in the years just ahead.

PROSPECTS FOR THE FUTURE

In assessing the performance of RCA between 1962 and 1966, and looking ahead at the prospects for continued growth and development, David Sarnoff told shareholders at the 1965 Annual Meeting, "In all my years with RCA, I have never seen our company more strongly positioned for progress than it is today—in personnel, in products and services, and in the promise of continuing profitability. Color, computers, components, and communications; broadcasting, service, records, and broadcast equipment are among the most active contributors to the country's growth—and they illustrate the breadth as well as the diversity of our strength."

These words were equally appropriate as 1966 drew to a close. Electronics in 1966 remained the nation's fastest growing industry, and its most challenging. No company was more determined than RCA to explore the many opportunities for service that electronics will offer in the years ahead.

This experimental "sun-pumped" laser, which is powered by the sun's rays collected in the parabolic mirror, was developed by RCA's Applied Technology organization, Camden, N. J., for NASA's Manned Spacecraft Center, Houston, Texas. This was the first step in a 50-million-mile communications link between Earth and spacecraft near Mars. Adjusting the equipment is RCA physicist Richard J. Tarzaiski, who helped develop the system. The device is believed to be the first to transmit television pictures over a light beam from a laser powered by sunlight.



RCA
Part V—the years 1966-71

Dr. James Hillier

During the years 1966 through 1971, RCA met the challenge of changing market conditions by a program of diversification in areas of high profit potential—particularly in service businesses—by the expansion of overseas activities, by the realignment of divisions, and by increased corporate marketing activities. RCA emerged, in this period, as a multinational company with industrial involvement on a worldwide scale. By the end of 1970, it had manufacturing and research activities in some 12 countries and marketing activities on all five continents.

Dr. James Hillier
Executive Vice President
Research and Engineering, RCA

studied at the University of Toronto, where he received a BA in Mathematics and Physics in 1937, MA in Physics in 1938, and PhD in Physics in 1941. Between 1937 and 1940, while Dr. Hillier was a research assistant at the University of Toronto, he and a colleague, Albert Prebus, designed and built the first successful high-resolution electron microscope in the Western Hemisphere. Following this achievement, Dr. Hillier joined RCA in 1940 as a research physicist at Camden, N.J. Working with a group under the direction of Dr. V. K. Zworykin, Dr. Hillier designed the first commercial electron microscope to be made available in the United States. In 1953, he was appointed Director of the Research Department of Melpar, Inc., returning to RCA a year later to become Administrative Engineer, Research and Engineering. In 1955, he was appointed Chief Engineer, RCA Industrial Electronic Products. In 1957, he returned to RCA Laboratories as General Manager and a year later was elected Vice President. He was named Vice President, RCA Research and Engineering, in 1968, and in January 1969 he was appointed to his present position. Dr. Hillier has written more than 100 technical papers and has been issued 40 U.S. patents. He is a Fellow of the American Physical Society, the AAAS, the IEEE, an Eminent Member of Eta Kappa Nu, a past president of the Electron Microscope Society of America, and a member of Sigma Xi. He served on the Governing Board of the American Institute of Physics during 1964-65. He has served on the New Jersey Higher Education Committee and as Chairman of the Advisory Council of the Department of Electrical Engineering of Princeton University. Dr. Hillier was a member of the Commerce Technical Advisory Board of the U.S. Department of Commerce for five years. He was elected a member of the National Academy of Engineering in 1967 and is presently a member of its Council.

A PROGRAM designed to modernize the company's identity was completed in 1969 with the changing of the corporate name from Radio Corporation of America to RCA Corporation. RCA's famed circular trademark with its symbolic lightning flash was replaced by a contemporary design in which the three letters form a distinctive single unit.

In early 1970, RCA established an Office of Consumer Affairs at the top corporate level. It has responsibilities for the safety and reliability of all RCA products and services and ensures that consumer interests receive prompt attention at all levels of the company.

An era came to an end on January 7, 1970, when the Board of Directors accepted the resignation of General David Sarnoff as Chairman of the Board and a director of RCA. At the same time, the Board elected General Sarnoff the first Honorary Chairman in the Corporation's history. The Board also adopted a resolution of appreciation, which stated, in part, that "more than any other man, David Sarnoff was the architect of RCA's rise to world leadership in electronics." General Sarnoff was succeeded by his son Robert W. Sarnoff.

Computer activities

By the end of 1970, RCA had made a greater investment in its computer operations than in any previous venture. A major new peripheral-equipment plant was opened in Marlboro, Mass., in 1969. The following year, the Marlboro facility was doubled in size, and plans were announced for a $16-million office building in that location to serve as the future headquarters for RCA's computer activities.

Final manuscript received April 30, 1971.

Throughout the 1966-1971 period, RCA strengthened its position in the remote computing field with the Spectra 70/46 and 70/61. In 1969, RCA also marketed the large-scale Spectra 70/60 batch processor.

Throughout the late '60s and early '70s, RCA continued to develop new computers, peripheral equipment, and components to meet the accelerating need for more versatile data processing systems. The Spectra 70/46 was introduced in 1967 and the large-scale Spectra 70/61 two years later to serve the growing market for remote computing systems. These two remote computing systems were the first RCA processors equipped with virtual memory, which means that the main computer memory can appear to be expanded almost limitlessly through a series of auxiliary devices and specially developed software.

However, RCA did not concentrate entirely on remote computing. In 1969, the company marketed a large-scale Spectra 70/60 batch processor designed to handle credit and reservations systems, automate production control, and serve data banks. The following year, RCA introduced a new series of small- to medium-class computers—the RCA 2, 3, 6, and 7. Two of these new processors also have virtual memory.

In 1970, RCA introduced a new series of small- to medium-class computers—the RCA 2, 3, 6, and 7.

Progress was also made in electronic composition systems. The speed of the RCA VideoComp was increased tenfold in 1968, making it possible to set the text of a novel the size of *War and Peace* in less than an hour. Two later developments further enhanced its capabilities: the ability to set complex line drawings and then position the drawings on a page together with text and the development of a program that enables the system to produce halftone photographs composed of small ideographic characters.

Consumer electronics

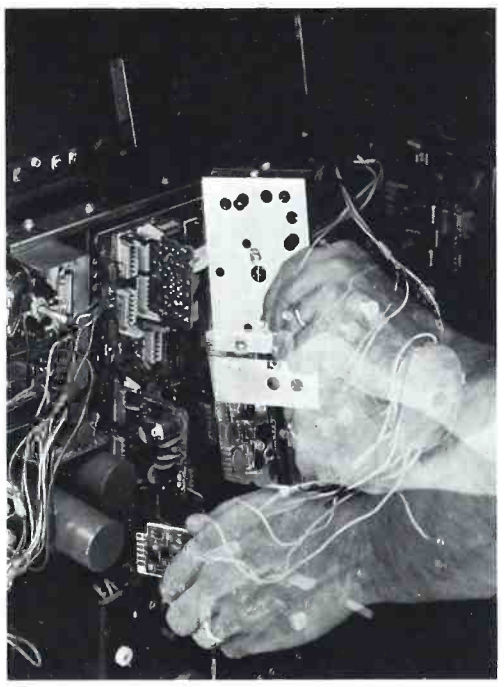
The domestic color TV boom of the early and middle 1960s began to level off in 1967 as the industry matured. Nevertheless, RCA maintained its leadership in color sales and total domestic consumer electronics retail volume. In 1969, computers began to be used to help design, produce, test, and market many RCA home entertainment products. The company recognized the potential of the youth market by highlighting colorful portable models throughout its radio, phonograph, tape recorder, and television lines.

In 1970, RCA introduced one of the most comprehensive consumer-warranty programs in the industry and instituted a multimedia advertising campaign to promote AccuColor—more accurate, brighter color with expanded automatic control.

Solid-state components were incorporated in RCA color TV sets for the first time in 1968. By the end of 1971, these components will have replaced tubes, other than the kinescope, in a large number of RCA color sets.

The RCA line of tape recorders was expanded in these years and ranges from professional-type stereo recorders to popular, handheld cassette players.

Throughout the five-year period, RCA maintained its leadership in color sales. This photo shows color television receivers on the assembly line at RCA's Bloomington, Indiana, plant.



Solid-state components have replaced tubes in a large number of RCA color sets. This photo shows RCA's solid-state modular chassis introduced in 1971.

The company also produced Stereo 8 tape decks for car owners in the United States. Four-channel sound in an eight-track cartridge configuration was introduced in 1970, providing a new dimension in musical realism.

RCA reentered the modular phonograph field in 1969 and added new models in various price ranges the following year. Late in 1970, RCA began test marketing personalized stereo consoles—an innovation that permitted the customer to choose from among 432 possible combinations of cabinet, speaker, and stereo components.

Electronic components and solid-state devices

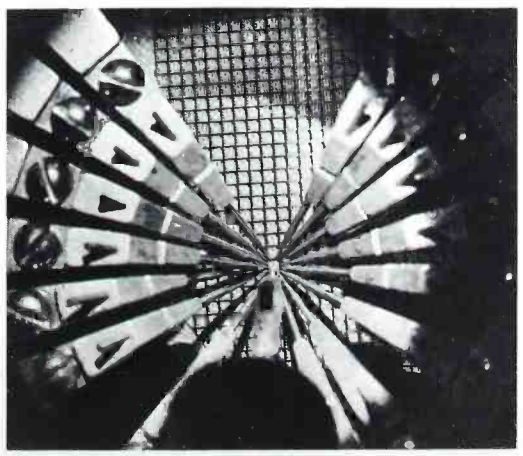
In recent years, RCA designed, produced, and marketed thousands of different types of electronic building blocks for uses that ranged from color TV to manned spacecraft. These were also years of technological change in the electronics industry. The receiving tube, one of the Corporation's oldest component lines, was slowly being replaced by products of the new solid-state technology. To coordinate activity in this field, RCA, in 1970, consolidated semiconductor activities into a Solid State Division. A new Solid State Technology Center was established at Somerville, N.J., as a focal point for semiconductor developments throughout RCA and in recognition of the need for a more intimate relationship between the RCA apparatus and systems producers and the producers of integrated circuits.

In 1967, the Corporation reinforced its position as the leading supplier of the triac, a new solid-state device that controls electrical operations with great precision and extremely low power consumption. These tiny components were used in many consumer products, including blenders, fans, and light dimmers. RCA triacs were also used in electronic scoreboards and in industrial lighting applications.

The following year, RCA made good progress in the application of microelectronics, using silicon monolithic integrated circuits. The company also pioneered the use of integrated circuits in consumer products and was the first in the industry to adopt integrated circuits for automatic fine tuning in color TV. RCA developed special COS/MOS integrated circuits for the aerospace market in 1968, which gave the company technological leadership in the field of low-power, low-speed digital integrated circuits.

In 1969, RCA developed a new, highly sensitive Silicon Target Vidicon through the combination of solid-state and electron-tube technology. The company also entered the digital display market with a NUMITRON readout device bright enough to be read in sunlight. It can be used for gas-pump indicators, desk calculators, cash registers, and automobile dashboards. In 1970, RCA expanded applications of silicon power transistors to include anti-pollution and vehicle safety systems.

Progress also was made in electron-tube technology. In 1967, new phosphors provided RCA color TV tubes with far brighter highlights than had been formerly possible. Two years later, the Corporation developed a new matrix color TV tube, twice as bright as any previous RCA tube.



An enlarged view of test-circuit probes contacting integrated circuit wafer at the Solid State Division.

In 1970, RCA developed transferred-electron amplifiers, a new family of multipurpose microwave solid-state devices. These devices, smaller and simpler than the traveling-wave tubes, have applications in electronic countermeasures; mobile, airborne, and spacecraft communications; and radar systems for weather and surveillance.

Broadcasting and recording activities

Color TV ceased to be a novelty as CBS and ABC followed NBC's lead into full-color network programming. Television became truly international in scope by 1967, when NBC arranged the first live color TV transmissions by satellite to England.

"Bonanza," the world's most popular TV series, had an estimated weekly audience of more than 400 million people in 83 countries.

RCA Records, which became part of NBC in 1969, made a number of artistic and marketing advances during this period. The Philadelphia Orchestra and its distinguished conductor, Eugene Ormandy, returned to the Red Seal label. RCA's sound-track recording of "The Sound of Music" became the best-selling album in the history of the industry, with sales of more than 13 million copies by the end of 1970. Van Cliburn's recording of Tchaikovsky's Piano Concerto #1 in B Flat Minor, was the first and only classical record to sell more than a million copies.

vations systems terminals at leading hotel and motel chains. The following year, technical maintenance services were extended for credit verification and airline reservations systems as well as data communications equipment. Also in 1970, RCA began to lease teletype equipment for both computing and communications uses.

Global communications

The rapid expansion of world business and the need for greater interaction among nations spurred the growth of global communications during the late 1960s. To serve this need, RCA Global Communications was operating more than 2,500 channels of various bandwidths by year-end 1970, nearly twice

NBC control room during live coverage of the Apollo mission in December, 1969.

The "Tonight" show hosted by Johnny Carson, was one of many successful programs presented by NBC during this five-year period.

At RCA Missile Test Project, computer specialists operate the Real Time Computer Systems, a vital part of the Range Safety function at Cape Kennedy.

Throughout this period, the NBC-TV Television Network attracted more advertisers than any other network. It was also first in attracting better educated and more affluent young adults, the category most prized by advertisers. In addition, in each of the years from 1967 through 1970, NBC-TV received more awards than any other broadcast organization: a total of more than 620, including Emmy and Peabody awards.

NBC News covered the headline-making stories of these years—the wars in Indochina and the Middle East, man's first landing on the moon, and the assassinations of Martin Luther King and Robert Kennedy. NBC Sports brought many of the top athletic events, including the New York Mets' victory in the 1969 World Series and the New York Jets' upset win in the 1970 Super Bowl, into the nation's homes.

NBC expanded its overseas operations and, by the end of 1970, was providing programs to 114 nations. That year,

Commercial services

Commercial and technical service volume of the RCA Service Company reached new peaks each year between 1967 and 1970. New branches were added to the nationwide network offering factory service to owners of RCA products, bringing the total to 180 by the end of 1970.

Commercial TV service activities also increased, largely because of the rising rate of conversions to color receivers by such institutions as hospitals, nursing homes, and hotels. In 1970, RCA reduced the cost of these conversions by designing a color installation compatible with existing black-and-white wiring.

The Service Company also handled maintenance and installation for RCA commercial communications products and provided service for other manufacturers and large users of such equipment. In 1969, it installed the hardware and provided remedial maintenance for more than 3,000 reser-

as many as were in use five years before.

The nature of the industry began to change during this period, with a pronounced trend toward increased use of telex and leased-channel services. Part of the reason for this was the development of new technological advances that permitted broad-based, tailor-made customer services at lower costs. For example, in 1967, RCA introduced AIRCON, a unique remote computing application that permitted companies that have their own private teleprinting network to plug in to a master computer for automatic relay of messages. The following year, RCA customers were able to use international voice-grade channels for simultaneous transmission of telegraph and voice, facsimile, and data communications over the same link.

In 1969, RCA inaugurated the Computer Telex Exchange, which provides international telex communications within seven seconds and reduces the

possibility of error. Another new service, Interpolated Voice Data, allows two-way voice conversation on a circuit at the same time that data flow at high speeds in both directions. During pauses in conversation, the circuit instantly switches from the voice mode to data transmission. Also in 1969, the Executive Hot Line was opened between New York City and San Juan, allowing a businessman in his Manhattan office to establish immediate contact with an associate in Puerto Rico merely by lifting the handset of his special telephone.

Commercial and industrial products

The market for broadcasting equipment expanded in the late 1960s under the impetus of increasing conversions of TV stations to color, a strong replacement market, and the opening of new UHF stations. However, after three consecutive peak years, domestic bookings waned in 1970 largely because disappointing general business conditions resulted in a decline in TV advertising revenue, forcing broadcasters to defer purchases of major equipment.

Throughout this period, RCA continued to be the leading supplier to the broadcast industry. In 1968, for example, 55 UHF stations went on the air for the first time, and RCA provided transmitting equipment for more than half of them. The company strengthened its leadership that year with the introduction of the TK-44A camera, which can take acceptable color pictures at only 15 footcandles, a light level too low for reading. Within two years, it became the best-selling camera in the industry.

In 1969, the Corporation introduced a 30-kW UHF transmitter that improved the technical quality of TV transmissions by a margin of two to one. RCA also continued to be the prime supplier of multiple-antenna systems for TV broadcasting. In 1970, two tower antennas were installed on the 100-story John Hancock Center in Chicago, and an agreement was signed to construct an antenna stack atop Mt. Sutro for San Francisco TV stations.

RCA technology was also part of the new age of aviation. Most of the major airlines, including Pan Am and TWA, selected RCA weather radar for installation in their new fleet of Boeing 747 jets and other aircraft. The TWA order, placed in 1968, was the largest single purchase of weather radar equipment in airline history. In addition, RCA navigation/communications systems were standard equipment on many business and commercial jets.

In other areas, RCA expanded its mobile two-way radio line in 1970 with medium-priced systems designed to serve the growing communications needs of small businesses.

Space and defense

When astronaut Neil Armstrong stepped from the Apollo 11 Lunar Module onto the magnificent desolation of the moon, his RCA-produced man-pack radio was his electronic link to home. It carried his historic first words across 225,000 miles of space to the world and on to posterity.

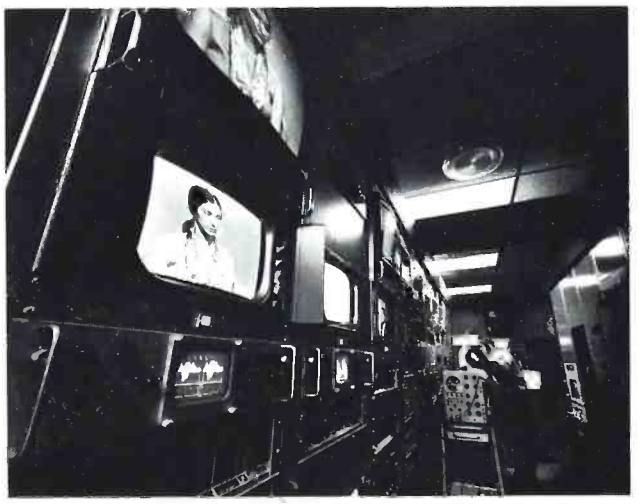
The radio was only one of the important RCA contributions to the Apollo program during the five-year period. In 1968, a tiny TV camera designed and built by the company for the Apollo 7 mission sent back the first live pictures of astronauts aboard a U.S. spacecraft. Another RCA camera flew on Apollo 8, man's first voyage to the vicinity of the moon. On later Apollo missions, RCA was responsible for the rendezvous and landing radars that helped guide the astronauts in the LM to and from the lunar surface, as well as the attitude and engine control assemblies that aided them in making pinpoint landings on the moon. The RCA LM communications system enabled the astronauts to maintain continuous voice contact with earth, and the VHF communications/ranging system kept the LM in constant touch with the Command Module when the two spacecraft were separated in flight. Two RCA countdown computers at Cape Kennedy provided critical ground support for the moon missions, monitoring 3,000 functions of the Saturn 5 rockets prior to launch.

RCA also has played a key role in developing spacecraft and systems for the nation's unmanned space program. RCA power supply and communication equipment was aboard all three Lunar Orbiter spacecraft that, in 1967, completely mapped the lunar surface.

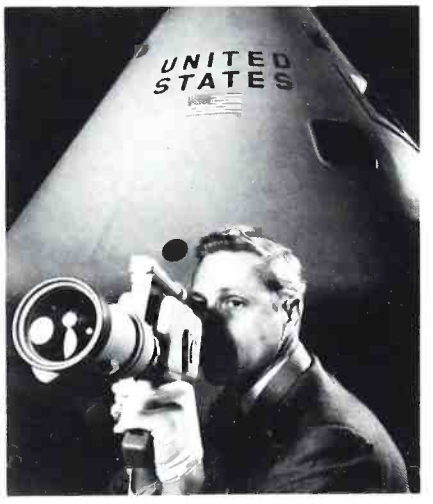
The company was also the nation's leading developer of meteorological satellites. By year-end 1970, more than 1.5 million television pictures had been returned from space by RCA-built satellites, most of them from TIROS/ESSA weather satellites. In 1970, the first two in a series of RCA-built ITOS satellites were placed in earth orbit. These larger, more sophisticated, second-generation spacecraft provided improved coverage of the earth's weather systems.

In another program, operational transit satellites built for the Navy provided ships at sea with the most

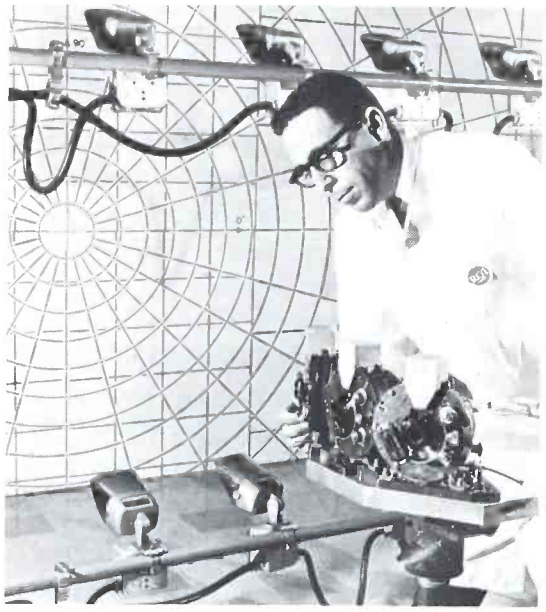
The global communications industry began to change in the late 1960s, with a trend toward increased use of telex and leased-channel services. Shown above is Globcom's Electronic Telegraph System.



RCA continued to be the leading supplier to the broadcast industry. This RCA broadcast equipment is installed in a new UHF station in Trenton, N.J.



In 1968, an RCA-built 4½-pound TV camera was carried aloft during the first manned Apollo flight. Dick Dunphy of Astro-Electronics Division demonstrates the camera.



The advanced vidicon camera system (AVCS) developed for NASA by RCA for the Nimbus weather satellite was the predecessor of the AVCS system used on several advanced TIROS operational missions throughout the late 1960s and early 1970s. In the photo, Mort Shepetin of the Astro-Electronics Division is preparing the tri-camera unit for calibration.

accurate navigational aid in history. RCA scientists and engineers also developed the power and data storage systems for NASA's experimental meteorological Nimbus satellite, and NASA selected RCA to build the high-resolution TV and recording systems for the first Earth Resources Technology Satellites, scheduled for launch in 1972 and 1973. The cameras will take highly detailed color pictures of the earth's surface to aid in the monitoring and controlling of natural resources.

RCA, in 1969, was assigned responsibility for the development of the Navy's new Aegis advanced surface missile system, and the preliminary design for the command and launch segments was completed in 1970. The $253-million contract was the biggest for RCA in more than a decade and might develop into the largest defense contract ever received by the company —possibly more than $1 billion. Other military projects during the five-year period included the study and development of an advanced airborne command center, over-the-horizon radars, and a robot sailboat that can be navigated by radio command to any point on the world's seas.

Leasing and renting

In recent years, American motorists have logged several billion miles annually in automobiles they do not own. They were customers of one of the faster growing segments of the service industry—vehicle leasing and renting. In 1967, The Hertz Corporation, the largest company in this field, became a wholly owned subsidiary of RCA. By the end of December, 1970, 150,000 cars and trucks were operated by Hertz and its licensees in the United States and 107 foreign countries. Hertz service was available at nearly 3,000 locations in more than 1,900 cities. Hertz and its subsidiaries also leased and rented construction, commercial, and industrial equipment and operated parking and exposition facilities.

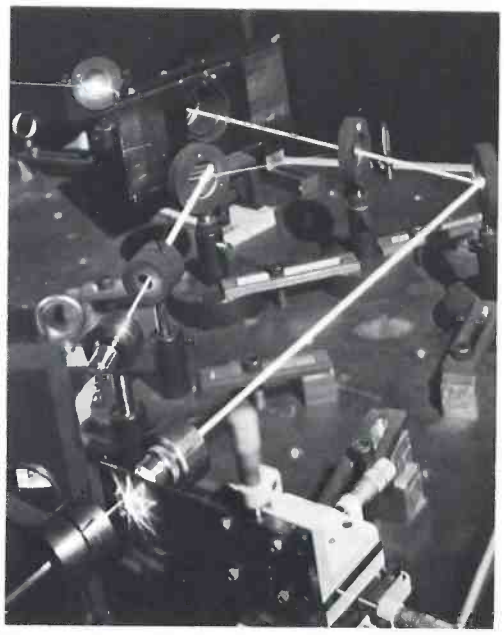
Late in 1968, Hertz unveiled a new service approach for the air traveler—the Sky Center at the Huntsville, Ala., jetport, where transportation, lodging, business, banking, and recreational facilities, all operated by Hertz, are housed under one roof. In 1970, arrangements were completed for Hertz to build and operate a hotel/motel complex at the Jacksonville, Fla., airport.

Overseas, Hertz reached an agreement with Soviet officials in 1969 to make auto rental available in several major Russian cities. Earlier that year, Hertz service was established in Romania and Bulgaria.

Hertz Equipment Rental Corporation entered the foreign market in 1970 with its new subsidiaries, Air Mac International Corporation and Air Mac Philippines, Inc. These concerns operate construction-equipment locations in Singapore, the Philippines, and Seattle, Wash.

Research and development

During the five-year period, thousands of scientists, engineers, technicians, and systems people at RCA laboratories in Princeton, N.J., Montreal, Tokyo, Zurich, and the product divisions provided the Corporation with viable technical alternatives on which to base future profit. These involved not only the discovery of new concepts



Research and development programs in laser technology and holography led to many new concepts and products. The photo shows one method used for constructing a hologram. An argon laser beam (top, left) enters an optical obstacle path where it is split into two beams by a half-silvered mirror and sent along separate paths to become the object and reference beams required to produce a hologram. The beam on the left is the object beam and can be seen to diverge into a cone just before it strikes the object (a transparency) to be holographed,

and products but also the evaluation of technical achievements made elsewhere.

Some of this activity was devoted to the realization of the promise of the laser. In 1967, RCA combined television and laser technology for the first time for transmission and recording of images. This system used a TV camera tube that sent its pictures to a gas laser, whose beam traced them on photographic film. The same year, a new laser technique was developed that made it possible to produce holograms of large stationary objects. In 1968, RCA's research in the control of light led to the development of the world's first holographic computer memory. Such memories are capable of storing large amounts of data in a very small space and are relatively immune to the effects of dust and scratches. The following year, RCA

In 1967, The Hertz Corporation became a wholly owned subsidiary of RCA. Shown below is the Sky Center at the Huntsville, Alabama jetport, a new service approach for the air traveler.

unveiled a laboratory model of a laser-based home video player. RCA plans to market a variety of home video player systems during the next decade under the SelectaVision trade name.

RCA scientists also developed gallium arsenide lasers—the most efficient solid-state lasers ever built.

One of the most important RCA research advances during this period was using liquid crystals for electronic control of the transmission and reflection of light. Liquid crystal products of the future may range from instrument displays for automobile dashboards to flat-screen TV receivers. Other achievements included the harnessing of an electronic "avalanche" within silicon diodes to produce the most powerful solid-state microwave generators ever built and the development of the silicon storage vidicon camera—a compact TV camera with stop-action capabilities.

In 1967, RCA laboratories, Tokyo branch, moved into new research laboratories just outside that city. Research there is concentrated on magnetic materials, semiconductors and semimetals, plasma physics, and communications theory.

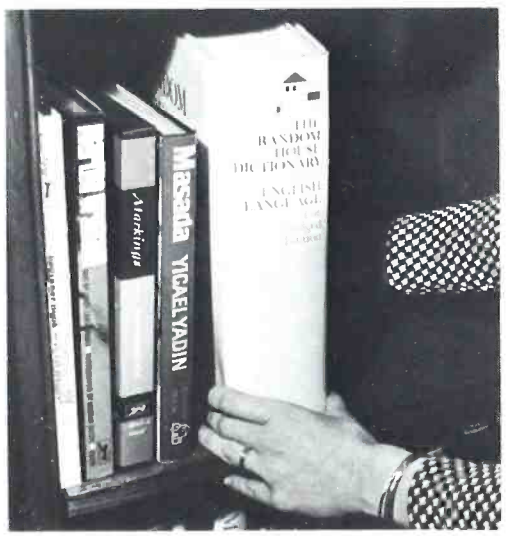
Publishing

From *Rosemary's Baby* in 1967 to *The Greening of America* in 1970, Random House titles were consistently represented on the best-seller lists. However, the achievements of RCA's publishing subsidiary were not limited to the trade book division.

The commercial and critical success of *The Random House Dictionary of the English Language,* published in 1966, led to the publication of a college edition in 1968 and an elementary school version in 1970. Random House maintained its position of leadership in children's books with the introduction, in 1968, of *The Right and Early Books* by Dr. Seuss.

The new RCA research laboratory in Tokyo opened in 1967.

To meet the changing requirements of modern education, Random House inaugurated a series of instructional materials for classroom use. Important multimedia programs were developed in all major languages and involved textbooks, audio tapes, and film strips. And supplementary materials were designed that offered individualized instruction for students at all grade levels who had difficulty in reading and mathematics. Efforts also were directed at the junior-college and community-college levels—the fastest growing segment of the college textbook market.

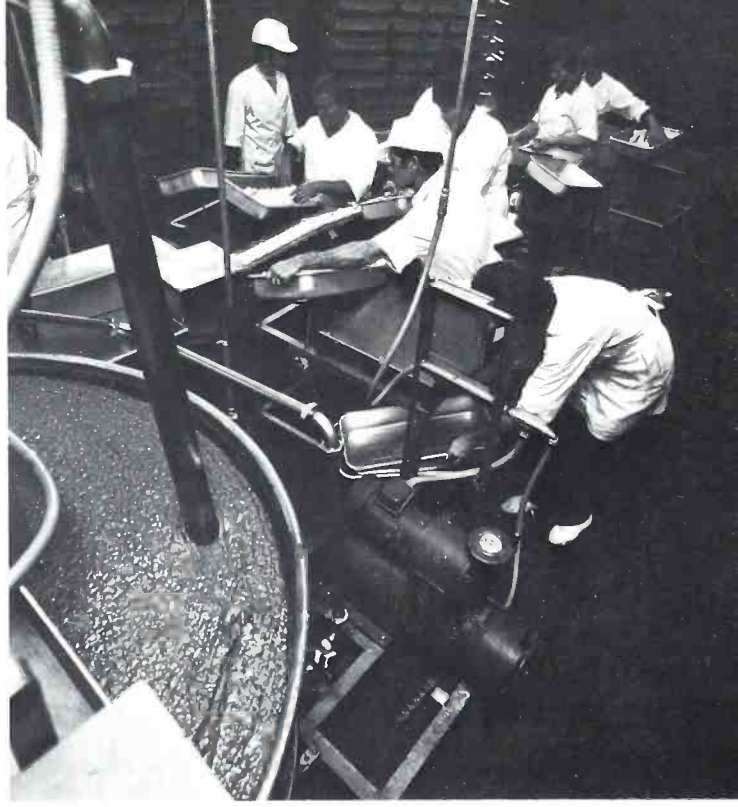


Heading an outstanding list of books published by Random House during 1966 was *The Random House Dictionary of the English Language*, the first major new dictionary in many years. Advance orders required an initial printing of 350,000 copies.

New business activities

During the five-year period, RCA followed a flexible growth policy of diversification and expansion of present activities, selective new business ventures, and increased emphasis on marketing to assure a sound balance between manufacturing and service businesses. With all these changes, however, RCA remained basically an electronics and communications company—with approximately 75 per cent of its products and services concentrated in these areas.

In addition to The Hertz Corporation, two other companies became wholly owned subsidiaries during this period. Banquet Foods, Inc., formerly the F. M. Stamper Company—a leader in the frozen prepared foods industry—became an RCA subsidiary in March, 1970. The same year, RCA acquired Cushman & Wakefield, Inc., one of the nation's leading commercial real estate firms. Cushman & Wakefield's operations encompass project consultation, office leasing, building



The F. M. Stamper Company—a leader in the frozen prepared foods industry—became a wholly owned subsidiary in 1970.

management, site improvement and development, sales, and appraisal. In late 1970, an agreement for merger was reached with Coronet Industries, Inc., of Dalton, Ga. Coronet's activities range from the manufacture of floor and wall coverings and commercial, residential, and institutional furniture to the fabrication of foams, plastics, and other materials.

RCA's managerial and technical capabilities were directed increasingly toward the improvement of public education and training in the United States. During this period, the Corporation received contracts to operate the Keystone Job Corps Center for Women in Pennsylvania and the Choanoke Area Development Center for seasonal farm workers and their families in North Carolina. And in 1970, RCA received a U.S. Department of Labor contract to operate a residential Job Corps Center for the training of underprivileged youth in New York City. The same year, the company contracted to direct a federally funded program aimed at upgrading the public school system of Camden, N.J.

In 1969, a new growth opportunity for RCA opened in the northernmost state, when the U.S. government accepted RCA Globcom's bid to purchase and operate the Alaska Communication System. Plans call for a telephone rate reduction that will save the people of Alaska some $40 million during the first three years of operation. By the end of 1970, RCA Alaska Communications had already built a microwave system and a tropospheric and micro-

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