ANNUAL REPORT

YEAR 1944

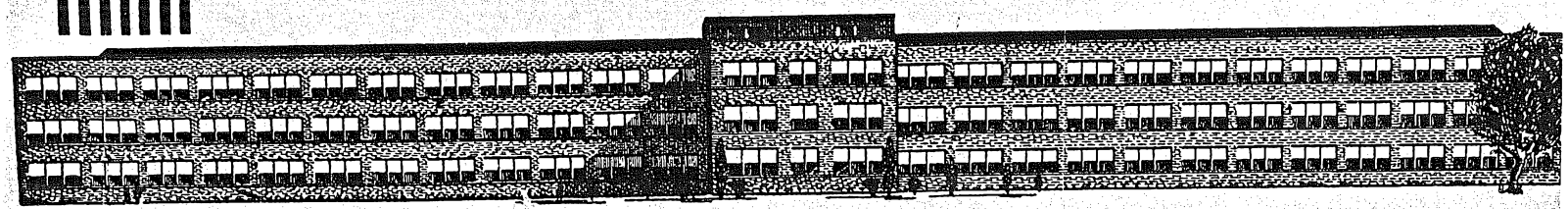
RCA LABORATORIES

RESEARCH DEPARTMENT

RCA LABORATORIES

RADIO CORPORATION OF AMERICA

PRINCETON N.J.



From RCA LABORATORIES, PRINCETON, N. J. Date Sent 3/28/45

Radio Corporation of America

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RCAL 2043

Mr. O. S. Schairer

February 12, 1945

E. W. Engstrom

ANNUAL REPORT
YEAR 1944
RCA LABORATORIES
RESEARCH DEPARTMENT

The prime objective throughout 1944 was to aid in the war effort. Requests of us to do research for the Army, the Navy and the Office of Scientific Research and Development exceeded our ability to respond, principally because of manpower limitations. We continued the practice of doing the early and fundamental research with RCA funds, transferring to a contract status as soon as military results could be demonstrated or predicted with some certainty.

Results of research at RCA Laboratories continue increasingly to lead first to small quantity orders for extensive field trials and then to substantial procurements. There have been production orders for manufacture at RCA Victor Plants, and others which have been divided with other companies. Where facilities within RCA have been fully utilized by other orders, complete procurement has been directed outside. In most instances this business has gone to licensees of RCA.

Appended is a summary report covering Research Department expenses for the year 1944, credits due to war contract research and net expense to RCA, all compared with budget estimates. Also appended is a statement of employment. Our estimated gross expenses were $3,145,249 and our actual expenses $3,023,368. The under expenditure resulted because we were unable to add needed members to our staff. Our total staff at the end of 1943 amounted to 499 as compared with a total staff of 495 on December 31, 1944. Thus, not only were we unable to make planned additions to the staff during 1944, but we did not entirely replace our losses during the year. Had we been able to make these additions we would have received increased credits, because the added effort would have been on contract work. As it was, our credits for 1944 were budgeted at $1,975,550 and we realized $2,064,787. This resulted in a net expense to RCA in 1944 of $958,581 in comparison with an estimate of $1,169,699.

At the beginning of the year we anticipated that some shift would be made during the second half of the year to a moderate program of work of a peace-time character. The changing war situation, however, brought about, instead, a greater need for keeping our efforts on contract work and on fundamental research directed toward war objectives. This is reflected in the above net expenses and credits.

In reporting more specifically on our research work, we have divided our activities into two broad classifications. The first is the work done under contract for the Army, the Navy and the Office of Scientific Research and Development. This results in the credit item on our expenditure statement.

A report on this work entitled: "Research Under Government Contracts in 1944," is appended. The second is the work sponsored by RCA, which is covered by the net expense item on our expenditure statement. A report on this work entitled: "Research in 1944 - Projects Sponsored by RCA," is appended. In order that these reports might be comprehensive and clear, it has been necessary to apply appropriate military secrecy classifications to each section.

Planning was continued on post-war programs. Except in a few instances where laboratory work could be done, our post-war work was limited to planning. We also continued the study and test of means for a continuing coordination between the Research Department of RCA Laboratories and other divisions and subsidiaries of RCA.

Members of our staff participated actively in the work of the Radio Technical Planning Board. Late in the year, we aided directly and indirectly, in the testimony before the Federal Communications Commission, in the review by the Commission of all of the radio spectrum up to 30,000 megacycles.

Sixty-two technical reports covering our research and development were issued by RCA Laboratories during the year. These were distributed to interested parties within the Company and to Government laboratories where it was thought the material would be found of interest. These reports were additional to those prepared under Government contracts and issued to contracting groups of the Army, the Navy and the Office of Scientific Research and Development.

The writing of technical papers related to our work and the giving of lectures by our research staff were much curtailed compared with pre-war years. Twenty-six technical papers were prepared for publication during the year. This moderate number enabled us to maintain prestige for the Company's research work in the publications of the technical press, without unduly taking time away from the war effort. Lectures before technical and semi-technical groups were limited to national conventions of the larger societies in our fields of interest, and to local technical and semi-technical groups where the necessary travel time was small. A total of forty lectures were presented by our technical staff.

A text book was published during the year by our acoustic research division head.

The Industry Service Division issued sixteen bulletins to licensees. These included regular technical bulletins, patent bulletins and new tube releases.

The RCA Laboratories at Princeton was honored by receiving two renewals of the Army-Navy "E" award, with second and third stars, for continued effort in our war work. A number of the members of our technical staff are serving as consultants to the Government on military problems, and several of them have received special recognition for the service they have rendered.

Mr. O. S. Schairer February 12, 1945

We suffered a great loss when, on the night of July 4-5, 1944, Mr. B. J. Thompson, Associate Research Director of the Laboratories, was killed in action during a flight in an Army plane in the Mediterranean Theater of Operations, while on a special mission for the Office of the Secretary of War. It is with profound regret that we report this loss of an unusually capable leader and associate.

Respectfully submitted,

E. W. Engstrom

Enclosures: Expenses 1944
Statement of Employment
Research Under Government Contract in 1944 (Secret)
Research 1944 - Projects Sponsored by RCA (Confidential)

RESEARCH DEPARTMENT

EXPENSES - 1944

	Actual 1944	Budget 1944
Gross Expenditures	$3,023,368	$3,145,249
Credits - War Contracts and Applied Research	2,064,787	1,975,550
Net Research Expense	958,581	1,169,699

RESEARCH DEPARTMENT

STATEMENT OF EMPLOYMENT

	Dec. 31, 1943	Dec. 31, 1944
Princeton	370	362
Communications	100	102
Industry Service	26	31
Purdue	1	0
	499	495

RCA LABORATORIES
RESEARCH DEPARTMENT

RESEARCH IN 1944

PROJECTS SPONSORED BY RCA

The research which has been carried out in 1944 under RCA sponsorship and which is reviewed in outline on the following pages was planned with major emphasis on war needs. The first applications of this research will in nearly all cases be military. This was in continuation of our policy of doing early and fundamental war research with RCA funds. As a result of this policy we have been able to take the lead in applying our experience in furthering the war effort and also to develop our skills in the fields of greatest interest to RCA. About a third of our effort during the year was on RCA projects, the balance of our work having been on war contracts with the Army, the Navy, and the Office of Scientific Research and Development.

I. FUNDAMENTAL RESEARCH

Chemical and Physical Effects of Microwaves

At the highest frequencies now in use for radar transmission we have come to the region where molecular resonance may be excited. The ramifications that may be expected from this effect are not known at present. There is a possibility that owing to this excitation the selective effects of radio waves on physiological and chemical processes, which have been sought for and not found heretofore, may be developed. The molecular effect of microwaves on the binding forces of various substances is of prime scientific interest and the use of these waves to influence chemical reaction is of great technical and industrial interest. Study of these effects started during the past year and is being continued to provide the background of knowledge necessary to determine the commercial possibilities in this field.

Investigation of Photoemission

Photoemission is of fundamental importance in television pickup tubes, image tubes and similar devices. Therefore, a great deal of time has been spent in research in this field. A large part of this work was done under direct NDRC contract. However, a certain percentage, having for its goal more fundamental knowledge, has been done under the sponsorship of RCA. This work includes the design and construction of a combined electron diffraction unit and shadow microscope, recently devised by the electron microscope group. With this instrument, it will be possible to determine basic factors of crystal structure relating to photoemission; information which was, heretofore, not available.

General Fluctuation Studies

As a result of continued broad basic studies of fluctuation phenomena, a number of important problems have been solved in connection with the "signal-to-noise" ratio in various types of systems such as B and C-scan pulsed radar systems, and modulated pulse carrier systems. The possible improvement to be obtained from the use of long-persistance phosphors was investigated with respect to signal-to-noise ratio.

II. RADIO TUBES

Super-High-Frequency Oscillator Tube

For some time, methods of generating microwave energy, using velocity modulation of an electron stream, have been under investigation at RCA Laboratories. A recent development which has come out of this work is an oscillator tube for superhetrodyne reception in the super-high-frequency band. This tube is unique, compared with previous designs, in that it will operate over a wide band of frequencies. The frequency of operation is controllable by means of an externally coupled circuit. It is expected that the tube will have wide application for post-war television and radio relaying. Modifications of the tube for this purpose are being undertaken at the Harrison plant of the RCA Victor Division.

Betatron Magnetron

In general, the production of extremely high frequencies, that is wavelengths of the order of a millimeter, requires either very high-velocity electrons or extremely small electrode size and spacing. The usual objection to high-velocity electrons is the high voltages required for their production. However, it is possible to obtain high-velocity electrons by direct magnetic induction; that is, a transformer wherein the secondary is a circular beam of electrons linking the changing magnetic flux. By combining this principle with theprinciple of the magnetron, it should be possible to construct a practical generator of millimeter waves. This is the aim of the present investigation.

The first step, that of accelerating the electrons to the required velocity, has to be accomplished in an experimental setup. The second step is that of obtaining sufficient current to satisfy the magnetron requirements. This problem is now being investigated, and experimental tubes are being built wherein the conditions of magnetic and electric field, theoretically necessary for large circulating currents, are fulfilled.

The final step will be that of designing and building the magnetron portion of the generator.

Ultra-High-Frequency Receiving Tubes

Beam-deflection mixer tubes have been found to have great advantages at u-h-f. Laboratory models of double-deflection mixers were built (at the request of the Navy) in which local-oscillator radiation was reduced 10,000 times below that of crystal receivers now being used

for searching out enemy radiations from 300 to 1000 megacycles. The crystal receivers, unfortunately, can be detected by the enemy, even at 100 miles; the new tube offers a possibility of reducing the range of detectability to a mile or so, without any sacrifice in receiver performance.

An investigation of the application of beam-deflection tubes to recovering the modulation from FM signals was carried on during the year.

Further work was done on secondary emitting materials to eliminate the internal activation process which had previously been required. While showing high initial amplification, tubes using emitting material made by this new process showed some falling off of performance during life. Further work is, therefore, under way on this development.

During the year we designed and built a special noise-generating tube which is intended to greatly simplify signal-to-noise measurements up to 3000 megacycles. The tube consists of a diode built as a section of coaxial transmission line.

All of this research, in addition to that done with these tubes for war purposes, will provide us with the background of experience necessary to make most effective use of these new and special tubes in the post-war commercial field.

Basic Ultra-High-Frequency Triode Design

In anticipation of the development of medium-power continuous-wave triodes for high frequency, a basic investigation of the effect of electron transit-time on the performance of large signal grid-controlled tubes was begun. The main object was to obtain data useful in the design of u-h-f grid-controlled tubes and to establish the ultimate limits of performance of such tubes at ultra-high frequencies.

Television Transmitting Tubes

Prior to the war, television transmitters of more than one kilowatt output power were not practical except on the first few television channels. Development of tubes and circuits has progressed since that time, though at a slow pace.

One of the tube research projects concerned the development of a tube having a peak power of the order of 40 kilowatts for use on the first group of seven television channels (up to 108 megacycles). Work has been continued slowly on this development, the RCA Victor Division at Camden cooperating with circuit tests. The project has

now reached the stage where a schedule has been laid out for its transfer to the tube engineering and manufacturing groups. Completion of this work will place RCA in an excellent position with respect to postwar commercialization of television transmitters for the channels below 108 megacycles.

In the range from 100 to 300 megacycles and higher, no tubes, which would give substantial amounts of output power, were available at the outbreak of the war. Since tubes for this range were of interest also in the war program, we began a little over a year ago, a basic research directed toward the development of a tube having a peak power output of 5 kilowatts and suitable for frequencies up to 300 to 400 megacycles. On testing this tube in a special transmitter, described later in this report, 5 kilowatts of peak power output were readily attained on a frequency of 288 megacycles.

III. CIRCUITS, COMPONENTS and TECHNIQUES

Circuit Developments

Inspired by the needs of high-speed facsimile operation, several circuit arrangements have been devised during the year which are of value in other work. These involve improvement in direct-current amplifiers, in methods of frequency modulation, and in audio-frequency discriminators.

New Capacitor for Television Receivers

Capacitors with certain special characteristics were needed for the high-voltage low-cost power supplies for projection-type television receivers. We developed a design for such capacitors in which we applied, for the first time, a titanium compound having a very high dielectric constant. The resulting capacitor occupied less than 1/10 the volume of the conventional mica capacitor of the same voltage and capacitance rating. Recent investigation of probable production costs indicates that the new capacitor will cost only about 1/5 as much as the mica unit.

This development is typical of the work of our materials laboratory which has produced many new materials, applications and techniques important to the success of our achievements.

Non-Reflecting Glass

Our research on the vapor process for reducing the reflection of glass surfaces has been completed with tests to show its successful application to glasses covering wide ranges in chemical composition. RCA has granted licenses for commercial use of this method.

Our research in the field of non-reflecting glass is now being directed towards methods of producing the non-reflecting film by treatment in acid solutions instead of by the vapor method which we have previously employed. A post-war application of glass surface treatment will be made in reducing the front surface reflection of the mirror in projection-type television receivers and probably the viewing screen.

IV. ANTENNAS and WAVE PROPAGATION

Communication Antenna Developments

A considerable amount of research work was done, during the year, on problems of antenna design for communication purposes. Some of these problems involved types of aircraft antennas for special purposes and with special characteristics.

Another problem involved communication deficiencies over the northern airplane route to Europe. On this project our engineers adapted the Beverage wave antenna (normally used for receiving only) to transmission with a performance improvement of about 10 to 1 compared with conventional antennas. As a result, these antennas have been generally adopted for long-wave transmission over far northern circuits.

Further research, carried out jointly by the Rocky Point Laboratory and the Signal Corps, indicated that the wave antennas should be useful for transmission on frequencies up to about 10 megacycles. It seems likely that this type of antenna will have a large number of possible post-war applications.

Picture-Sound Broadcast Antenna

Considerable thought has been given in past years to the design of an antenna for television transmitters. At the beginning of the year these thoughts crystallized and, anticipating the possible early need for such an antenna, work was started on the design of one to operate in the first television channel, 50-56 megacycles.

Past experience in the design of Turnstile antennas for FM has indicated that this type of radiator might be readily adaptable for use at television frequencies. Accordingly, a design which incorporates the Turnstile principle was evolved with added modifications to enable it to meet the stringent requirements of television broadcasting. The outstanding characteristics of the new design are:

(1) The antenna can be completely adjusted before installation.

(2) The radiation efficiency of this antenna will be considerably greater than any in operation at the present time.

(3) The addition of a simple network enables the same antenna to be used as a radiator for both the picture and sound transmitters.

Measurement of Antenna Characteristics

In the design and construction of antenna systems it is necessary to have considerable knowledge of the electrical properties of antennas. In general, these properties depend upon the antenna size and shape. Theoretical calculations of the characteristics have been limited to only a few simple antenna shapes because of the extreme mathematical complexity involved. Many other types of radiators such as cylinders, cones and spheres have very useful properties for many applications.

The increased demands, placed on the performance of modern antenna systems by the multitude of different services and limitations of size and location necessary for specific applications, have brought forceably to mind the need for greater knowledge on this subject. Therefore a research program was started during the year to obtain data on the characteristics of various sizes and shapes of antennas by actual measurement. When completed, these data will be of considerable help in understanding the general and specific influence of the geometry of the antenna on its electrical properties.

An exhaustive investigation of the electrical characteristics of cylindrical radiators has recently been completed.

Antenna Pattern Calculator

A device is under development for designing and checking multi-element antenna arrays. The calculator is an entirely electronic device patterned after a method originated at RCA Laboratories.

It produces, on a cathode-ray tube, a continuous trace of the field pattern produced by any array of from one to five antenna radiators located in any configuration within a circle four wavelengths in diameter. The currents in the radiators may have any phase angle and amplitude relationship. The pattern may be seen on either rectangular or polar coordinates and the radiation efficiency of the array may be determined. The calculator, exclusive of the cathode-ray oscillograph on which the patterns appear, will be contained in a single cabinet.

The trend in broadcasting transmitters toward directional antenna arrays has made it necessary in the past to do a large amount of calculation and field measurement work in deciding upon the location and arrangement of the antenna radiators. All of this work will be reduced to a routine few minutes of work with this new instrument. For instance, some time ago in planning the antenna arrays for station WTAR in Norfolk, Virginia, about one month of calculation and field work was necessary. This same problem can be solved on this calculator in a few minutes.

Rotary Line

The function of transmission lines, in general, is to carry electrical energy efficiently from one place to another. Electric currents in radio-frequency transmission lines obey the same natural laws as the currents in 60-cycle power transmission. However, because the frequency is very high, there are phenomena of radio-frequency lines not commonly observed with power lines. Unless a special condition is fulfilled by the receiver of energy, the so-called termination, there will be periodic variations of current along the line. Mathematical analysis of transmission lines enables one to determine from a series of measurements the exact form the termination should take.

A "rotary line" has been developed which greatly facilitates measurement of the current variations. The "rotary line" is inserted as a section of the transmission line. The current variations, which are then shown instantaneously on an oscillograph, completely describe the termination. The effect of adjustments at the termination is immediately and completely seen. This device also has value for demonstrating transmission line phenomena.

V. ACOUSTICS

Anti-Noise Microphone

An anti-noise microphone is one which has very high discrimination against noise when used at normal close-talking position. Such a microphone is very useful on airplanes, shipboard, tanks and other locations having high noise levels. An RCA project was started early in the year, based on a new idea in anti-noise systems which makes it possible to achieve very high discrimination against noise. Such a microphone was constructed and tests of its operation proved very successful. It was demonstrated to the Navy who showed great interest in the device. It is expected that they will shortly place an order for a quantity for military use. The information on this development has now been turned over to the Indianapolis plant of the RCA Victor Division where the microphones will be manufactured.

Midget Microphone for Television Broadcasting

In television broadcasting the microphone for sound pick-up requires even more rapid and ingenious manipulation, than does the one used on the sound motion picture stage because of the necessarily more continuous action in the television studio. It is, therefore, desirable that the microphone be as light in weight as possible so as to avoid the need for a heavy boom structure. During 1944 research was started on this problem and a weight reduction from 2 1/2 lbs. to 1 lb. was first accomplished. This microphone had such great advantage over the previous type for television pick-up work that we were urged by NBC to carry the development further. By use of a new permanent magnet material and an ingenious design of the mechanism it was possible to develop another microphone weighing only 1/2 lb. and having performance equivalent to the first unit. The NBC were testing this microphone at the close of the year and they urged its production for television studio use. They are also considering other uses in the broadcasting field.

High-Fidelity Microphone for FM

Standards set by the FCC state that the response of the microphone used on FM transmitters shall be uniform from 30 to 15,000 cycles. The RCA type 44B velocity microphone satisfies these requirements between 30 and 10,000 cycles. However, the response of this microphone falls off gradually above 10,000 cycles. At 15,000 cycles it is down about 5 db. The high-frequency response of a velocity microphone is determined by the length of path from front to back or by the baffle size.

To obtain uniform response up to 15,000 cycles it is necessary to use a relatively small baffle which, of course, means a reduction in flux density and sensitivity. Since the magnet structure constitues the baffle, study of both its acoustic and magnetic characteristics was carried on to determine a structure which would yield uniform response up to 15,000 cycles and a sensitivity equal to the 44B. As a result of this study, a high-fidelity velocity microphone was developed in which the response over the range from 30 to 15,000 cycles is uniform to within one db and the sensitivity is equal to the 44B.

Duplex Cone Loud Speaker

During the year, a new type of loud speaker was developed by RCA Laboratories for use in monitoring broadcast or sound recording programs, or for high-quality commercial sound. Toward the end of the year, this loud speaker was field tested by the National Broadcasting Company and was judged superior to any loud speaker previously available. The loud speaker employs two concentric conical diaphragms, each driven by its own voice coil. The unique feature of this loud speaker is that the large cone is a continuation of the small cone. This design makes it possible to obtain uniform response, a wide directional pattern and low distortion of the wide frequency band of 40 to 15,000 cycles. The RCA Victor Division is considering the manufacture of these speakers.

VI. POINT-TO-POINT COMMUNICATION and RADIO RELAYING

Radio Relaying

Research, started before the war and continued since at an accelerated pace for war purposes, has provided tube and circuit components which will permit radio relay systems to operate at higher radio carrier frequencies. Radio relaying is particularly important to RCA, because of the certain growth of television broadcasting after the war. It was felt important, therefore, to begin, as an RCA project during the past year, a thorough study of the subject which would serve as a basis for determining the RCA policy with respect to research, manufacture, operation and licensing in the field of post-war radio relaying.

VII. FACSIMILE

Facsimile Duplicator

Early in the year a comprehensive report was prepared by RCA Laboratories bringing together a historical review of our research and development in this field, listing the features of the various recording processes and the applications to which they were best suited, and giving some projection of future possibilities. This report was prepared for the RCA Laboratories Planning Committee. Reviewing the field about the middle of the year the New Projects Committee of the RCA Victor Division found tape facsimile under way as a military application and approved a plan for adapting the design to post-war commercial service. They also recommended active product design of the facsimile duplicator and gave it first priority among the several possible facsimile projects. The Laboratories were able to provide a promising basic design and, by the end of the year, the RCA Victor plant at Indianapolis had nearly completed 6 samples.

The next step is the remote duplicator for facsimile transmission from one office to another. This necessitates synchronizing equipment and, to meet this need, the laboratories have developed during the year, special circuits and drive motors. Bench tests show that we will be able to supply Indianapolis with basic design data on this problem as soon as they are ready for it.

The major work on the duplicator, however, has been the research on paper and chemical solutions to obtain acceptable recorded copy. This has involved some very specialized work in certain classes of organic dyes. Close cooperation has been established with a paper manufacturer and one of the large dye companies. A combination has been found of a new solution and a modified paper stock which gives a dark blue-purple black image of good contrast. The stability of the background on exposure to light has been much improved and is thought to be satisfactory for most applications.

In the field of tape facsimile, a simplified synchronous drive has been developed and a small recorder model assembled. Information on this has been passed along to Indianapolis at several conferences.

Some time has also been devoted to cooperation with the U. S. Weather Bureau who are operating two facsimile map circuits with our equipment, and are considering means for expanding this service eventually on a nation wide scale.

VIII. TELEVISION

Television Transmitter

Early in the year, we started development of a test transmitter capable of wide-band modulation and for use in testing the high-frequency tube described earlier in this report. About the middle of the year, the transmitter development had reached the stage where it could be used to test the tube. Five kilowatts of peak output power were readily attained on a frequency of 288 megacycles.

Subsequent to this, an antenna was erected on the roof of the main laboratory building at Princeton and field intensity measurements were made to investigate the propagation losses which might be encountered at this frequency. Among other tests, reception of television pictures at 288 megacycles was investigated in a residence location about 4 miles distant over rather unfavorable terrain. The picture quality was excellent and the signal strength was such as to indicate that adequate service would be obtained over much greater distances if a higher transmitting antenna were used.

The next step will be to try transmission under conditions more representative of a broadcast service area. This is planned for early in 1945 by moving the transmitter to the Empire State Building in New York City. In this connection, work was already well along at the end of the year on the design of the transmission line and antenna for the New York installation.

Cathode-Ray Tubes for Television

This research pertains to components which have application in a wide variety of television viewing tubes, and is general in nature.

Work was done on improving cathodes in order to obtain higher current density, lower power consumption, and less ion spot. This included an investigation of "thorium-on-tungsten-on-tantalum", and "thorium-on-molybdenum-on-tantalum", and of the geometric form of the cathode.

A study was made of the aberrations in the second lens of cathode-ray guns, in order to obtain an appraisal of the relative merits of electrostatic and magnetic lenses.

The problem of obtaining high light output and high contrast is of great importance for kinescope development. A series of tests were made on evaporated fluorescent screens as a means of accomplishing these ends.

Projection System for Home Television

Our development of reflection type optics for television and the molding of the lenses was directed to war uses. Reflection type optics were employed for producing large images of radar pictures used for tactical purposes. Such optical systems were supplied (by RCA Victor) in large quantity to the General Electric Company for use in radar equipment they are producing for the Navy. Research was continued on the development of molds and molding techniques for making plastic lenses. Experience gained through this work will be very useful in the post-war commercialization of television.

As a result of experience with projection kinescope and reflective optical systems, it was concluded that a system using a 5-inch diameter kinescope and a 14-inch diameter spherical mirror would represent a good engineering design and provide a picture of adequate brightness, size and resolution. We constructed, two such systems using glass elements, one for tests in Princeton, and the other in Camden. Later during the year the Victor Division produced a small quantity of receivers for field tests and demonstrations based upon this development and using a lens mold made by us.

Cooperation with FCC and RTPB

On September 25rd, the Federal Communications Commission visited the RCA Laboratories as guests of RCA. The program included a tour of the laboratories and demonstrations of work in progress. The purpose of having the Commission here was to provide its members with information which would be helpful to them in connection with the hearings to be held later in the year to consider frequency allocations throughout the radio spectrum. Demonstrations were given on FM and television reception, the latter including some military developments relating to television which were shown to the Commissioners with the permission of the Government departments concerned.

RCA Laboratories did additional work on the automatic-frequency-control type of synchronizing circuit and supplied, to the Radio Technical Planning Board, the latest information on this subject. This circuit provides improved picture stability under conditions of interference and weak signal.

During the FCC Hearing, which ended on November 2nd, 1944, members of RCA Laboratories contributed to the RCA testimony and to that of the RTPB. The RCA testimony dealt primarily with propagation matters affecting allocations for broadcast services in the region above 30 megacycles. RCA engineers attempted, for the guidance of the Commission, to clear away the confusion which appeared to exist in the interpretation of information which was available on the propagation in the region mentioned.

IX. SPECIAL ELECTRONIC DEVICES and APPLICATIONS

Electron Microscope and Allied Electronic Research Tools

Although very practical electron microscopes are in production and on the market, research aimed towards improving this type of instrument has continued throughout 1944. Important improvements were made in the cathode design and method of adjustment, which have led to the elimination of troublesome spurious spots and also to the possibility of an interchangeable condensor aperture which greatly decreases problems of correctly focusing the instrument. Considerable work was done on the design of electron lenses for the microscope with a consequent improvement in their efficiency.

The investigation of an electron microanalyser, which identifies the chemical elements in microscopically small specimens through characteristic retardations of electrons passing through the objects in question, was continued. This work included the study of a large number of materials to determine the range of usefulness of the device, the development of a new deflected beam system which greatly improved the operation of the instrument, and the perfecting of a special object chamber which makes possible the analysis of gasses. At the request of another laboratory engaged in war research, the development of a specialized object chamber with liquid air cooled walls was started to permit the analysis of very pure chemical surfaces.

Considerable work was done on developing an improved, high-resolution electron diffraction camera. This instrument is so arranged that it also functions as a shadow microscope, thus permitting a much greater knowledge of conditions at the specimen. Experimental instruments based on this principle have already given very good results.

Storage Tube Development

A number of electronic devices require for their operation some means of storing the information contained in an electrical signal and at some predetermined period later recovering the information. Such equipment would, for example, be useful for a number of radar applications. The storage tube, wherein the information is stored in the form of electric charges on a special mosaic, can perform this function. Therefore, the development of such a tube was undertaken about two years ago.

About the middle of last year, a very important application of such tubes to radar had developed, namely that of ground clutter elimination. Great interest in this development has been shown by the OSRD, our Army and Navy, and the British. This development is proceeding

as an RCA project. Storage tubes meeting most of the requirements of the applications in question have been built experimentally and it is expected that continued research will overcome the remaining difficulties shortly.

We are now under great pressure from the Signal Corps to push this development to a successful conclusion as rapidly as possible. Ours is the only laboratory that has developed equipment which appears to offer hope for a practical solution of this problem of ground clutter elimination.

High-Speed Scanners

For several years research has been proceeding at RCA Laboratories with the objective of scanning a scene rapidly enough with a radio beam so that a continuous received radio picture could be obtained. During the past year substantial progress has been made in the construction of a practical apparatus. The Army, Navy and OSRD have all shown increasing interest in this project that has been proceeding at RCA expense. Recently a cooperative project has been initiated with the Radiation Laboratory at MIT to supply an airborne version of the equipment to the U.S. Navy. Conversations with Signal Corps officers and demonstrations of our ground equipment to them have indicated that it is likely to be applicable to one of their very high priority projects for which no other equipment has been found suitable. We are cooperating in the test and development of apparatus for this purpose.

Gunfire Control

One of our major war contracts during 1944 was for the development of an automatic electronic fire-control equipment for anti-aircraft guns. Our completion of this assignment was so successful that the Armed Services have encouraged continued RCA participation in the fire-control field. We are in an advantageous position to do so because of our research on electronic counters and because of our radar experience. It is likely that the major use of radar in the future will be as a component element of complete systems. Therefore, if RCA wishes to remain in the radar field as a prime contractor it must undertake the engineering and manufacturing of complete systems. In view of this general situation it was decided that RCA would seek actively to develop its position in the field of gunfire control apparatus. In accordance with this policy, we have continued research and development on gunfire control systems at RCA expense, following the completion of our Army contract for the director now undergoing tests in the European war theatre. This work will be of value in preparing us to assist the RCA Victor Division in getting ready for their expected production of fire-control equipment and to further our undertaking of additional development contracts for such apparatus.

Time Measurement with Electronic Counters

Applications of electronic counter circuits have been under investigation at RCA Laboratories for a number of years. Several electronic timer equipments, measuring time in intervals of 10 microseconds, were supplied to the Army and Navy about two years ago for use in measuring projectile velocities. Development of these instruments has continued because of both their military and peacetime applications. Early last year improved equipment measuring time in intervals of 1 microsecond was supplied to the Services. In addition to its greater accuracy of timing, this equipment was much smaller and lighter in weight than that originally supplied.

RCA research, during the past year, has provided still further reduction in size, weight and number of tubes, while retaining the previous accuracy of measurement. Such units are expected to find extensive post-war uses as laboratory instruments and as components in electronic computing machines.

Using this same technique, equipment has also been developed for measuring any frequency from 1000 to 1,000,000 cycles in one second with a precision of plus or minus one cycle. Similar apparatus is now in use to count the irregular pulses from a Geiger tube and thus give a measure of X-ray radiations.

In addition to the peacetime applications promised by these devices, there has been a continued interest by the military services.

Heat Detecting Devices

Before radar became practical through developments in ultra-high-frequency radio, much work was done by the Armed Services in developing methods for locating airplanes, ships, etc., by detecting the heat radiated by them. Where it is necessary to maintain radio silence, heat detecting devices could be used to great advantage. This early work did not lead to practical results because of the sluggishness of available detectors.

We began research in this field during 1943, bringing together our experience in the fields of heat-sensitive devices, optics, television and general electronics. This work was continued during the past year, and apparatus was developed which, when demonstrated to the Navy, was judged to have military value. As a result of this demonstration, we received, later in the year, a contract to develop and construct similar equipment suitable for service tests on shipboard.

X. AVIATION APPLICATIONS

Applications of Radar to Civil Aviation

Through our war contract work, we have gained much experience and skill in the field of radar equipment design and utilization. It is desirable to make all possible use of this knowledge in the post-war period in providing needed commercial products involving this type of equipment. A study was therefore made, during the year, of the application of radar principles to aviation instrumentation and a report containing proposals for complete systems was under preparation at the close of the year. This report, and similar material to be prepared by the RCA Victor Division, are to be consolidated and used as a basis for RCA proposals which will be submitted to the government agencies concerned with civil aviation planning, for their consideration and recommendations. The actual development of apparatus will not be undertaken until system planning by the government and others is further advanced.

Dehydration of Penicillin

Early in the year, a study was begun, on the application of radio-frequency heating to the dehydration of various medicinal liquids. One of the first to be studied was penicillin, since it appeared that the application of radio-frequency heating to this material might provide definite advantages over the existing commercial method of processing. The present method consists of freeze drying at low temperature under a high vacuum and requires many hours of time and very expensive equipment. Our study has shown that, by the use of radio-frequency power, we can accomplish the same result with much less costly apparatus and a procedure which provides a more effective manufacturing schedule.

The radio-frequency method involves two stages. The first is a bulk-reduction process which concentrates the original liquid down to the point where it can be placed in the small ampoules which are used for final shipment. The second stage involves the final dehydration of the liquid in the ampoules to a completely dry state.

The dehydration of penicillin requires this special treatment for drying because, in its liquid state, this drug loses its potency rapidly if its temperature is raised to room temperature or higher. By applying a moderate vacuum and heating the liquid slightly by radio-frequency power, it is possible to boil off the excess liquid rapidly at about room temperature. Tests have shown that this results in no loss of effectiveness of the drug.

During the first part of the year, equipment for the bulk reduction of penicillin was developed and installed in the New Brunswick plant of E. R. Squibb and Sons where it has been in successful operation ever since.

The second stage of the radio-frequency treatment required the development of a mechanism for rapidly spinning the small ampoules to prevent the liquid from foaming out of them as it is being dried. The design of this equipment was rapidly approaching completion at the end of the year.

Similar methods of dehydration appear to be applicable to other drugs, anti-toxins and other medicinal liquids such as blood plasma. Some of these were tried during the year with successful results.

Pasteurization and Evaporation of Milk by Radio Frequency

Early in the year, work was started, on the application of radio-frequency heating to the pasteurization and evaporation of milk. In the work on evaporation of milk, it was found that this could be easily accomplished by the use of radio-frequency power and that the milk so treated retained the good flavor of fresh unevaporated milk. This flavor is usually lost by present conventional methods of evaporation.

In the work on pasteurization of milk it was found that by very rapid heating and very rapid cooling of the milk over a very short time period, it was possible to decrease the bacteria count and also avoid the cooked taste which would result if the high temperature were retained for any length of time.

The results obtained on bacteria count by this method were quite remarkable. Milk, which present methods could not bring within the standard low bacteria count specified for milk to be sold commercially, was quite acceptable when processed by the radio-frequency method. The only disadvantage found with this method lies in the fact that this treatment has a homogenizing effect on the milk and while it does not change the butter-fat content, it does decrease the ability of the cream to come to the top of the milk. So far no solution of this problem has been found.

XII. INDUSTRY SERVICE DIVISION

Industry Service Division Activities

Our normal licensee service activities were greatly curtailed during this year, due to the fact that the major portion of our staff and facilities were devoted exclusively to development work for the armed forces. Review of this work appears elsewhere in this report. Nevertheless, close contact was maintained with our old licensees, and as new classes of licensees were brought in we were able to give them much help.

Considerable work was done in investigating and reducing to practical form circuits and apparatus for projection television and FM receivers. The objective in this case was to prepare information and construct models which could be utilized by licensees as a basis for production design. Much work was also done in connection with low-reflecting glass surfaces. This work had a bearing on military applications in addition to being of interest to RCA licensees.

A considerable number of licensee engineers visited the Industry Service Division Laboratory primarily to discuss post-war commercial possibilities and design trends in the FM and television fields. Particular interest was expressed in low-cost television signal generating and testing equipment, new types of tubes and the design of optical systems for projection television. Bulletins were issued to licensees during the year giving detailed information on these subjects and based on development work and models built in our Laboratory. In addition, a comprehensive Patent Bulletin, listing recent RCA patents and others which licensees have the right to use, was issued. Facilities of the laboratory were used by various licensees, as heretofore, for tests and measurements of their apparatus. The recently installed "Stratochamber" was particularly useful to licensees for tests on apparatus being manufactured for the Government.

A comprehensive report giving the results of a study of the field of nuclear physics, which dealt with recent work in atomic research, atomic power and the like was prepared and distributed to interested parties within the RCA group. A similar study is in progress dealing with the field of electronics as related to living matter.

SECRET

RCA LABORATORIES
RESEARCH DEPARTMENT

RESEARCH UNDER GOVERNMENT CONTRACTS IN 1944

About two-thirds of our research during 1944 was done under war contracts with the Army, Navy and the Office of Scientific Research and Development, to meet specific research objectives or to develop and construct specific apparatus of interest to the armed services. These contracts were, for the most part, based on detailed proposals which we were able to present to the government agencies for their consideration because of early and fundamental war research carried on under RCA sponsorship. This early work made it possible for us to determine what lines of investigation would utilize our specialized skills and facilities to the best advantage in meeting immediate military needs. In thus utilizing our experience to serve the war effort best we have at the same time kept our activities within the fields of greatest interest to RCA. Furthermore, the quantity production which has resulted from our developments under war contracts has been of a kind well suited to the manufacturing experience of the RCA Victor Division. Our work during the year has provided more new manufacturing business than RCA Victor has had capacity to undertake. However, the equipment orders which did not go to RCA Victor have been valuable business for our licensees and therefore of value to RCA.

In the following pages we will describe briefly in topical form our work under contracts during 1944.

I. Military Radio Communications

II. Radar

III. Underwater Sound

IV. General Electronics

V. Radio Tubes

I. MILITARY RADIO COMMUNICATION

Transmissions from an Aircraft Carrier to its Planes

Development work has been under way for the past year and one-half on a system of communicating between ground and airplanes which is of particular interest to the Navy in connection with the operation of fighter planes from aircraft carriers. Briefly, the transmissions from the carrier automatically set up ideograms on an indicator in front of the pilot, or, alternatively, prepare a printed record. There are selective features which make it possible to send a message to a selected plane or to a number of airplanes simultaneously, as desired. Special features protect the transmissions from deliberate interference from the enemy. It is anticipated that the development will be completed early in 1945. Plans for prototype production are now under way, and it is quite likely that the RCA Victor Division will manufacture some 25 units. If the prototype models perform as anticipated, present Army and Navy interest indicates that production in terms of thousands of units will be planned. Since the device in question has interesting post-war possibilities, the experience obtained by RCA Victor should have definite value to RCA.

Vest-Pocket Transceiver

A vest-pocket combined transmitter and receiver was developed during 1944 and the required information supplied whereby the Office of Strategic Services had 530 units produced by an outside contractor. A lesser number of a heavier unit was also produced. The heavier unit is operated in conjunction with a magnetic wire recorder whereby both sides of a conversation up to 60 minutes in length may be recorded. This equipment was field tested in England and on the Continent with very promising results.

Radio Relay Equipment

During the past year, a development which provided for relaying by radio of eight channels of telegraph or telephones on a carrier frequency of about 1400 megacycles was completed for the Signal Corps. The next step appears to be the development of similar relaying equipment for use with broad band signals such as television and radar. A program for such work and also for the investigation of relaying at still higher frequencies is now under consideration to determine its military interest.

Interference Reduction

Under an NDRC contract, we investigated possible improvements of FM radio telephone systems used by our mechanized ground forces, with respect to jamming (deliberate interference by the enemy). Four receivers having improved characteristics were built and sent to government groups for field tests.

Other investigations were carried out under contract for the purpose of improving facsimile-picture and other transmission services with respect to interference and jamming.

Jamming of Enemy Radiotelegraph Communications

We have developed techniques and apparatus to jam enemy radiotelegraph communications many times more effectively than has been possible with previous methods. Our method automatically shifts frequency to follow shifts in the frequency of the enemy. This work was done under contract with the OSRD. Prototype samples of this equipment will be designed and produced by an organization outside of the RCA.

Secrecy Methods

Under contracts with the Army, a system is under development to provide privacy in facsimile transmission. The terminal equipment for this system was nearing completion at the end of 1944. The research and development work will continue well into 1945.

Early in 1944 the Riverhead and Rocky Point Laboratories, in cooperation with the Navy, undertook to develop equipment and try out a system of radio communication intended to make it possible for a ship to communicate with a land station in such a manner that an enemy could not detect the presence of the ship or the fact that it had radiated signals.

After completion of the special equipment, a series of tests were made in which Rocky Point and Riverhead respectively simulated transmitting and receiving shore stations while a station near Chicago simulated a ship. These tests having given good results, the equipment was taken outside the country and tested again under naval operating conditions. All equipment functioned satisfactorily and the system seems quite promising for its intended purpose.

At the beginning of the year we brought to a close our work at Princeton on another secrecy system which we had been developing under a contract with the Office of Scientific Research and Development. Although the projected investigation was successfully completed, the apparatus constructed was not judged to have sufficient military value to warrant further development at present.

II. RADAR

FM-Radar Aids to Bombing

During the year, we carried out an extensive program of research for the Navy on FM radar aids to low-altitude bombing. The basic principles for this work are the results of RCA research and ours was the only organization working on these principles.

The RCA Victor Division has been in production during the past year on some FM radar equipment for releasing bombs at the proper point before the target. This equipment, which had been developed at RCA Laboratories, required an antenna of considerable size. As aircraft are designed for higher and higher speeds, it becomes more and more important to eliminate protruding structures such as radio antennas because of their wind resistance. As a result of this, we developed, during 1944, bomb dropping equipment in which such a high frequency was used that the antenna structure could be sufficiently reduced in size to permit its installation within the wing of the plane. Information on this development has been turned over to the Admiral Corporation who have contracts to make the equipment for the Navy.

We have recently completed the development of a modification of these radar bombing equipments to make it unnecessary for the pilot to fly at a predetermined altitude. This modified equipment has been applied to production by both the RCA Victor Dvision and the Admiral Corporation. Further development is being carried on to give the pilot additional freedom of maneuvering during bombing runs.

The development of a complete automatic bomb dropping equipment was also finished during the year. This equipment determines automatically the course the plane is to fly as well as the dropping point. The course is set by means of FM radar signals and the time for dropping the bomb is determined automatically by these same radar signals. Flight tests indicated that the equipment we developed provided for very accurate bombing. Information on our developments was turned over to the Admiral Corporation and they produced a limited number of these equipments.

During the latter part of the year, at the request of the Navy, great emphasis was placed on modifying radar bombing equipment to make it available for the release of types of projectiles other than bombs. Our type of computer is particularly suitable for use with such equipment.

Precise Navigation for Bombing

Over five years ago a method of precise navigation was originated in the Industry Service Division of RCA Laboratories. This was applicable to aircraft navigation up to approximately 300 miles from base stations. After a time, the Army became interested and a contract to develop this navigational method for "blind" bombing was received.

Early last year, work was proceeding to tie in our navigational equipment with the airplane's bomb-dropping device. About the middle of the

year, flight tests before representatives of the Royal Air Force and our own 12th Air Force resulted in our being asked to supply research personnel for field tests in theatres of operation. Three engineers of the Industry Service Division went to the European war theatre to assist in combat tests of the equipment. Accuracy better than that attained by visual methods is reported as the result of the field tests. The production of this equipment was, therefore, given a priority higher than that for any other radar device. The RCA Victor Division is building this equipment in large quantities. Two of our engineers remain in the European theatre to assist in the use of this equipment.

Long-Range Navigation

A new type of navigational equipment has been developed during the war through work initiated at the Radiation Laboratory at Massachusetts Institute of Technology. This equipment was very much more accurate for navigation over a long range than the radio-compass apparatus used previously.

During the year, the Industry Service Division worked on this equipment to simplify it. As a result of this work, the tube compliment and weight of the equipment were both reduced by one-half. The RCA Victor Division now has a very sizable order for the construction of this equipment.

Research is continuing with the object of making this system operable over still longer ranges.

Light-Weight Radar Beacon

During 1943, a project was initiated under OSRD contract for the development of a portable or airborne radar beacon which would operate in a higher frequency region than any equipment of this type previously constructed. This system required the development of new tubes as well as new circuit and antenna components.

This project was completed in 1944 with the delivery of tubes and complete apparatus to the Radiation Laboratory at Massachusetts Institute of Technology. Aid was also furnished to the RCA Victor Division who have been selected as the manufacturer of the tubes and air-borne models of the beacon. It is expected that this development will have considerable application during the remainder of the war and also in the post-war civilian aircraft navigation program.

Radar Wide-Band Antenna

In order to permit wide flexibility of frequency selection, to provide means for avoiding the effects of enemy jamming, it was desirable to have a directive antenna for radar which would operate over a wide band of carrier frequencies without adjustment and with good radiation efficiency. The development of such an antenna was completed early in the year under an Army contract. The RCA Victor Division is now working on pre-production samples of a radar system using this broad band antenna.

Radar Indicator Screens

The type of cathode-ray-tube screen employed to reproduce the radar indication is very important in determining the efficacy of the radar equipment. If the screen can be given the property of retaining the image of the trace for several seconds, until the beam returns to sweep out a new trace, it is possible to design radar systems which can portray complete up-to-the-minute maps of the terrain being explored, and also to produce equipment which integrates the signal in such a way that the indication is relatively insensitive to radio interference. An intensive research program was set up at RCA Laboratories and elsewhere, aimed at the development of such a phosphor screen. This work has been highly successful and the results have been applied in about 500,000 radar cathode-ray tubes manufactured at Lancaster.

In order to coordinate the work on radar screens here and in England, a member of the Laboratories staff was sent abroad by the Office of Scientific Research and Development to study the British research and manufacture of cathode-ray tubes. Some of our special screen materials have no British counterparts, and several pounds of these materials were sent to England at the request of the British Admiralty.

A new type of screen which is transparent and which therefore can be used where the ambient illumination is high was under investigation during the year. This development is very promising although it has not yet been brought to a point where such screens can be applied in practical tubes.

III. UNDERWATER SOUND

Obstacle Detector

Early in the year, the NDRC called our attention to the vital need of a means for detecting submerged objects which serve as barriers to landing craft in shallow water. Research along this line was started, and we evolved a very small ultrasonic device which operated under water to give the direction and approximate distance of an obstacle in a manner somewhat analogous to radar. Operation was possible at distances up to about 50 feet. It is interesting to point out the almost unbelievable fact that the frequency of vibration produced in water by this device is the same as the frequency corresponding to the middle of the standard broadcast band - 1,000,000 cycles.

Exploring parties preceding landing craft will be able to use this device to do their jobs more rapidly and with greater certainty than in the past when they had to feel their way along. Subsequent to successful demonstration of our development to representatives of the NDRC and the Navy, this device was placed in production in the Indianapolis plant of the RCA Victor Division.

Heterodyne Depth Charge

In this device, a supersonic radiator and receiver are used to fire the depth charge automatically when it is closest to the submarine. The original model which we had developed was put in production early in 1944 by the Operadio Manufacturing Company and more than 25,000 units have been manufactured. We have continued our development work on the device, to help overcome manufacturing difficulties and to work out improvements which have been incorporated in the production. One of these improvements was a new laminated magnetostriction driving rod, which increased the output more than four times and reduced the noise considerably.

Echo-Ranging Projector

During the latter part of 1943 and the early part of 1944 we carried out a study of magnetostriction projectors used in underwater sound echo-ranging equipment. The efficiency of these projectors was quite low, about 12%. We felt that this efficiency could be improved and therefore a development program was started. As a result, a new type of driving system was developed incorporating a laminated rod and having the entire assembly mounted on a screw thread. The efficiency was found to

be four times that of the conventional driving system. Using a screw thread for fastening the driving system instead of the conventional practice of soldering the tube to the diaphragm makes it possible to tune and test each unit separately. This work resulted in a Navy contract to develop a complete projector. Several of these projectors were developed and the increased efficiency was almost twice that of the conventional projector. The RCA Victor Division has made a pre-production sample of a projector using the new type driving system.

Magnetostriction Microphone for an Acoustic Mine

Mines intended to be exploded by sounds of an approaching ship in the water have, heretofore, utilized a Rochelle salt crystal as their microphone element. These crystals are very delicate and easily affected by high temperature and humidity. At the request of the Naval Ordnance Laboratory, we developed a magnetostriction microphone to replace these crystal elements. This unit was found to be as effective as the crystal microphone in tripping the mine, much more rugged mechanically, and practically unaffected by temperature and humidity. The question of further action based on our development is now under consideration by the Naval Ordnance Laboratory.

Sound Signalling System

This project, which was carried on under a Signal Corps contract, had as its purpose the development of a system for underwater voice communication having a range of several miles. It involved the development of both transmitting and receiving equipment, transmission being by voice-modulated 50,000-cycle sound waves. The apparatus is arranged to permit the use of four systems of modulation, any one of which may be selected by merely turning a knob. This is the first time that an underwater voice transmission has employed modulation other than conventional amplitude modulation. The combined radiator-microphone is of the quartz-crystal-sandwich type with a total band width of approximately 6,000 cycles centered at 50,000 cycles.

Two complete systems were built which made it possible to carry on a two-way conversation. The best transmission results were obtained with the amplitude-modulated, single-sideband, carrier-suppressed type of modulation. Reflections gave considerable trouble when other types of modulation were used.

Upon completion of the work the project was transferred to the Navy. The systems were turned over to the Naval Research Laboratory for further tests.

IV. GENERAL ELECTRONICS

Television

In 1944, as a result of the immediate need, by the Navy, for quantities of a new type of camera tube of higher sensitivity which we had developed, it was necessary to provide a pilot-plant setup to manufacture these tubes in Princeton. We made about 200 of these complicated tubes, which were used in apparatus built by the RCA Victor Division for Navy service test. These tubes provided a 100-fold increase of sensitivity compared with the conventional 4 1/2-inch iconoscope.

Later developments have been directed towards the reduction of size and weight of both the tube and the accompanying apparatus. Toward the end of the year, a pickup tube with equivalent performance had been developed with only one-half the diameter and two-thirds the length of the previous design. The camera was reduced to one-fourth of its original size, and the weight of the complete equipment including transmitter and power supply was only one-half that of the previous design. This equipment is much more suitable than the previous design for locations where space is limited.

Infrared Developments

The development of infrared detecting equipment, which started some years ago as an RCA project, has been continued under Navy and Office of Scientific Research and Development contracts along a number of different lines. These include the design and construction of specialized telescopes for particular applications, the improvement of previous designs by decreasing their size and weight and increasing their operating life, and the improvement of the image tube.

As a result of these developments, substantial procurement orders have been placed by the Navy for a number of different types of telescopes. These instruments are being manufactured by the RCA Victor Division at Indianapolis. Image tubes for them are being produced in quantity at Lancaster, and in lesser number by Farnsworth following the RCA design.

During the year, two additional special instruments which we developed were tested by the Army Engineer Board and found satisfactory. An order for some 2,000 instruments was placed with the Sperry Corporation and later a large order with Bell and Howell.

Another special instrument developed during the year, using a 7-inch-focal-length Schmidt optical system, was tested in the field by the Navy. A pilot order for 50 units was placed in the Indianapolis plant of the RCA Victor Division.

Improvements in the power supply systems and in the image tube have been made during the year, with the result that the instruments are becoming simpler and more economical in operation. At the close of the year, work was progressing toward obtaining an image of greater brightness, as a result of extensive basic research on new phosphors.

Heat Detecting Device

As a result of basic research sponsored by RCA and a demonstration for the Navy of equipment which we had built, we began work on a contract, to construct complete apparatus for scanning the horizon and detecting distant objects by means of minute amounts of heat which they radiate. The heat-sensitive element which we have developed for such use, and which we believe will find many other applications, is more suited to quantity production than other devices of comparably great sensitivity. This contract is scheduled for completion early in 1945.

Gunfire Control

During the war period, we have conducted research on electric and electronic computing devices for use in gunfire control. This work has proceeded under contracts from the Army, the Navy and the Office of Scientific Research and Development.

In 1943 we were asked by the Army to construct a model of a complete gunfire director for an anti-aircraft gun. Our research on computors had particularly fitted us for the building of this director.

Last year, the director was completed and passed laboratory tests, as well as firing range tests by the Army. As a result of these tests, the equipment was sent to the European war theatre for combat tests and two of our engineers went to France to assist.

During 1944, RCA reaffirmed its original intention of actively entering the gunfire-control field. As a result, both RCA Laboratories and the Victor Division undertook engineering development work at RCA's initiative in order to be in a position to start production with maximum speed if a quantity order was negotiated by the Army.

RCA Laboratories, at the request of the Army, is undertaking further researchnwork along two lines: first, the conversion of the present director to control larger caliber guns; and second, to investigate applications of electronic gun-director techniques in the field of guided missiles.

A Reading Device for the Blind

A problem which has always existed but which, as a result of war injuries, has become particularly acute is that of devising artificial aids to take the place of sense faculties which have been impaired. A machine which would permit a blind person to read ordinary printed matter would be an important aid in this category. The development of such a device began as an RCA project and is being continued under an Office of Scientific Research and Development contract.

The method consists of generating characteristic sounds representing letters and words, using a photo tube and a light beam to obtain an electrical signal from the letters.

An important problem in this connection is to find a method of reproduction which gives an easily learned, unambiguous signal. In order to determine the most satisfactory signals, recordings of letter and word sounds for several practical pickup methods were made, using an instrument built to "read" from letters on 16 mm. film. These records will be studied at the Haskins Laboratories by psychologists to determine their usefulness.

At the same time the practical design of pickups which can be used with ordinary printing is being investigated, and the construction of some units is planned for the near future.

V. RADIO TUBES

Receiving Tubes

In the ultra-high-frequency range, of the three methods of controlling electrons, namely: by grids, by velocity variation or by change in direction (i.e., deflection), the latter method, which has received little attention in other laboratories, is being fully investigated here. Beam-deflection mixer tubes have been found to have unusual advantages at ultra-high-frequencies, both as regards their very high signal-to-noise ratio and their adaptability to electron multipliers. During 1944, the all-metal beam-deflection mixer tube, which had been developed in 1943 for the Signal Corps, was greatly improved by an extension of the frequency range to 1500 megacycles or higher, by an increase of 20% in signal-to-noise ratio and by the introduction of a one-stage multiplier which increased the amplification five-fold. The multiplier in these tubes employed a secondary emitting electrode which was pre-processed before assembly, thus eliminating the internal activation process which had previously been necessary.

Two small ultra-high-frequency diodes were developed during 1944, the smallest having an effective size of only 1/4-inch by 3/4-inch, i.e., it occupied a volume of less than one-fifth the effective volume of an "acorn" tube. Improved tubes of this size are now being made experimentally at the RCA Victor Division plant at Harrison.

High-Power Pulse Triodes at 600 Megacycles

Work in this field under contracts from the Army and Navy has continued since early in 1940. Progress to the extent of a ten-fold increase in peak power each year has rewarded our efforts. The Lancaster plant of the RCA Victor Division is now producing a tube which resulted from the previous stages of this research.

The present project, under joint Army and Navy sponsorship, calls for further increase in power. This has entailed an investigation of grid materials to avoid difficulties of grid emission which are basic to the obtaining of still higher power from these tubes. A solution of this problem would have far-reaching consequences in view of the serious limitations imposed by materials now available. This problem is being attacked on several fronts.

Magnetron Development

The multi-cavity magnetron has been much used in military equipment because of its efficiency in generating considerable power at centimeter wave-lengths. After extended effort at RCA Laboratories, it has been possible to solve the difficult problem of reducing the operating voltage and thereby reducing the size and weight of the tube and its equipment while still obtaining practical output for special uses. Cooperation between the engineers at Princeton and at Lancaster is continuing for the purpose of facilitating the production on a government order for these

tubes which is scheduled to begin by April, 1945, at Lancaster.

A tunable pulse magnetron was developed for systems work at Rocky Point and some ten tubes were made at Princeton after which specifications were turned over to the Sperry Gyroscope Company for production.

Work was begun during the year on new tunable continuous-wave magnetrons. This work has recently been continued under a contract from the Naval Research Laboratory.

Electronic Frequency Modulation

A new method of frequency modulating magnetrons has been devised which holds promise of meeting the stringent requirements imposed on the FM characteristics of microwave generators for certain important military applications and, in addition, will furnish the basis for a new type of reactance tube of low-loading for ultra-high-frequency use. The method requires relatively low modulating power and results in little amplitude modulation and high efficiency. It is believed that tubes of this type may have considerable importance in future FM developments.