CONTENTS

VOL. 1, NO. 5 • FEB. - MAR. 1956

RCA ENGINEER

"RCA Engineer" Staff

W. O. Hadlock, Editor
R. J. Hall, Assistant Editor
M. L. Malfaro, Editorial Secretary
J. L. Parvin, Art and Production
J. O. Gaynor, Photography

Engineering Editors

P. R. Bennett, Mgr., Radio & Phonograph Engineering, RCA Victor Radio & 'Victrola' Div.
R. S. Burnap, Mgr., Commercial Engineering, Tube Division
J. B. Davis, Engineering Editor, Engineering Products Division
C. A. Meyer, Mgr., Commercial Engineering Technical Services, Tube Division
C. M. Sinnett, Mgr. Advanced Development Engineering, RCA Victor Television Division

TECHNICAL JOURNAL PUBLISHED BY **RADIO CORPORATION OF AMERICA,** PRODUCT ENGINEERING, CAMDEN, N. J.
Send all inquiries to Bldg. 2-8, Camden, N. J.

OBJECTIVES

To disseminate to RCA engineers technical information of professional value.

•

To publish in an appropriate manner important technical developments at RCA, and the role of the engineer.

•

To serve as a medium of interchange of technical information between various engineering groups at RCA.

•

To create a community of engineering interest within the company by stressing the interrelated nature of all technical contributions.

•

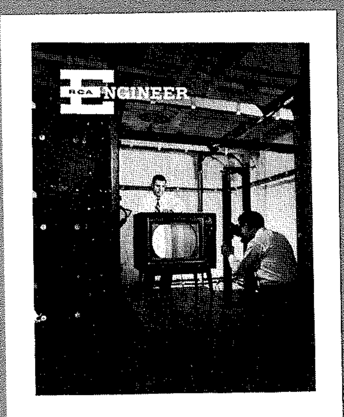
To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.

•

To provide a convenient means by which the RCA engineer may review his professional work before associates and engineering management.

•

To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.



OUR COVER

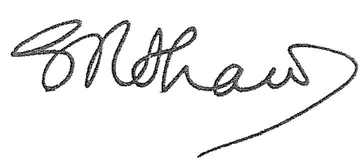
Our cover this issue depicts laboratory measurements being made to determine the effects of variable fields on color television receiver operation. Photo was taken in the Helmholtz test chamber at RCA Victor Television Division Engineering Laboratories, Cherry Hill, N. J. A. G. Lazzery, foreground, is shown observing performance with a cathetometer, while B. R. Clay (behind receiver) makes required compensating adjustments. See "Effects of Magnetic Fields on Color TV Receiver Performance", by B. R. Clay, in this issue.

REVIEWING PROFESSIONAL ACCOMPLISHMENT

How are we doing professionally and where do we want to be in another five years? What have we accomplished, and where have we fallen short, and why? These are the questions we must ask ourselves as engineers just as any good businessman does when he takes inventory and makes plans. We should evaluate our present status and, more important, establish goals for our future growth.

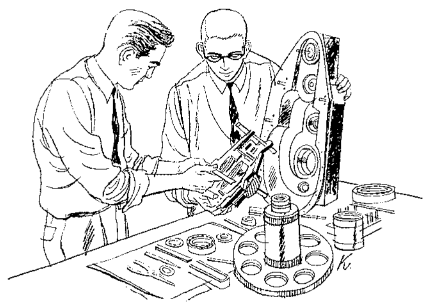
Professional growth is something which is difficult to see from day to day. Just as in our experimental work, a longer look is often more revealing. It is always surprising to compare the contents of a yearly report with the goals of the plan made out at the beginning. Some items nearly follow a straight line, but more often the path is a "tacking" one—and sometimes the by-products outrank the original objectives in importance. A review will show that it's just as important to know when to drop an unfruitful course of action as it is to capitalize on successes.

Let us all then take inventory of our professional growth over, say, the last 12-month period! When we take this long-range look at our technical progress, let's make sure that we examine it for breadth as well as depth. In achieving our technical goals, have we narrowed our horizons? Family and job are certainly central interests for all of us, but the forward-looking engineer will recognize the need to broaden his scope further. One method of doing this is to allot some of our time for the professional society as well as the community. Another way is to discuss professional accomplishment with associates. Still another invaluable and convenient method of reviewing professional work before engineering associates and management is to prepare technical papers for publication in professional journals. One of these available to you is the RCA ENGINEER.



Chief Engineer, Tube Division
Radio Corporation of America
Harrison, N. J.

HUMAN RELATIONS AND THE MANUFACTURING ENGINEER



By: **A. SKELE**
Record Manufacturing Engineering
RCA Victor Record Division
Indianapolis, Indiana

MASS PRODUCTION and ever increasing productivity are the two outstanding characteristics of the American industry. The ability to convert ideas and plans into tangible goods and services using mass production methods is the basis for our famed high standard of living. The desire to do everything better and faster, with less effort and expenditure results in increased productivity and improved living conditions. The idea of increasing productivity is now so familiar that sometimes it is taken for granted—witness the calculations and charts of economic forecasts and projections, and the use of the concept in wage negotiations. Actually there is nothing automatic or spontaneous about increasing productivity; it is the result of concentrated work and effort of all the people in industry—management, scientists, engineers, supervisors, and labor. Therefore, the success in the quest for better productivity and better living depends to a great degree upon the cooperation and good will between groups and individuals in the great industrial team.

THE MANUFACTURING ENGINEER'S FUNCTIONS

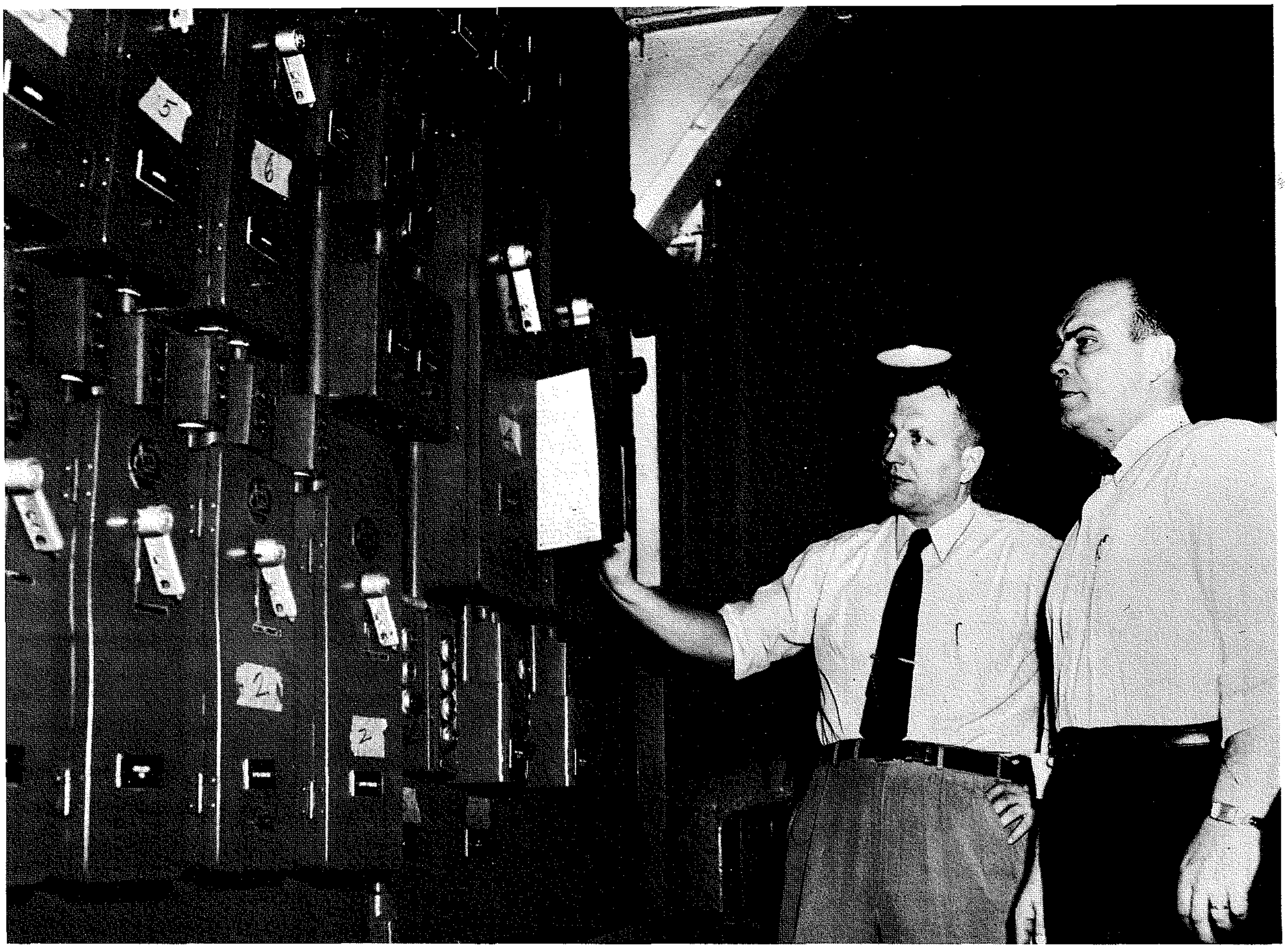
The Manufacturing Engineer occupies a unique position in this team. It is his responsibility to determine and install the physical facilities and processes necessary for the manufacture of a new product; also to improve the existing production facilities and methods. His skill and ability to apply principles of good human relations determine to a great extent how smooth and fast a manufacturing process or a newly designed product can be transferred from the development laboratory to the assembly line, and also how smooth and fast the assembly line will run. To a great extent he is a liaison man between the engineering and the shop. His daily work brings him in contact with other engineers, supervisors, and workers; he must be able to appreciate not only the engineering aspects of a problem but also the viewpoint of the production men. Although men in engineering and manufacturing departments work toward the same goal—to produce a high quality product at the lowest possible cost—each has a different approach.

FIND A LOGICAL COMPROMISE IN APPROACH

Design Engineers often think in terms of quality and performance of the product, sometimes even at the expense of higher manufacturing cost. The supervisors and foremen in manufacturing departments are continuously looking for short cuts and simplified methods in fabricating the products; some of the tolerances and "specs" on the blueprints would seem to them to require unnecessary cost increases. The two approaches could lead to contradictions and conflicts, and it is up to the Manufacturing Engineer to find a compromise and still come up with a superior product. It is evident that his part of the work cannot be successfully accomplished without good human relations and understanding of human psychology.

The skill of Manufacturing Engineers in human relations is especially important when a change in an existing process or a new process is being introduced. It is an inherent charac-

MR. AUGUSTS SKELE was born in Latvia in 1911. He was graduated from the University of Latvia in 1943 with a degree in mechanical engineering. From 1941 to 1944, he worked as a project engineer and later as Manager of Engineering for the Association of Latvian Metal Industry. In 1944, he was deported to Germany and, in 1949, came to the United States. He joined RCA in 1950 as a project engineer with the Indianapolis Record Factory Engineering Section. He is presently in charge of the Project Engineering Group of that section.



View of the author (at left) standing beside some factory equipment which he engineered. Mr. J. R. Hill, Compound General Foreman, is with Mr. Skele, and they are looking at the control panel for the recently installed hammer mills.

teristic of human nature to resist changes from known and accustomed ways of doing things to ways that are new and unknown. Yet, to make progress such changes are necessary and must be made. As new methods are devised and newly designed equipment is installed in the production line it is necessary for a period of time to make minor changes and adjustments until satisfactory performance is obtained.

INITIATE NEW IDEAS — INSTILL COOPERATIVE SPIRIT

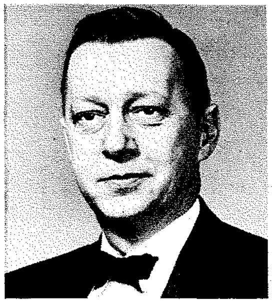
During these periods of change the ordinarily smooth flow of production is difficult to maintain; men are unfamiliar with new equipment and new job assignments; supervisors worry about production quotas and sometimes feel disappointed about the new method and equipment—in short, nobody is happy. This period of transition from the old to the new or improved method can be shortened considerably if the Manufacturing Engineer has done a good job of "selling" the new method or process to the production men. With whole-hearted support of the men on production lines even a small improvement in process can bring about spectacular results. On the other hand, the best of equipment and installation will not give a satisfactory performance if the spirit of cooperation is lacking between the engineering and production departments. Thus, the ability of the Manufacturing Engineer to maintain good human relations can and does have considerable influence on the growth of productivity.

However, it is not only the company or industry that has a vital interest in good human relations. A Manufacturing Engineer has a personal stake in it, because his own future depends on how well he applies the principles of good human relations in his work.

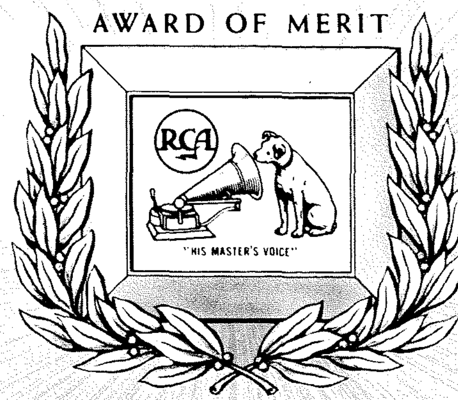
BUILD FOLLOWING BY LEADING

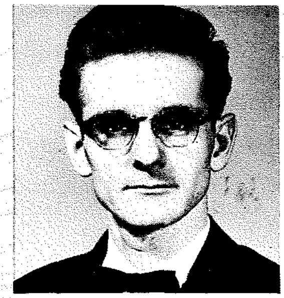
Although Engineering is a challenging profession and can satisfy a man's ambitions, sometimes it is only a step in his business career, and may or may not result in a promotion to a more responsible job. His success in this respect depends less upon professional skill, more upon his ability to deal with people effectively, and to build a following by leading. A leader knows and applies well the basic principles of good relations; he shows respect for the individual, appreciates his wants, and is objective.

It is a well known axiom that good human relations with consumers and customers is a must for a company to grow and prosper. The idea that it is equally important to maintain good human relations within a company is of a comparatively recent development; yet today there are few industrial leaders who would disagree with it. Better cooperation, less turnover in personnel, less absenteeism result in better productivity and a better product. The Manufacturing Engineer is in a position to make a substantial contribution to the efforts of management to maintain good human relations. In doing so he will achieve personal satisfaction as well as tangible benefits for himself and for his company.

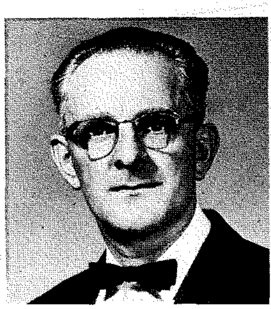


J. L. Franke



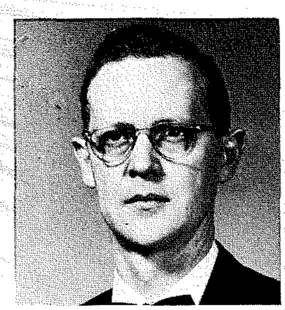


D. D. Van Ormer



E. B. Cain

FOUR RCA ENGINEERS RECEIVE COMPANY'S HIGHEST AWARD



L. A. Wood

On January 21st of this year, at the Barclay Hotel in Philadelphia, RCA conferred its highest award on twenty of its salaried employes. Four of the twenty recipients of the RCA Victor Award of Merit are RCA engineers.

Awards were presented at dinner ceremonies by D. Y. Smith, Vice President and General Manager, Tube Division. The Award winners were presented gold money clips, watches and citations. Each year for the past eleven years the RCA Victor Award of Merit Society has elected into its ranks employes demonstrating outstanding ability in their contributions to the progress of the Company. The Editors take pride in publishing Citations and brief biographies of the following engineers.

J. LEONARD FRANKE, *Chief Engineer RCA Victor Radio and "Victrola" Division*

"By extraordinary leadership and personal dedication to his work, Mr. Franke guided the engineering of six new products in 1955, in addition to revamping the Radio and "Victrola" line, which alone would have been a major achievement. He has inspired a high morale among his staff, evidenced by their many achievements despite a tremendous work load. Their accomplishments include perfection of the industry's first non-breakable "Impac" plastic portable cases, the first full High Fidelity line, the first RCA printed boards for radio use, two new transistor radios, a superior tape recorder, and a new battery radio-phono portable. These engineering achievements of the highest order, and the resulting unprecedented volume, have been of incalculable value in assuring RCA leadership in the field in 1955."

MR. FRANKE started at G.E., where he was a graduate of the Apprentice Course. In 1930 he transferred to RCA at Camden as a draftsman, and continued engineering studies during evening classes.

In 1935 he became a mechanical engineer in the Auto-Radio Engineering Division, where he was employed until the war in 1941. Throughout the war Mr. Franke was employed as Engineering Supervisor on a secret Navy project, later publicized as the Proximity Fuse. "After-the-war" activities included work as Supervisor of Mechanical Engineering in Radio and Phonograph at Camden, and as Section Manager of Radio Engineering. In 1954, Mr. Franke was named Chief Engineer of Radio & "Victrola" upon the formation of that Division. He is a Senior Member of IRE.

ELMER B. CAIN, *Manager, Mechanical Design RCA Victor Television Division*

"Inspiring his engineers and draftsmen to a degree of performance seldom matched, Mr. Cain spearheaded the mechanical design of 1955's "Big Change" television line, the largest and most diversified one in the history of the Company. The release of these receivers for production in the shortest time ever scheduled helped maintain RCA leadership and contributed to the Division's record sales performance in 1955. Almost 60 receivers were designed during the year, incorporating many advances. By his exceptional cooperation, he has aided Styling on appearance features, suggested design changes to reduce costs and simplify manufacturing, and assisted Purchasing in vendor relationships."

MR. CAIN completed a 4-year apprenticeship in tool design in 3 years with the Welsbach Company in Gloucester, N.J., in 1925. Mr. Cain then joined the Victor Talking Machine Company as a Tool Designer. After brief service with the Camden County Boy Scouts, he returned to Victor in 1927 as a Tool Designer, and has had continuous service to date. In 1935 Mr. Cain was promoted from Machine Design Checker to Mechanical Engineer. Since then he has been responsible for mechanical design of home radio receivers. In 1941 he was assigned to the mechanical design of "Block" equipment, which led to post-war television. In 1947, Mr. Cain was made manager of the Mechanical Design Group in Black and White Television Engineering. He has ten patents to his credit.

DAVID D. VAN ORMER, *Senior Engineer Color Kinescope Operations Dept., Tube Division*

"Industry leadership of the RCA 21-inch color picture tube in 1955 was due in large measure to Mr. Van Ormer's contributions to the design and analysis of the formed mask type. His evaluations of various color tube types figured importantly in top managements decision to concentrate all engineering efforts on the present product. Following his many basic contributions to the soundly engineered original design, in 1955 he guided engineering of process changes that greatly improved quality. Mr. Van Ormer's vast technical experience and his willing cooperation have earned the esteem of associates. His insight and analyses have been invaluable in guiding RCA's decision to concentrate on making the one right product, which was available in the shortest possible time and well in advance of competitors."

MR. VAN ORMER received his B.S. degree in Physics and Mathematics from the University of Delaware in 1947, and has continued studies in physics at Indiana University and F and M College. He worked as Research Assistant at the University of Delaware and at Indiana University. Mr. Van Ormer came to RCA in 1948 as an engineer in Cathode Ray Tube Design. He started working in color engineering in 1949 at Lancaster, concentrating on gun design for color kinescopes.

Mr. Van Ormer is a Member of IRE, the Sigma Pi Sigma, and the Phi Kappa Phi, honorary societies at University of Delaware.

LAWRENCE A. WOOD, *Manager, Product Engineering RCA Victor Record Division*

"In 1955 Mr. Wood originated and guided many developments reducing costs and improving quality and customer service. A fully automatic record press, use of a pre-form heater, and high speed stamping are some of the advances promising increased manufacturing flexibility and important cost reductions, which he recommended and whose development he has guided. His Packaging Group was outstanding in 1955 for the speed and success with which they completed the packaging design for the Personal Music Service program. Outstanding as an engineer and supervisor, alert to new ideas, and skillful in developing and proving new processes, record compounds, equipment, packaging, and standards, he has contributed notably to RCA's success in 1955."

MR. WOOD received his B.S. degree in Ch. E. from Purdue University in 1936. From 1936 to 1943, he was employed by Reilly Tar and Chemical Corporation as development engineer and Production Superintendent. He joined RCA Victor Record Division in 1943 as a development engineer on phonograph record compounds. In 1945, he was made a Supervisor of the Plastics Group and in 1946 was made Manager of Product Engineering.

COMMUNICATION BY TROPOSPHERIC SCATTER PROPAGATION

by **L. E. THOMPSON**
Communications Engineering
Commercial Electronic Products
Camden, N. J.

LELAND E. THOMPSON Mr. Thompson graduated from the University of South Dakota in 1929 with the degree of B.S. in E.E. Since that time his work at the General Electric Company and RCA has been exclusively in the Radio Communication field. This work has included development of both military and commercial equipment, including shipboard receivers, mobile systems and multiplex microwave relay systems. At present Mr. Thompson is engaged in the study of propagation, modulation systems and multiplex systems for use on scatter propagation circuits.

Mr. Thompson is a Senior Member of the I.R.E.

FOR MANY years observers have reported reception of signals in the VHF and UHF ranges far beyond the horizon. At first the reports indicated these signals were extremely unreliable. They could be received only part of the time and the phenomenon was considered more of a nuisance in the form of interference than as a reliable means of communication.

The lower atmosphere at times has super refractive qualities and it was known that occasionally very sharp discontinuities in the index of refraction existed which would cause reflections of waves at these frequencies. These mechanisms were generally accepted as the explanation for the observed results and probably did account for most of the early observations.

As higher-power transmitters and high-gain antennas came into use it was observed that signals far beyond the horizon could be received continuously and reliably. The signal variation was great but the amplitude was always far above the theoretical diffraction field.

It was clear that a hitherto unsuspected mechanism was responsible for the observed results. Because of the rapid fading characteristics of the received signals, a theory of scattering was postulated. A list of some of the early theoretical investigators is given in the bibliography. Briefly, turbulence in the troposphere produces spatial fluctuations in refractive index owing to highly local variations in humidity, temperature or pressure. These inhomogeneities exist at all times and transmitted energy impinging on them is scattered in all directions. The intensity of the scattered energy depends on the angle of scatter θ as shown in Figure 1, increasing as the angle decreases. There is, therefore, a limited volume of the atmosphere which is in the line of sight of both transmitter and receiver from which the principal part of the received energy comes.

As the distance between transmitter and receiver increases, the scatter angle increases, the scatter volume increases, and the height of volume in the atmosphere increases. The net result is that the median received signal power decreases fairly rapidly with distance, being about 60 db below the free space value at 100 miles and about 70 db below at 200 miles. Beyond this distance it is believed the attenuation is at a higher rate but the available data are inconclusive.

Since the received signals come from a number of "scatterers" in the volume which are moving around randomly, the short time variations in signal amplitude are Rayliegh distributed. Over a long period of time, experimental data indicate the hourly median signals follow a Gaussian distribution curve with a variation of about 8 db per standard deviation.

Because the received signal is composed of a number of components coming from different parts of the scatter volume, the transmission bandwidth is limited. Aircraft in any area illuminated by both transmitting and receiving antennas is an additional cause of multipath distortion and deep fading.

Both the experimental work to date, and the theory, show that there is little dependence on radio frequency. Therefore, at microwave frequencies where extremely high antenna gain and narrow beamwidths can be realized, it is expected that this type of propagation will be practical for communication and television relaying over distances of up to at least 200 miles.

Much more experimental work is necessary to determine the limits of transmission bandwidth with different types of modulation, antenna sizes, radio frequencies and distances. RCA is actively engaged in this development, both at the RCA Laboratories and Defense and Commercial Electronic Products in Camden.

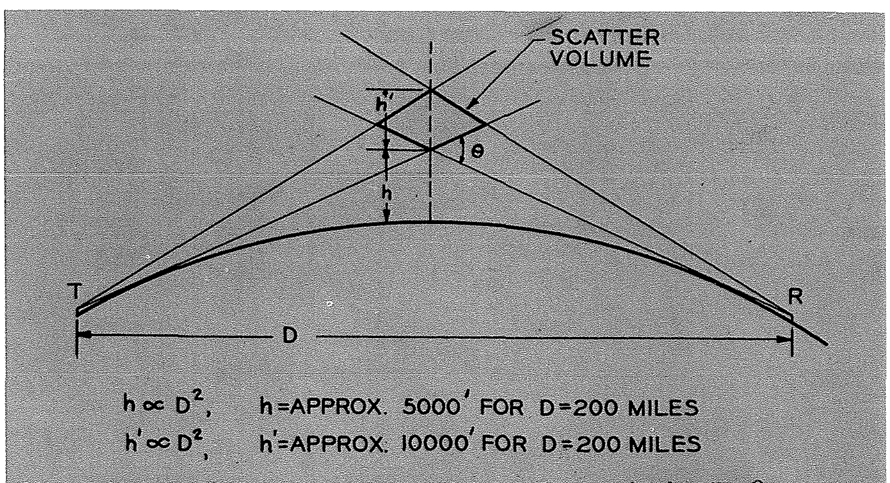
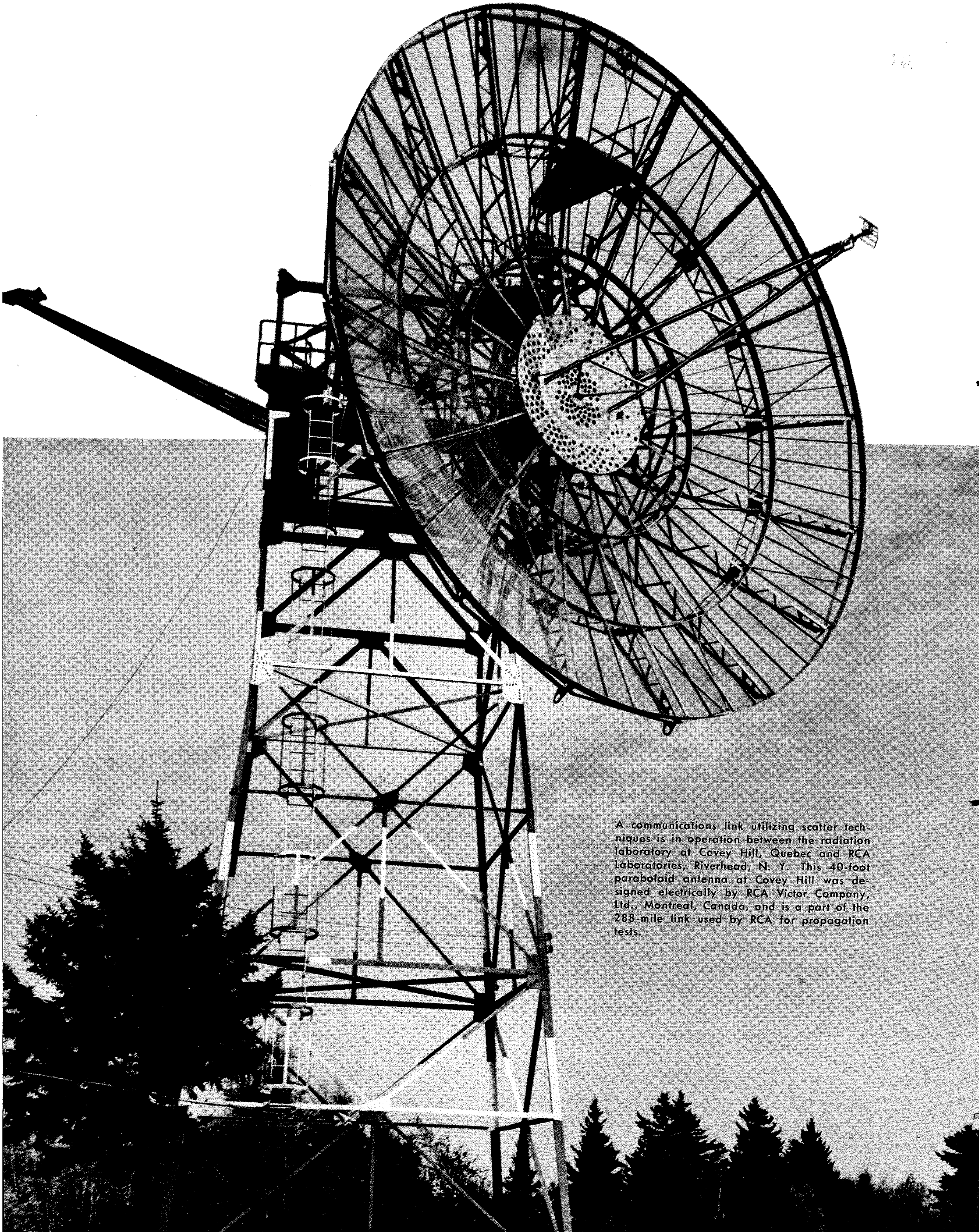


Fig. 1—Intensity of scatter energy depends on the angle of scatter θ.

BIBLIOGRAPHY

1. H. G. Booker and W. E. Gordon, "A Theory of Radio Scattering in the Troposphere," Proc. I.R.E., Vol. 38, page 401, 1950.
2. E. C. S. Megaw, "Scattering of Electro-Magnetic Waves by Atmospheric Turbulence," Nature, Vol. 166, page 1100, 1950.
3. H. Staras, "Scattering of Electro-Magnetic Energy in a Randomly Inhomogeneous Atmosphere," Journal of Applied Physics, Vol. 23, page 1152, 1952.
4. A. H. Lagrone, "Volume Integration of Scattered Radio Waves," Proc. I.R.E., Vol. 40, page 54, 1952.



A communications link utilizing scatter techniques is in operation between the radiation laboratory at Covey Hill, Quebec and RCA Laboratories, Riverhead, N. Y. This 40-foot paraboloid antenna at Covey Hill was designed electrically by RCA Victor Company, Ltd., Montreal, Canada, and is a part of the 288-mile link used by RCA for propagation tests.

PROJECT TURNKEY: A TROPOSHERIC SCATTER CIRCUIT

by

R. W. ALLEN,
W. D. CLEMENT
***and* H. J. HAMLIN**

Surface Communications Engineering
Defense Electronic Products
Camden, N. J.

Editor's Note: The preceding page by L. E. Thompson discusses the general aspects of communication by tropospheric scatter propagation. The following article relates a specific application in which a complete communications system was installed for the U. S. Signal Corps. The experience of engineers in the Special Purpose Transmitter group in high-power UHF television was of invaluable assistance to the engineers of Surface Communications Engineering in the successful completion of this project.

In May, 1954, a contract was awarded to RCA by the Signal Corps for the first scatter link system installed in the United States to be used by an operating agency intended for the handling of communications type traffic. This link will be used to determine the suitability of scatter type circuits in meeting future Signal Corps requirements.

CONTRACT SPECIFICATIONS

The purpose of the contract was to establish two radio-link terminal stations which would provide a point-to-point, full duplex, multi-channel communications system of toll circuit quality. The contract specified that the system should operate in the frequency range between 350 and 400 megacycles and that it employ tropospheric scatter propagation techniques.

The responsibilities delegated to RCA were the design and installation of the necessary equipment for a complete system, including instrumentation for measurements and the provision of services and instructions pertaining to the operation of the system; running spare parts to keep the system operable for a year, and drawings of sufficient quality to enable reproduction of RCA-furnished equipment were to be supplied. In addition, RCA was to operate the system for 30 days before final delivery to the Signal Corps.

It was necessary to design a "jack field," an antenna system, a power amplifier, and metering and monitoring equipment for the system. The jack field consists of a panel similar to telephone switchboards. It enables the station operator to select combinations of multiplexing equipment and gives the system the advantage of versatility. An antenna system using 28 foot parabolic reflectors was required—one each for transmitting and receiving at each station. The antennas were to have at least a 26 db calculated effective gain over a half-wave dipole. They also were to be capable of withstanding 100 mile-per-hour winds and a 1-inch thick ice coating without permanent deformation. The power amplifier design was to include its own cooling system, and provide a power output of at least 5 kw. Safety devices both for the protection of the equipment and operating personnel were specified. Government-furnished equipment was to be used to provide means for modulation and multiplexing, and to supply r-f drive to the amplifier. Instrumentation equipment for metering and monitoring the system was to be purchased commercially, if available, and supplied by RCA.

SITES SELECTED

The sites selected for the stations were Fort Monroe, Virginia, and Woodbridge, Virginia. Extensive building modifications were required to prepare for installation at Fort Monroe. In addition, power lines at Fort Monroe had to be brought to the building. A water-to-air heat exchanger was provided for cooling of the amplifier, since there was no existing water line at the site. At the Woodbridge site where water was readily available, a water-to-water heat exchanger was used. Prior to installation, plans for the station layouts had to be approved and cabinets to house the government-furnished equipment had to be designed. In addition to these, interconnection diagrams for the jack field and government-furnished equipment were required. After installation and checkout of the stations the 30-day operational and instruction period could begin.

The 30-day operation period was beneficial to RCA and the Signal Corps because minor deficiencies in the system operation could be observed and corrected, first-hand data could be obtained, and Signal Corps personnel could be instructed on the system operation. Upon completion of the operation period, the data was to be presented in a final report, which also was to recommend changes and additions to the radio-link system to improve the performance.

TRANSMITTER DESIGN

Although the initial contract specified a power output of 5 kw it was decided that the design goal would be 10 kw. It was believed that since tubes of this power capability were available, the higher power would be desirable to help insure communications over the system under all atmospheric conditions. Our basic problem was the design and construction of two UHF amplifiers capable of delivering this 10 kilowatts of c-w power. The required gain of these units was approximately 200. One additional and important requirement of these amplifiers was that they be capable of 24-hour a day operation. This demanded a conservative design.

It was decided that the units would consist of two stages of amplification. The RCA-6448 water cooled UHF tetrode was chosen for the final amplifier. This stage was to be driven by the RCA-6181 tetrode. Both of these tubes had previously been used by the Television Transmitter Group with excellent results.[9] The tubes, however, had never been used in the 350 to 400 mc frequency region, which was our specific operating range. This became the first unit to be designed and used for scatter

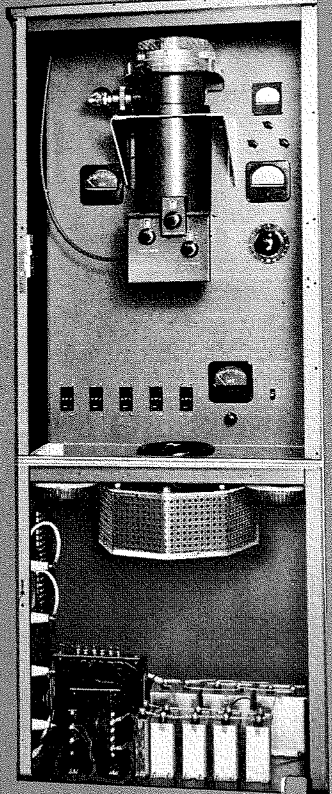
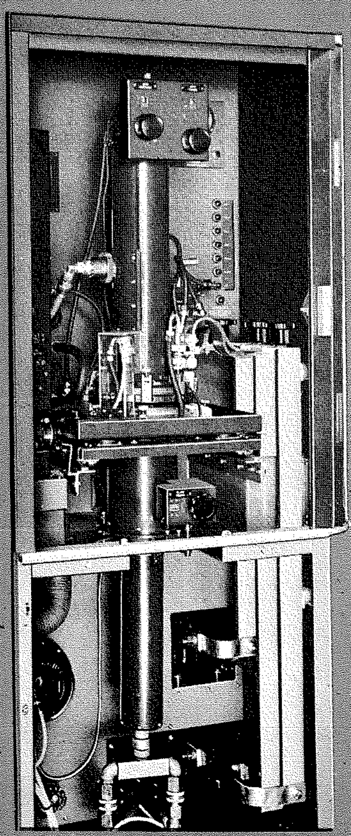


Fig. 1—IPA and control cabinet with 6181 cavity at top. All tuning controls for the cavity are accessible from the front. The bottom half of the cabinet contains the filament supply for the PA in an adjacent cabinet.

Fig. 2—Final power amplifier cabinet. All power and cooling connections are the "quick-disconnect" type to permit removal of the entire PA assembly for service.



transmission utilizing tetrode amplifiers exclusively. Because of the extremely short delivery cycle, it was hoped that the power amplifier cavities of the TTU-1B and TTU-12A television transmitters could be rebuilt to operate at this lower frequency. After investigation this proved less desirable and a new design was started. We were, however, able to use the basic design of the grid cavity for the 6448 from the TTU-12A. This cavity merely had to be changed to operate at the lower frequencies. We were also able to use many mechanical and constructional ideas given to us by Television Transmitter Engineering from both their past and present transmitters.

The intermediate power amplifier (RCA-6181) circuits are folded-over coaxial cavities. The ½ wavelength input circuit is completely enclosed within the ¼ wavelength output circuit. It was necessary to use a ½ wavelength input circuit because the first ¼ wavelength at the high-frequency end of the operating band was located inside of the tube.

It was known that a resonance in the screen-grid control-grid circuit of the 6181 tetrode would exist even with the shortest possible external connection of these two elements for grounded-grid operation. It was hoped that the construction of the cavity would keep this resonance far enough above the desired operating frequency to avoid oscillations in the circuit. This was initially tried but without success. An excellent oscillator and a poor amplifier resulted. It was then decided that this resonance must be moved below the operating frequencies if a stable amplifier was to be obtained. A ¼ wavelength cavity was placed between the control and screen grids. This circuit was resonated at 225 mc. It was also terminated in a "lossy" short-circuit to suppress any oscillating tendency. All oscillations were thereby squelched and one kilowatt of c-w power was obtained over the specified frequency range with the desired bandwidth.

Although the final amplifier drive requirements were approximately one-half the obtained power, it was gratifying to see the RCA-6181 tetrode operating at the one-kilowatt c-w level. With the completion of an intermediate power amplifier our efforts were increased on the 6448 final amplifier. During this time the power supplies were being designed for this particular amplifier coupled with the arrangement of sequential and automatic control and protective circuits. High-speed electronic protective circuits, coupled with both mechanical and electrical interlocks throughout the amplifier, provide a high degree of safety for both operating personnel and equipment in the event of faults.

FINAL POWER AMPLIFIER

The final power amplifier circuitry is composed of a ¾ wavelength grid cavity of dissimilar impedance sections and a ¼ wavelength plate cavity. The entire power amplifier unit is mounted on a sliding cradle assembly providing ease of removal and replacement from its cabinet enclosure. This is a feature originated on the TTU-12A television transmitter.

At the upper end of the operating band the current maximum point is located very close to the ceramic plate seal of the tube, complicating the output coupling problem. Direct coupling was necessary to extract the required power from the ¼ wavelength circuit. The features of low stored energy and circuit losses in a ¼ wavelength circuit operating at the 10 kw power level, and mechanical simplicity of the circuit were considered highly desirable. The direct coupling required for the proper loading at the upper frequency limit of the band caused a high-voltage build-up at the coupling point when operated at the low-frequency end. This demanded a substantial variation in the loading requirements. The 50-ohm antenna system had to be transformed over an 8:1 range to provide the correct loading of the tube over the entire frequency range. This transformation was accomplished by the development of a unit to be inserted in the 3⅛″ output transmission line directly following the plate circuit of the 6448 tetrode. This unit consists of a movable, fixed-length, low-impedance, ¼ wavelength section, cut for the mid-frequency of the operating band, working in conjunction with a fixed high-impedance section and a medium impedance, variable length section. By the time the IPA and PA cavities were completed, the cabinet housings containing the power supplies, control and protective circuits were also finished. This allowed an immediate assembly of a complete amplifier. On February 1, 1955, about 8½ months after the contract was awarded, operating tests were started on the overall amplifier. The desired output of 10 kilowatts was obtained with the tubes operating very conservatively. The amplifier was shipped as a completed unit after 18 hours of running test from the time the construction was completed. Before shipment, the unit was operated with an output of 17 kw with no difficulty. The second amplifier was shipped one month after the first unit. The link was completed during the first few weeks of April and on the 19th of that month the system was placed on a 24 hour day operating schedule. Chart I indicates the operating condition of the r-f tubes in the 10-kw scatter transmitters, and is typical of the conservative operating conditions established throughout the system.

ANTENNA DESIGN CONSIDERATIONS

The required antenna gain of 26 db over a half-wave dipole was obtained with 28-foot diameter parabolic reflectors. Although these reflectors were commercially available, special totally enclosed horn feeds had to be designed by the vendor to permit all-weather operation. Horn type construction also made the antennas usable over the entire frequency range of 350 to 400 mc. Since rigid coaxial transmission line was used, a special scissor arrangement of swivel elbows was employed to permit the antennas to be adjusted over a few degrees in azimuth and elevation.

At the Woodbridge site it was necessary to erect a tower to allow the main lobes of the antennas to clear existing obstacles. Self supporting and guyed structures were considered, along with some existing structures. The latter were found to be inadequate to withstand tremendous forces anticipated on the antennas in the event of hurricane-velocity winds. The guyed structure was chosen as the most economical method of meeting the particular requirements. As installed, the structure stands 175 feet above ground level, with the transmitting antenna mounted above the receiving antenna. From information obtained from test borings it was determined that oversize foundations and anchors were required for the tower. The site is within a few thousand yards of tide water, and at times the field is entirely submerged. Erection was accomplished in two sections using a crane. Several existing open-wire transmission lines near the site complicated the task. RCA 3⅛-inch rigid coaxial UHF transmission line was installed for both "transmit" and "receive" antennas because of its low loss and high power handling capability. A protective ice cover was provided for the horizontal portion of the line. The entire tower structure was marked in accordance with CAA regulations.

Since the antennas are highly directive by nature, it was necessary to sight them in carefully. Maps of the sites were obtained and the actual latitude and longitude of each location determined. From these, the true bearings were calculated using spherical trigonometry. True north-south lines were established by transit

CHART I

Intermediate Power Amplifier

RCA 6181	*Operating Conditions*	*Max. Ratings*
Plate Voltage	850 volts	2000
Plate Current	.92 amps	1.25
Screen Grid Voltage	310 volts	500
Screen Grid Current	+7 ma.	40 watts input
Control Grid Voltage	-55 volts	-300
Control Grid Current	+14 ma.	200
Input Power	70 watts	
Output Power	450 watts	
Input VSWR	1.5	
Output VSWR	1.1	
Filament Voltage	120 volts	

Power Amplifier

RCA 6448	*Operating Conditions*	*Max. Ratings*
Plate Voltage	5800 volts	7000
Plate Current	3.8 amps	6.5
Screen Grid Voltage	760 volts	1000
Screen Grid Current	.6 amps	600 watts input
Control Grid Voltage	-175 volts	-300
Control Grid Current	150 ma.	500
Input Power	450 watts	
Output Power	11.0 KW	
Input VSWR	1.1	
Reflected power on output line	200 watts	
Filament Voltage	1.35 volts/phase	
Plate water flow	11 gal./min.	
Exit water temperature	116°F	158°F

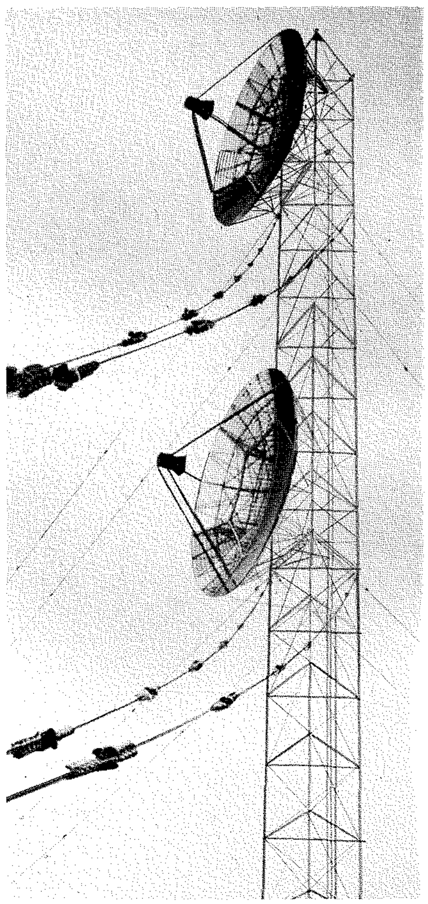


Fig. 3—Antenna and tower installation at Woodbridge. Insulators on guy wires are to prevent interference with existing communications installations.

from known existing accurate bench marks at Fort Monroe, and by sighting on the star Polaris at Woodbridge. The antennas were then adjusted until the outer rim of each reflector was equidistant at all points from a plane perpendicular to the calculated bearing, as determined by the transit. It had been previously determined that best results are obtained when the antennas are aimed at the effective radio horizon, or, in this case, horizontally.

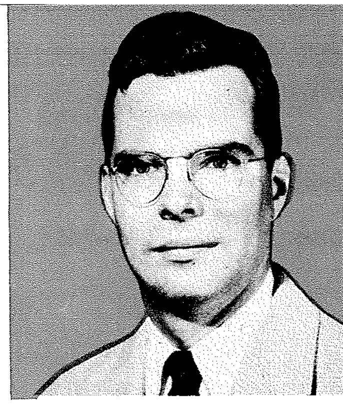
FINAL SYSTEM COMPLETION

The transmitting and terminal equipment was housed in existing buildings. At Woodbridge the installation was made in the Department of the Army Transmitting Station, which houses many other high power transmitters. At Fort Monroe it was necessary to modify a building which had been used for storage, as mentioned previously.

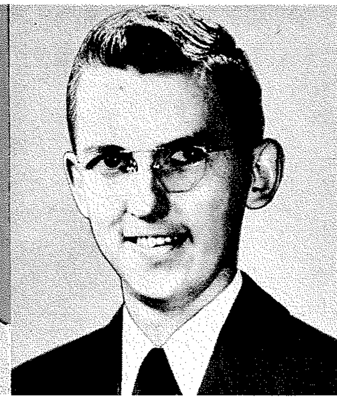
In addition to providing a communications link, this circuit was intended to provide data for evaluating scatter transmission. To do this, provisions were made for recording r-f signal level, modulating signal level and noise in the multiplex voice channels. Provision was also made for measuring harmonic distortion. The r-f signal level was measured by calibrating the receiver AGC with a signal generator. Voice channel noise was fed to an amplifier with approximately logarithmic amplitude response, rectified and recorded. This permitted measurement over a wide range without recalibration. For distortion measurements, a pure sine wave tone was used to modulate the transmitter while the received fundamental, 2nd and 3rd harmonics were measured at the other end of the circuit. This required the use of selective filters with narrow pass band and steep skirts, in order to reduce noise and permit measurements with the multiplex equipment in operation. Typical bandwidth of the 3rd harmonic filter at 63000 cps was 300 cps at 3 db and 2000 cps at 60 db. This was attained through the use of 6 tandem-connected, parallel-resonant circuits made up of high Q toroidal coils and glass dielectric capacitors. The filters are included in an oven, which was necessary to assure frequency stability.

The entire operation had to be coordinated to satisfy the requirements of several government agencies. Additional coordination was required for large subcontracts to tower and antenna manufacturers and to the RCA Service Company.

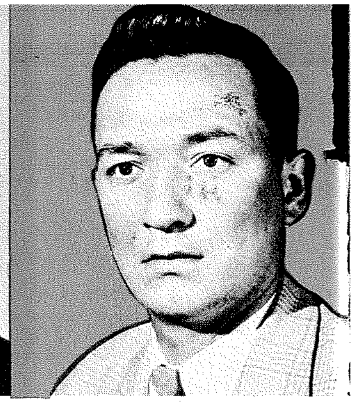
On the basis of comparisons between theory and experiment, it is possible to predict with reasonable certainty the yearly median signal level for a given circuit. The expected yearly median signal level at the receiver input for this circuit is about 100 microvolts. It is expected that by using well known techniques such as diversity reception, this type of circuit may be made very reliable and entirely suitable for year-round communications.



RICHARD W. ALLEN is a graduate of Worcester Polytechnic Institute with a B.S. degree in E.E. in 1944. He has done design work in connection with communications transmitters, an airborne television transmitter, and a shipborne Loran receiver. Mr. Allen was Project Engineer on the job described in this article.



WESTON D. CLEMENT—received his B.S. degree in E.E. from the University of New Hampshire in 1953 and shortly thereafter joined RCA. In 1954 he became a member of Surface Communications Engineering where he did much of the cavity design work on the IPA and PA stages of the 10-kw Amplifier. At present, Mr. Clement is taking courses leading to an M.S. degree at the Drexel Institute of Technology.



HILBURN J. HAMLIN who is responsible for the power and control circuit design for the 10-kw Amplifier, received his B.S. degree in Radio Engineering in 1953 from the Indiana Technical College. Since his graduation, Mr. Hamlin has been with RCA, initially engaged in the design and development of mine firing devices. Prior to this, Mr. Hamlin served for six years with the U. S. Navy.

REFERENCES

1. R. W. Bauchman, M. Katzin, W. Binnian, Proc. IRE, 35 p. 89 (1947).
2. H. G. Booker and W. E. Gordon, Proc. IRE, 38 p. 401 (1950).
3. C. L. Pekeris, Phys. Rev. 71 p. 268 (1947).
4. H. G. Booker and J. T. deBettencourt, Proc. IRE.
5. W. W. Gordon, Proc. IRE.
6. H. Staras, Jour. Appl. Phys., 23 p. 1152 (1952)
7. H. Staras, "A Mathematical Study of Beyond the Horizon Scatter Propagation," Ph.D. thesis, Univ. of Md. (1955), to be published.
8. W. P. Bennett, "A 15 Kilowatt Beam Power Tube for UHF Service," RCA ENGINEER, June-July 1955, Vol. 1, No. 1.
9. L. L. Koros, "A Novel Ultra-High-Frequency High-Power-Amplifier System," RCA Review, June 1955, Vol. XVI, No. 2.

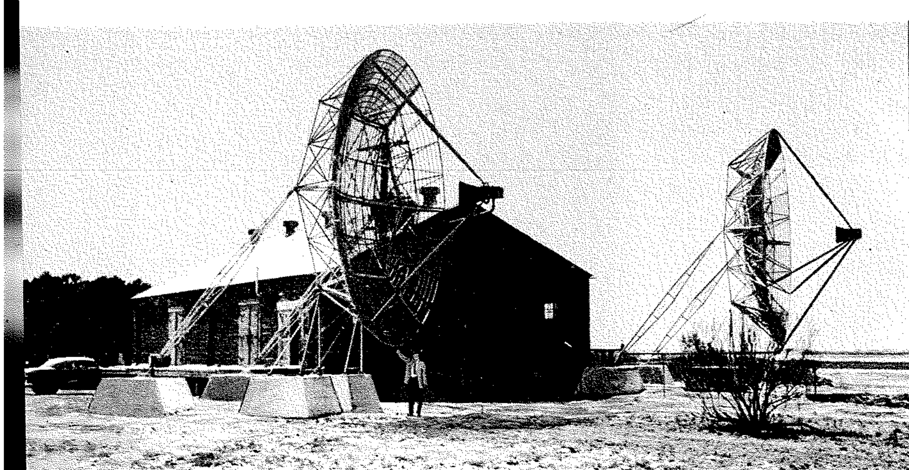


Fig. 4—Transmitter building and antennas at Ft. Monroe. Notice size comparison between reflector at left and man below.

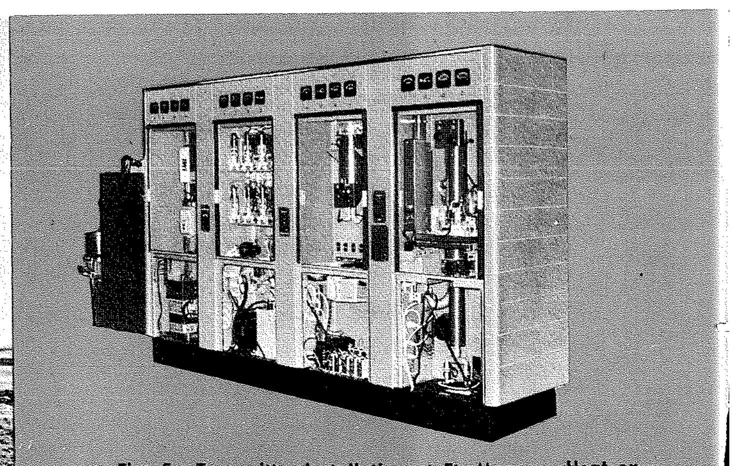


Fig. 5—Transmitter installation at Ft. Monroe. Heat exchanger and pumps are located to the left of the cabinets.

TRANSISTORIZED SYNC SEPARATOR CIRCUITS

by **H. C. GOODRICH**
Advanced Development Engineering
RCA Victor Television Division
Cherry Hill, N.J.

THE UNIQUE saturation limiting property of the junction transistor offers an inherent advantage in television sync separator circuits where double clipping of a signal is desired. Although sync separation appears to be a simple function, sync circuits have been a subject for careful study to obtain economical circuits which will operate reliably under a wide variety of conditions. Those factors leading to increased reliability and simplicity should have application in other types of pulse circuits. Some of the conditions encountered in a home television receiver are listed below:

1. A signal strength range on the order of 100,000 to 1;
2. Variations in sync percentage from the nominal 25 percent;
3. Variation in tube (or transistor) characteristics including initial characteristics, aging, changes with temperature;
4. Variations in line voltage;
5. Impulse noise of various types;
6. Airplane flutter;
7. Reflections and multipath reception.

Vacuum tube circuits have been developed which meet these conditions in a reasonably satisfactory manner. Although such circuits may be relatively conventional in structure, they are the result of much engineering and field testing, and make optimum use of the characteristics of the particular tubes employed.

Transistors differ from vacuum tubes in many important respects. As a result, most present day existing vacuum tube circuits will not work effectively with transistors. The purpose of this article is to discuss the characteristics of transistors which are particularly relevant to pulse aplications and to illustrate the application of this information to the design of sync separators of good performance and reasonable cost. Certain transistor characteristics such as low input impedance, uncontrollable forward collector conductivity, temperature-sensitive leakage, and limited voltage ratings generally represent disadvantages for sync circuit applications. On the other hand, the high transconductance, sharp cutoff and saturation characteristics, and the absence of heaters, represent definite advantages favoring the use of transistors. Also, the existence of both p-n-p and n-p-n transistor types offers increased flexibility in devising circuits. Thus the application of transistors to sync circuits presents both new problems and new opportunities to the circuit designer.

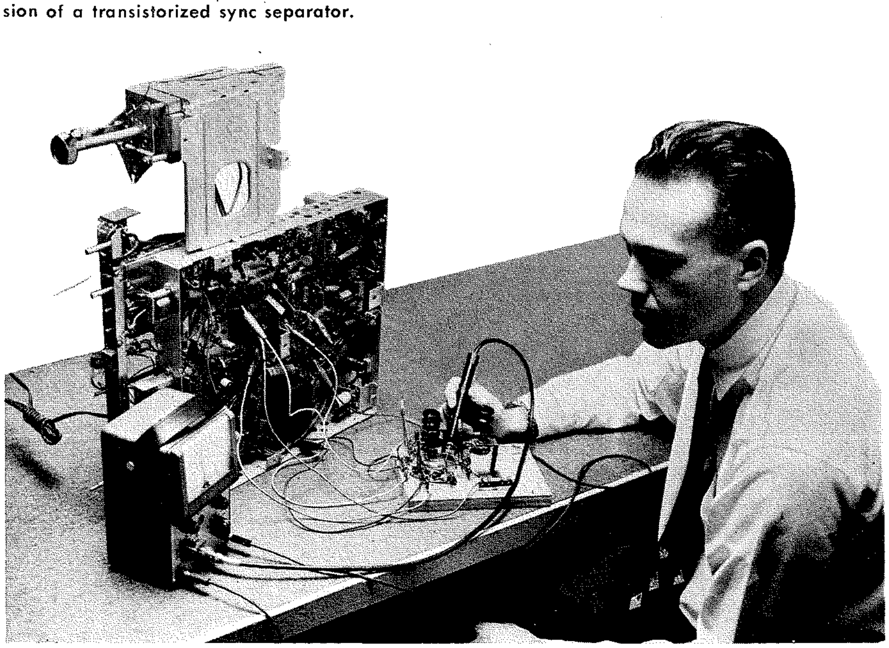
THE JUNCTION TRANSISTOR AS A PULSE AMPLIFIER

All of the three basic transistor amplifier types—common emitter, common base, and common collector—can be used as sync amplifiers. The common emitter connection gives the poorest rise and fall times for a given transistor. However, since it is the only one giving both voltage and current gain, both of which are usually required, it is the most useful. Most of the following discussion of pulse amplifier characteristics is therefore devoted to the common emitter type.

Fig. 1a illustrates the common emitter circuit and Fig. 1b shows one form of its equivalent circuit with perameters for the low-frequency 2N34 and an experimental medium frequency transistor.* Since the vertical straightness of the received picture depends on the timing accuracy of the sync pulses, reasonably good rise-time of the horizontal sync amplifier is highly desirable. An important limitation on rise-time is set by the time constant of $r_{bb'}$ and $C_{b'e}$. A low-frequency transistor may have a rise-time actually in excess of the 5 μsec width of horizontal sync when operated with common emitter. The 10 to 90 percent rise and decay-times of the medium-frequency experimental transistor with a 10,000 ohm collector load are on the order of 2 μsec. Both rise and decay-times increase with increasing collector load resistance as indicated in Fig. 2. The

* The 2N139 is the commercial outgrowth of the earlier experimental medium frequency transistor used in this work.

The author shown checking a breadboard version of a transistorized sync separator.



TRANSISTORIZED SYNC

continued

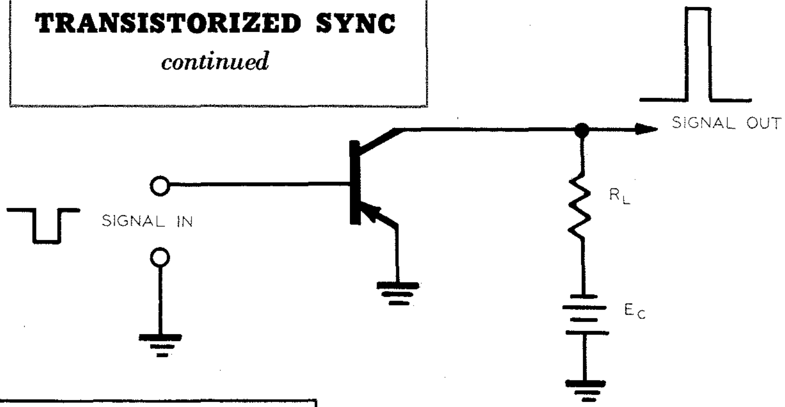


Fig. 1a—Common-emitter circuit

TYPICAL VALUES FOR $I_c = 1$ MA

		2N34	exp. med. freq. trans.
$r_{bb'}$	ohms	250	75
$r_{b'e}$	ohms	1000	500
$C_{b'e}$	μμf	10,000	1000
$r_{b'c}$	meg	1	0.1
$C_{b'c}$	μμf	35	10
g_m	mhos	0.032	0.032

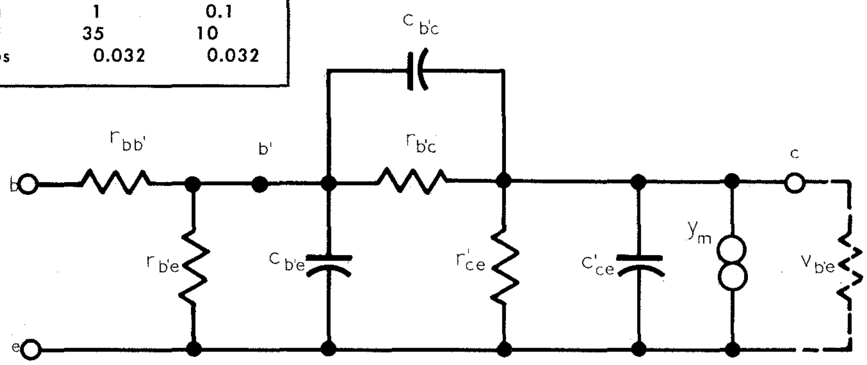


Fig. 1b—Pi-equivalent circuit

rise-time can be reduced greatly by overdriving, as will be discussed later. The equivalent circuit of Fig. 1b indicates that any driving source resistance will lengthen the rise-time by effectively adding to $r_{bb'}$. This effect is shown in Fig. 3.

Fig. 4 illustrates the collector family of curves for a junction transistor. A fortunate aspect of this characteristic for sync separators is the abrupt knee which occurs near zero collector voltage. Thus an amplifier with the proper load may be driven into increasing collector conduction until abruptly limited by collector voltage saturation. Such an amplifier, when driven from cutoff to saturation, produces a double-clipped output with an amplitude only a few tenths of a volt less than the collector supply voltage. The relatively flat collector characteristic above the knee is a result of the fact that the current carriers passing through the base layer to the collector travel by diffusion instead of being attracted by an electrostatic field as is the case in a vacuum tube. The value of the collector voltage thus has little effect on the collector current as long as it is sufficient to attract the carriers that have reached the collector junction.

Pulse-driving a transistor into collector saturation modifies both the rise and fall-time at the output. The application of a pulse which drives the base-emitter junction further in a forward direction than is necessary just to saturate the collector will be called *overdriving* the transistor. Overdriving produces a marked decrease in rise-time. As an example, applying an input signal voltage double that required to just saturate the collector of experimental transistor reduced the rise-time from 2 μsec to 0.2 μsec. Lesser amounts of overdriving will produce lesser degrees of pulse steepening. The variation in rise-time as a function of base-driving current in excess of that required to saturate the collector on sync tips is given in Fig. 5 for the experimental transistor and the 2N34. Since the output transistor of a sync separator will normally be overdriven to some extent to achieve double clipping, a considerable degree of pulse steepening will result. However, the use of an inherently low-frequency transistor which requires a large degree of overdriving to produce an acceptable rise-time is wasteful of gain and has a deleterious effect on the trailing edge of the output.

The further effect of overdriving a junction transistor is that the trailing edge of the output pulse may be delayed, i.e., the pulse may be effectively widened. This effect has been called "back-porch" or storage effect, and is a function of the degree of overdriving as shown in Fig. 6. "Back-porch" results from the fact that, while collector saturation limits the collector current to a value equal to the supply voltage divided by the load resistance, overdriving produces a minority carrier current flow into the base in excess of this limit. Some of the excess carriers are thus stored in the base and continue to flow to the collector after the input signal has returned to zero or reversed. Serious "back-porch" effect shifts the average timing of the sync output pulses and will cause a phase shift in many types of horizontal phase detectors. Other types of phase detectors work primarily from the front portion of the sync pulses and will be little affected. In any case it is possible with a medium-frequency transistor to get adequate overdriving for good limiting and rise-time without producing serious "back-porch" effect.

TWO-STAGE SYNC SEPARATORS

A critical factor in a transistorized sync separator is maintaining the proper separation bias level. Even with a good agc system the video level applied to the separator will change considerably with changes in line voltage, agc control setting, and the extreme range in signal levels which may be encountered. Fig. 7 illustrates how the separation level, i.e., the level where the separator begins to conduct, must change with signal level. This obviously requires the use of self-adjusting rather than fixed bias.

Fig. 8 illustrates one form of two-stage sync separator. The emitter current flowing through R_1 establishes an emitter voltage which biases the base-emitter junction of T_1 in the reverse direction except during sync. Collector current flows during sync to produce sync output pulses across R_2. E_2 and R_2 are proportioned to avoid collector saturation, so that the pulse amplitude across R_2 varies somewhat with variations in input amplitude. The emitter current likewise varies with signal amplitude so that the bias is kept at the proper level for separation on all signals. The first stage is analogous to the cathode-biased vacuum-tube separator frequently used and is relatively non-critical of transistor characteristics, assuming that the transistor has adequate high-frequency response to give the required rise-time. The collector current vs. base-to-emitter voltage characteristic at low currents has been found fairly constant from unit to unit, at least for a given transistor type. The input resistance varies considerably, particularly with variations in α, but this does not affect the circuit operation if the signal source has a sufficiently low impedance. The advantage of placing bias resistor R_1 in the emitter circuit is that if the dc impedance of the base circuit is low, the collector-to-base leakage current, I_{co}, does not appreciably affect the bias. Between sync pulses the base-emitter junction is biased in the reverse direction, and any leakage at this junction, I_{eo}, will flow through R_1. In a transistor having characteristics which are satisfactory for the circuit, I_{eo} should be small compared with the average emitter current, and hence have only a minor effect on bias.

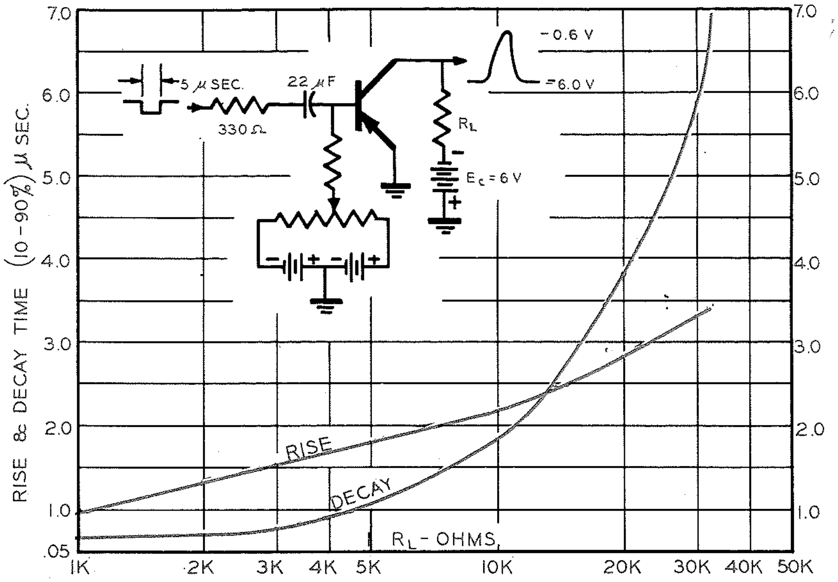


Fig. 2—Rise and decay time vs. collector load of an experimental medium frequency transistor.

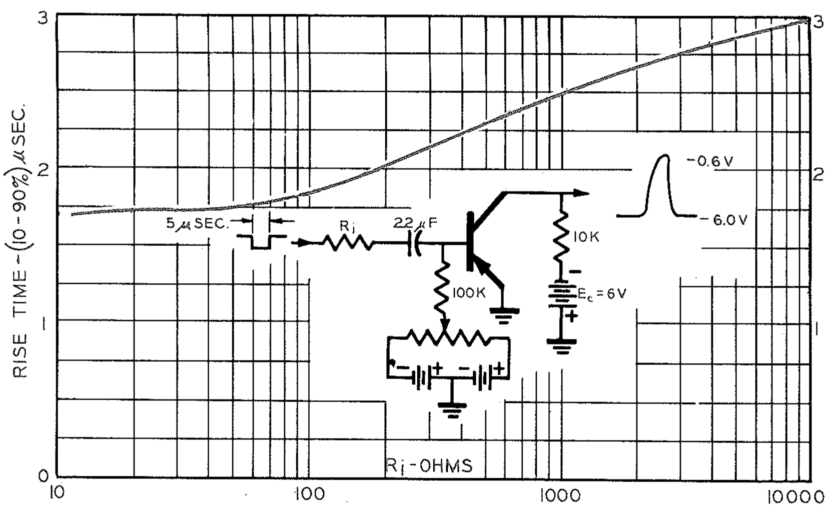


Fig. 3—Rise time vs. external base resistance of an experimental medium frequency transistor.

In the circuit of Fig. 8 a second transistor T_2 is used to amplify and limit the amplitude of the pulses across R_2. T_2 is operated so that it is driven to saturation during sync by any usable signal. This provides sync of uniform amplitude and cuts off any noise pulses at sync level. The effect of increasing temperature on T_2 will be increase I_{eo} and I_{co}. This represents an increase in bias, and the effect on rise-time and storage can be predicted from Figs. 5 and 6.

The sync polarity of the circuit may be reversed by operating T_1 as a common collector amplifier or by operating T_2 as a common emitter amplifier. Fig. 8 is presented as an example of a two-stage separator, and the discussion therefore explains some of the design factors involved. Many variations are possible. Since for each of the two stages there are three possible amplifier types (common emitter, base or collector) two basic transistor types (p-n-p or n-p-n) and three means of biasing (self-base bias, self-emitter bias, or direct coupling), the number of possible combinations is in the hundreds. Many such combinations have obvious disadvantages, but many others would be workable

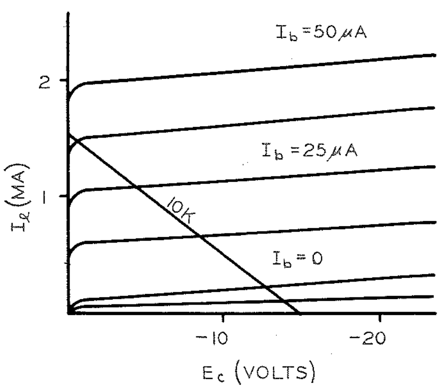


Fig. 4—Typical collector characteristic for junction transistor.

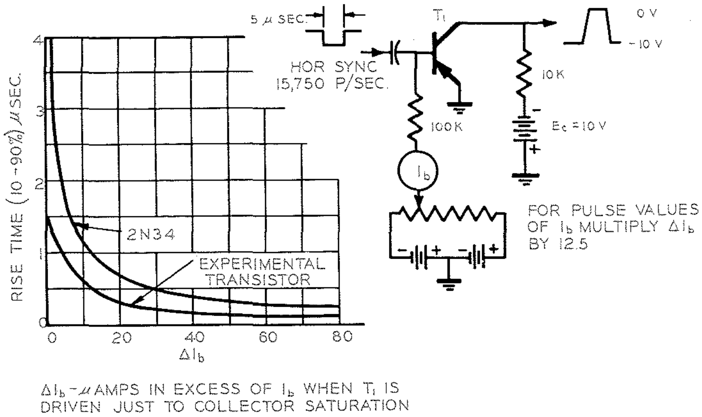


Fig. 5—Rise-time with overdriving.

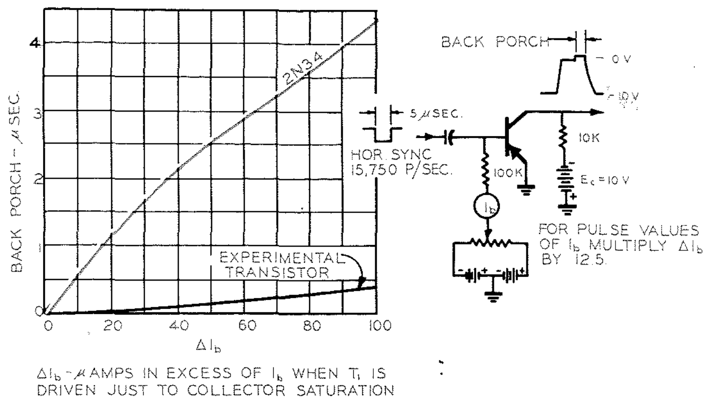


Fig. 6—Back-porch width with overdriving.

circuits. The two-stage separator is primarily useful where a high sync gain is required.

ONE-STAGE SYNC SEPARATORS

The two functions of sync separation and sync clipping are usually performed by separate vacuum tubes in commercial television receivers. A two-stage transistor separator was discussed in the previous section. However, the sharp cut-off and saturation characteristics of the junction transistor make possible its use as a one-stage separator, in which the same stage both separates and clips the sync pulses.

The one-stage separator is shown in Fig. 9. The bias developed by the emitter current flow through R_1 permits T_1 to conduct only during sync. At this time T_1 is driven to collector saturation, thus clipping the tops of sync as well as any noise that may be present. The output of T_1 is thus double clipped and will have a fixed output amplitude approximately equal to E_2. A one-stage separator can also be built with the self-bias elements R_1 and C_1 in the base circuit, but this has the disadvantage that collector leakage current I_{co} passes through the bias resistor.

There are certain differences in the self-biasing action between Fig. 9 and T_1 of Fig. 8. In Fig. 8, T_1 is not driven to saturation. The average collector current will thus vary with signal level. Since the collector current is the major component of the emitter current, it will cause adjustments in emitter bias with signal level. The change in current required to produce a given change in bias current is low because of the base-to-emitter current gain of the transistor.

In Fig. 9, since the collector is driven to saturation during sync at all signal levels, the collector current cannot increase with signal level. If the emitter bias is to adjust properly to varying signal levels, the adjustment must then come from changes in base-to-emitter current flow. At collector saturation normal transistor action ceases, and the base-emitter junction takes on the characteristic of a forwardly biased diode. The input resistance of the experimental transistor under these conditions falls well below 100 ohms. In this circuit the rectified input signal itself must provide the variations in bias, without benefit of the current gain of the transistor. The relationship between the required input signal level and source impedance and the variations encountered in signal amplitude and I_{co} will be illustrated by an example. The separator circuit of Fig. 9 was installed in an RCA KCS-82 receiver and driven by a "bootstrap" circuit from the cathode of the video amplifier. The source impedance to the separator was 250 ohms and the absolute level of sync tips varied from +1 to +4 volts above ground for maximum combined excursions of agc control setting and signal strength. Since the emitter bias closely follows the level of sync tips, this means a 3-volt variation across R_1. This change in current through R_1 due to change in signal level will be called ΔI_s; in this case it is equal to 30 microamperes.

Let us allow a 50 microamperes variation in I_{co} with temperature and unit to unit differences. Now equating ΔI_b, the maximum resultant variation in current charging C_1 during each sync pulse, to the variations in currents discharging C_1:

$$\Delta I_b = \Delta I_s + \Delta I_{co} = 80 \text{ microamperes}$$

Dividing the above average value by the duty factor of sync to get the base

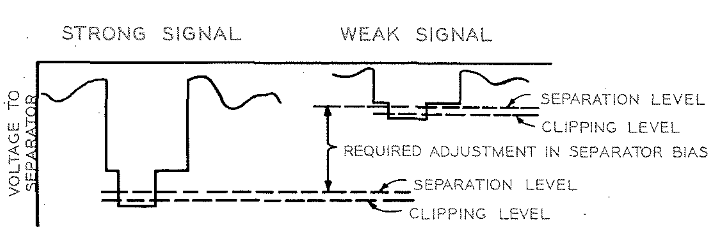


Fig. 7—Adjustment of separation level.

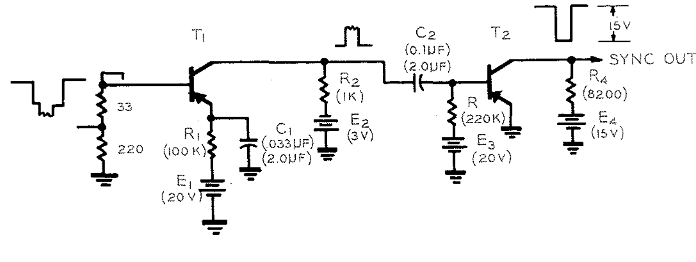


Fig. 8—Two-stage sync separator.

current flowing during each sync pulse gives about 1 ma. The normal video input signal is about 4 volts across the 250-ohm load. Sync normally represents 1 volt of this signal, so that 4 ma of sync current flows in the source load. Since the input resistance of the transistor at saturation is very low, most of this current is available as input current to the transistor. Thus there is a safety factor to take care of weak signals or low percentage sync. Note that if the allowance made for I_{eo} could be reduced, the signal source impedance could be raised.

problem is the use of two separators, one optimized for horizontal and one for vertical. This represents an added expense, although the practicality of the one transistor separator makes it less so.

Another possibility is the common channel separator circuit of Fig. 10 which gives a marked improvement in noise immunity. This circuit is basically the common-emitter, single-transistor separator previously described, adapted for positive power supply operation. However, it has two R-C time constant combinations in the emitter circuit which are brought into play at the proper time by diode D_1.

During each sync pulse, the emitter current of T_1 biases D_1 in the forward direction, placing the long time constant of R_3-R_4-C_3 in the bias circuit. However, after a noise pulse the excess charge on C_3 will keep D_1 open; and horizontal separation can resume as soon as the potential across the short time constant combination R_1-R_2-C_2 reaches the normal value. The double time constant circuit gives about an 8 to 1 improvement in the horizontal noise immunity of a common channel separator.

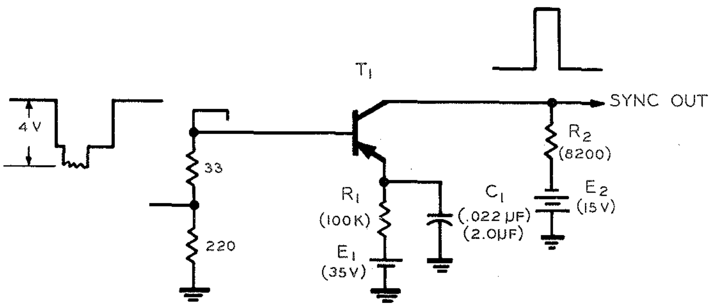


Fig. 9—One-stage sync separator.

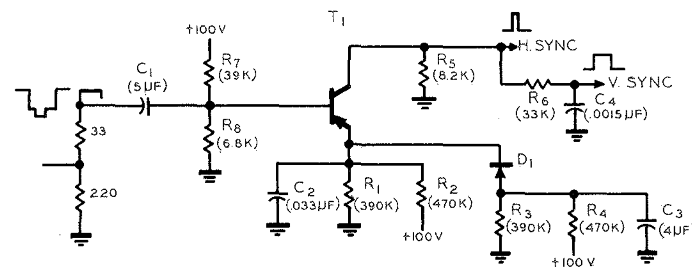


Fig. 10—One-stage sync separator with diode controlled time-constant.

SYNC SEPARATOR NOISE IMMUNITY

One characteristic of a sync separator which aids the impulse noise immunity of the picture synchronization is the ability to clip off noise so that it never exceeds the level of the sync output. The separators described in the previous sections do this. Another very important factor is that the separator not block or cut off for long periods following noise pulses. Impulse noise disturbances are normally of relatively short duration and low duty factor. The loss of sync information during the actual noise pulses usually does little harm. However, if the separator has long time constants that can charge on the noise pulses and keep the separator cut off for a long time thereafter, a serious loss of sync information results.

A long separation time constant is necessary for the separation of vertical sync. If horizontal sync is taken from the same circuit, the time constant must be on the order of 100 times that required for horizontal separation alone. This seriously affects horizontal noise immunity. One of the most effective solutions to the

HUNTER C. GOODRICH received the B.A. degree in Physics from Wayne University in 1942. During the following three years he worked as an engineer for the Signal Corps Engineering Laboratory on the development of radio interference measuring equipment. In 1945 he joined RCA where he has worked on advanced development projects such as signal seeking radios, magnetic convergence of the color kinescope and transistorization of television receiver circuits.

PERFORMANCE OF ONE-STAGE SEPARATOR

The separator of Fig. 10 was installed in an RCA KCS-82 receiver and checked against commercial requirements. It was found that the weakest intelligible signal could be held in sync and that no blanking appeared in the sync output until sync was reduced below 15 percent. The sync output had a 0.4 μsec rise-time and a 1 μsec decay. The resulting raster had no noticeable bends. In the presence of impulse noise, synchronization was comparable with the unmodified receiver. The disturbance due to airplane flutter was somewhat less than in the standard receiver. Transistor interchangeability among the experimental transistors was good and heating the transistors to 60°C gave no appreciable change in performance. Of the transistors so tested, the highest I_{eo} was 80 μa at 60°C. The circuit showed good line voltage tolerance, giving good separation from 85 to 135 volts. Commercial performance standards have thus been met with somewhat less circuitry than is usually employed with vacuum tubes.

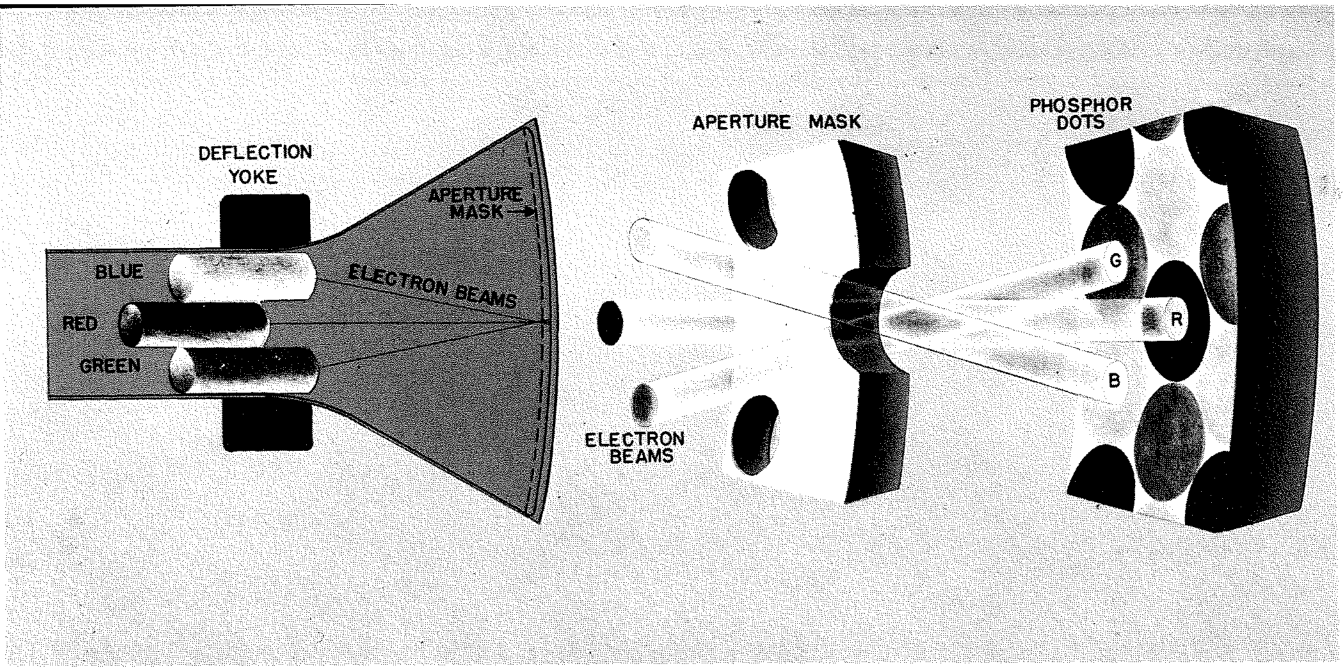


Fig. 1—Functional diagram showing the operation of the RCA-21AXP22 Color Kinescope. At the left, the three electron beams are seen to converge at the aperture mask. At right is an illustration of the divergence of the three beams, each striking the correct phosphor dot in a dot trio.

THE EFFECT OF MAGNETIC FIELDS ON COLOR TELEVISION RECEIVER PERFORMANCE

by **B. R. CLAY**
Color Television Engineering
RCA Victor Television Division
Cherry Hill, N. J.

THE COLOR television receiver depends not only on the design and performance of its circuits for producing a high-quality picture for the viewer, but on the performance of the kinescope as well. The RCA 21AXP-22[1] kinescope is capable of producing excellent color pictures. The application of this tube to color television receivers, however, has required the development of new circuits and techniques not necessary in black-and-white design practice.

Some of the problems encountered in the application of the RCA 21AXP-22 color kinescope are as follows: (1) the three rasters (each one from a separate electron gun and deflected by a common yoke) must be kept in proper registration, (2) circuits driving the guns must keep the correct ratio of signal amplitudes and electrode voltages to maintain a balanced chromatic picture and a uniform color temperature for the grey scale, and finally (3) a means must be provided for correcting the effect of magnetic fields on the color produced by the kinescope. This latter problem is of interest here.

It is the aim of this article to discuss the effects of the earth's magnetic field on the color receiver's picture and mention means of correcting for these effects.

THE MAGNETIC-EFFECTS PROBLEM

Any disturbing magnetic field, such as the earth's, prevents the electron beams from going along their planned trajectories. This effect is of little consequence in a black-and-white kinescope since the raster is merely de-centered slightly. When a black-and-white receiver is turned about its vertical axis, the raster shift is usually not noticed because of overscan, but centering means can provide correction if necessary. The color kinescope, however, is more seriously affected. In addition to raster shift, the earth's field causes a general color change as the set is rotated, because of the alteration of the relationship between the electron beam landings and phosphor-dot trios. This effect is beam displacement; when the color change is uniform it is called "purity shift." The direction of centering shift and purity shift depends upon the direction of the earth's flux through the beam, and, of course, the amount of shift depends upon the magnetic intensity.

BEAM LANDING CONSIDERATIONS

If a pure red field is to be obtained, the electrons from the red gun must hit only red-emitting phosphor dots and should land wholly on these dots. In order to accomplish this, only one condition must be met; i.e., the electrons passing through the holes in the shadow mask must do so at the correct angle. In order to allow for some reasonable tolerance in this angle, the beam is masked to a size smaller in diameter than the phosphor dot. As will be described in detail later, this difference in diameter will allow some landing error, without detrimental effect on the picture.

The tube is designed so that a straight line drawn from the center of any phosphor dot through its corresponding hole in the shadow mask terminates on the deflection plane at a point called its color center. There are three color centers on the deflection plane — one for each primary color.

It follows, then, that an electron

1. "Gun Development of the RCA21AXP22 Color Kinescope," R. E. Benway and R. H. Hughes. RCA ENGINEER, Vol. 1, No. 2, Aug-Sept. 1955.

leaving the red gun must appear to have passed through the red color center, and the yoke must be positioned so that its deflection plane is superposed on the plane containing the primary color centers. The electron trajectory then passes through the shadow mask holes at the correct angle.

Any condition which disturbs the angle of beam path from shadow mask hole to phosphor dot such as the earth's magnetic field may produce a landing inaccuracy. This can cause impurity or shading of the field when the error is greater than the tolerances built into the kinescope. Other contributing factors are imperfections in the yoke, such as lack of coincidence of vertical and horizontal deflection planes[2], and tolerances in tube manufacture.

DISTURBING EFFECTS OF EARTH'S FIELD

The effect of the earth's field may be divided into two categories; 1) ***Pre-Deflection*** . . . disturbances which affect the three beams compositely by bending them into an arc, preventing them from passing through their designated color centers in the deflection plane, and 2) ***Post Deflection*** . . . disturbances which occur after the beams have been deflected by the yoke; i.e., a beam changes direction as it sweeps out a raster and, as a consequence, its angle with respect to the earth's field changes. Since not all areas on the face of the kinescope are illuminated by beams making the same angle with the disturbing field, the amount and direction of beam landing error may be different for each part of the picture.

Pre-deflection effects are corrected by the use of a purifying magnet on the neck of the kinescope. Post-deflection effects are corrected by both the purifying magnet and the color equalizer attached to the outer edges of the kinescope face. Both of these corrective measures (described later) are necessary for satisfactory color receiver operation.

THE NEED FOR EXTENSIVE TESTS

To determine the effectiveness of such corrective devices in nullifying field errors, it was necessary to measure various shifts for each direction of field. It is not safe to assume that a receiver will operate within the limits of direction and horizontal intensity shown on the map of Fig. 4, because large steel masses in bridges, buildings, etc., distort the terrestrial field. The receiver's magnetic environment, conceivably, could be different in a city from that in an open, uncluttered countryside.

If a receiver is to be designed for operation in such a wide variety of circumstances, one must conduct experiments and tests in the presence of such fields. Obviously, to move a laboratory into many such locations would be impractical and time consuming. The laboratory, therefore, must be provided with a large earth-like magnetic field of controllable direction and intensity to simulate the flux-field conditions to be encountered.

"HELMHOLTZ" TEST CHAMBER

In simulating the earth's magnetic conditions in the laboratory, a magnetic field must be generated having a uniform intensity and direction within a volume larger than the color

Fig. 2— The post-deflection disturbance on a beam in a plane which contains the kinescope axis.

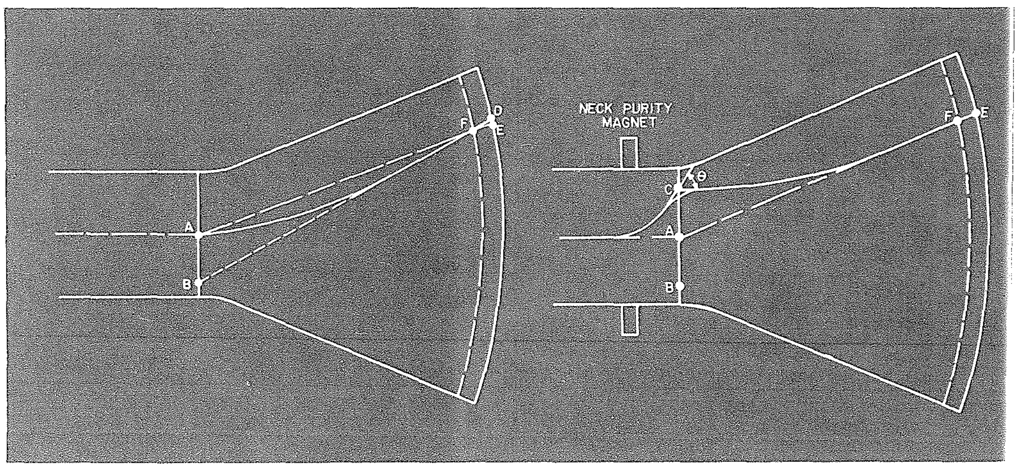


Fig. 2(a)—The deflection center for a given gun is at A (left above). However, the electron trajectory is shown in a curved arc (after centering so as to go through the same hole, F) arriving at D. The distance DE is the error in landing caused by lines of flux perpendicular to page. A straight line drawn from D through F intersects the deflection plane at B. The error AB may be corrected by the neck purifying magnet.

Fig. 2(b)—The corrected trajectory is shown above at right. The neck purity is adjusted so as to bend the beam near the point C in the deflection plane. The yoke is fed with direct current to recenter the raster through the angle O. A line from E through F terminates at A, the color center.

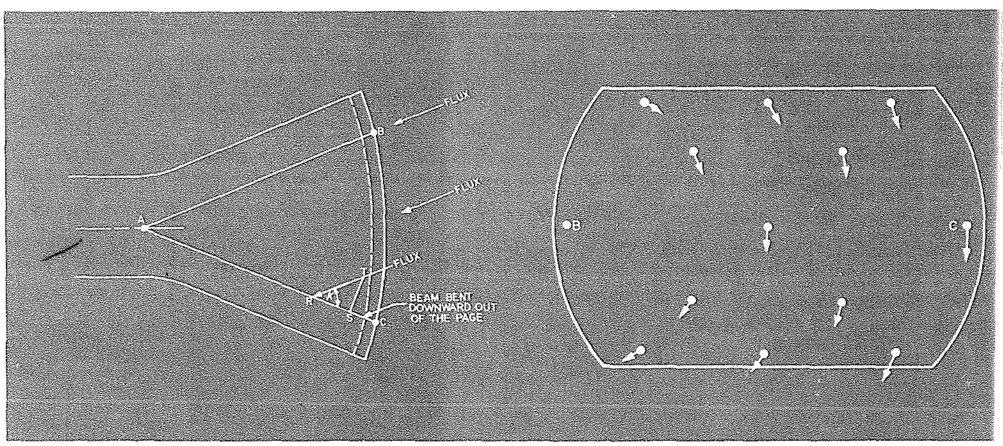


Fig. 3—(a) Side view—The flux effective in bending the beam is that component which is perpendicular to the beam. Let RT be the magnetic intensity at R, K be the angle between the beam and the flux, and ST be the magnitude of the effective component.

$$ST = RT \sin K$$

Fig. 3—(b) Front view—The component of flux perpendicular to the beam at B is zero, and at C is maximum. Resultant shift (mutually perpendicular to the beam and the projected component of flux) is downward as shown above.

2. The deflection plane is perpendicular to the Z-axis and is called a plane only because of its approximation to the ideal plane actually desired. In practice it is a 3-dimensional surface.

television receiver under test. Hermann Helmholtz discovered that, when two short circular solenoids are spaced one radius apart and connected to mutually aid, a field is produced between them which is substantially uniform within a small spherical volume—the diameter of which is slightly smaller than the radius of one coil.[3]

To apply the Helmholz principle, a chamber was built using square coils (for structural convenience) supported on nine-foot frames. In practice, the direction of the field inside the chamber must be controllable. In order to obtain any orientation of the field, three pairs of mutually perpendicular coils were used. Thus X, Y and Z-axis fields are obtained simultaneously, and the fields add vectorially (see Fig. 13). Three separately-regulated power supplies are used to feed current to the coils. The power supplies can be adjusted independently so that the resultant field may be produced at any angle and at any field strength desired. More than twelve miles of wire were used in winding the six coils. The three power supplies each deliver 300 v. at 2 amp. and combined are capable of *providing fields up to ten times as strong as those produced by the earth.* By a proper selection of currents, the earth's field may also be cancelled in order to create a field-free space. Observations made when no field is present give information on tube errors, yoke errors, dynamic convergence errors, and the like. Magnetic retentivity of the cone can cause landing errors. Thus, when the kinescope becomes magnetized, it must be demagnetized. The field-free space may be used to determine the extent of remnant magnetization within the kinescope.

A platform inside the Helmholtz chamber gives ample working space for two men and supports a television receiver so that its center of volume can be located at the geometric center of the fields.

Since metallic masses must not be near the chamber, the power supplies and control equipment are located elsewhere. Remote controls for each of the three axial fields are provided by a console within the chamber.

In order to measure the error in the landing of an electron beam on its phosphor dot, a microscope having a reticle graduated to read in thousandths of an inch is used. The earth's field produces significant errors in landing of as little as 0.00025 inches and as great as 0.008 inches. To measure a small landing displacement is difficult because the magnitude of this error is comparable to the vibrational displacement of the

3. For more complete information on this subject, see "Coil Arrangements for Producing a Uniform Magnetic Field" by Forest K. Harris. Research Paper RP-716, U. S. Dept. of Commerce, National Bureau of Standards.

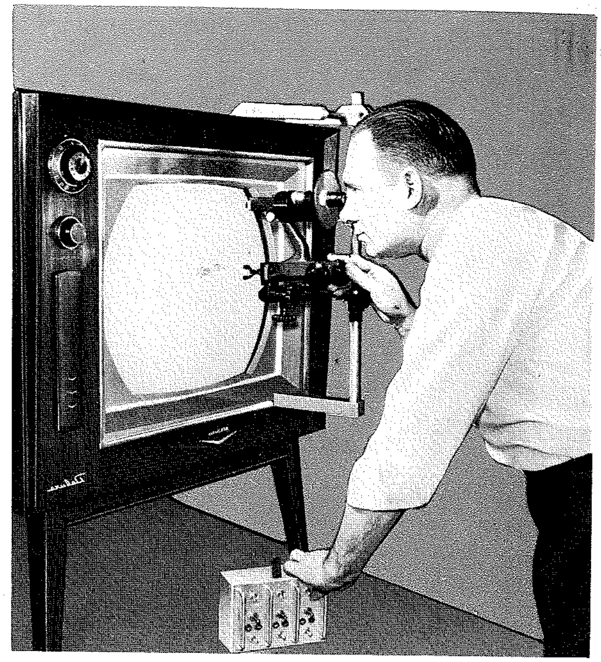


Fig. 5 — Measurements of landing shift versus magnetic field change are being made by technician, Leo Draus. The remote control box is used to vary the field in the Helmholtz Chamber.

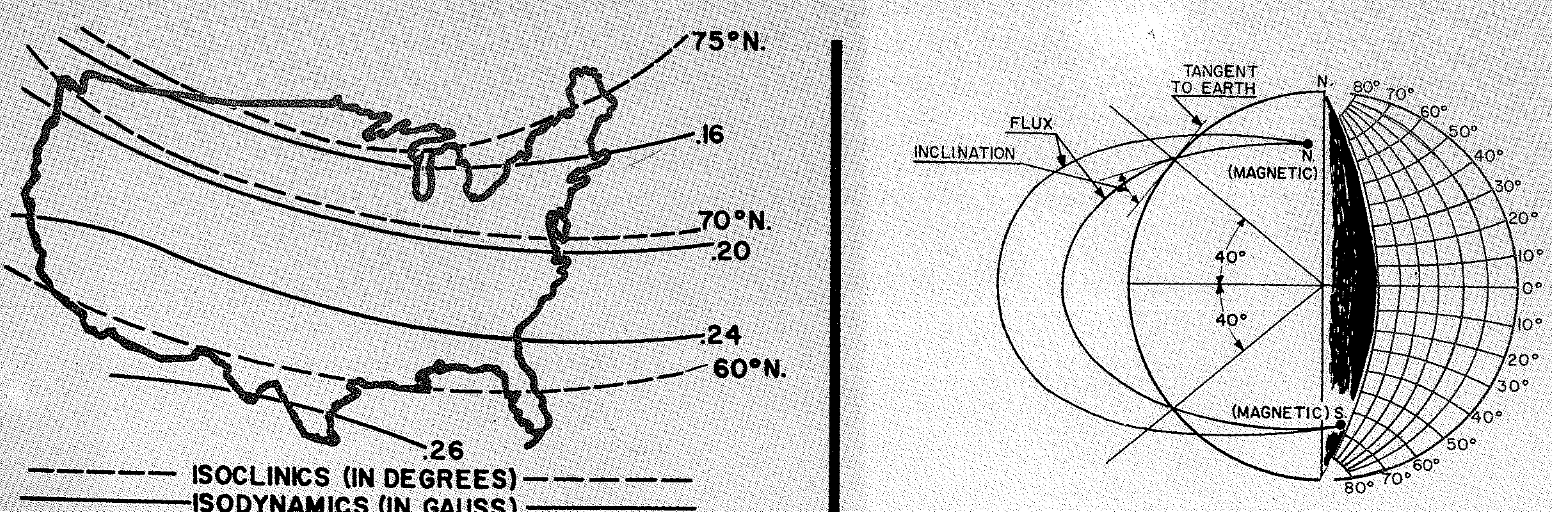


Fig. 4—(a & b) Inclination and horizontal-intensity variations of the earth's magnetic field.

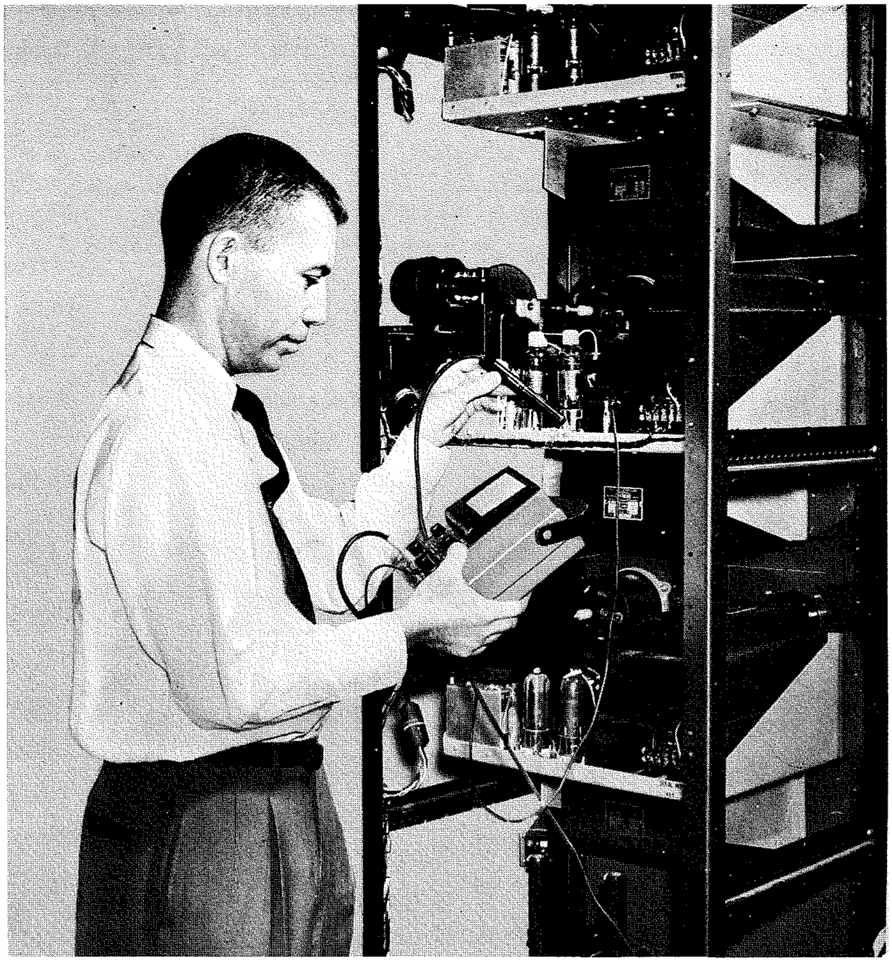


Fig. 6—The Helmholtz Chamber control equipment, including the drive motors and power supplies, is being inspected by the author.

microscope mount. This measurement, therefore, is done at many times the strength of the earth's field. The result is then divided by the same factor and so is the error. Care is taken that errors due to saturation phenomena are avoided and data errors resulting from retentivity in parts of the kinescope owing to the intense field are eliminated. The kinescope is demagnetized by an a-c field between measurements.

RESULTS OF INVESTIGATIONS

Some of the results of investigations are summarized in Figs. 3, 10, 11, and 12 which show effects observed in the Helmholtz chamber. A careful study of the sketches will illustrate the magnetic behavior of the kinescope. Figs. 10, 11, and 12 show the direction and relative amount of error (caused by a disturbing magnetic field), in the landing of an electron beam on its primary phosphor dot. Here it is seen that the vectors do not have the same direction and length all over the screen, but show a symmetrical error pattern.

The above irregularity of vector direction may cause different areas to shift toward different colors as follows:

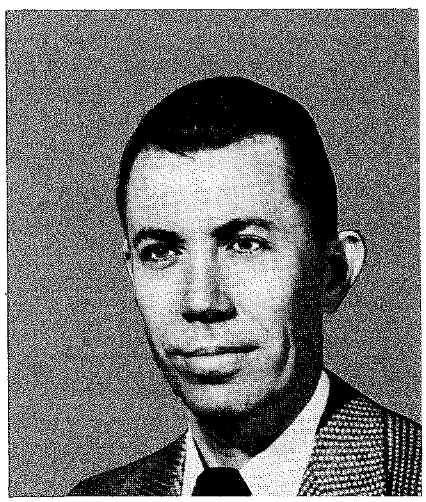
Let's assume that only the red dots are illuminated and that the electron beams are perfectly centered on the dots. Now, let us apply a disturbing field such as the Z-axis field (Fig. 12). If the resultant shift is great enough to move the beam landing from its phosphor dot, an adjacent dot may become illuminated. The dot trios are always arranged in equilateral triangles so that blue is at the bottom, red at the right, and green at the left. After the landing shift noted above, the upper left-hand corner is down and to the left, so in this general area the color tends toward blue. At the top center of the raster, the landing shift will be horizontal and to the left, so here the color shift tends toward green. Under these conditions, this area is called the green zone.

Therefore, it can be seen that the zonal color resulting from a particular landing shift is determined by the direction of the shift and color dot geometry. To arrive at a uniform color shift, all vectors would have to point in the same direction and be the same length.

Any shift directed along a radius to the center of the kinescope face is called a radial error, while those at 90° to the radials are called tangential errors. Since the terrestrial field enters the horizon at about 60° to 75° in the United States, one would expect a large vertical or Y-component of field through a television set (note Fig. 11). Y-fields cause both radial and tangential errors. The direction of the horizontal component may be along the kinescope's Z-axis if the set is facing north or south, or it may be along the X-axis if the receiver faces east or west. Z-fields cause only tangential errors whereas X-fields produce both. However, as previously noted, large structural steel masses do distort the earth's field and so the exact direction of the receiver's magnetic heading cannot be predicted. The receiver must therefore be compensated for a wide variety of conditions.

NECK PURIFYING MAGNET

The function of the neck purifying magnet is to provide a transverse field in a plane perpendicular to the Z-axis, thus bending the beams so that they *effectively* pass through their color centers. This field is adjustable both in strength and direction. The purifying magnet is adjusted in accordance with the angle of entry and intensity



B. R. CLAY—Mr. Clay received his Bachelor's degree in Physics from Indiana University in 1949. In August of that year he was employed by Clippard Instrument Laboratories of Cincinnati as an Instrument Design Engineer. In May 1950 he joined RCA in his present position as a Development Engineer in the Color Television Receiver Section of the RCA Victor Television Division. Since that time, Mr. Clay has been engaged in circuit design and development, and is now specializing in applied magnetics.

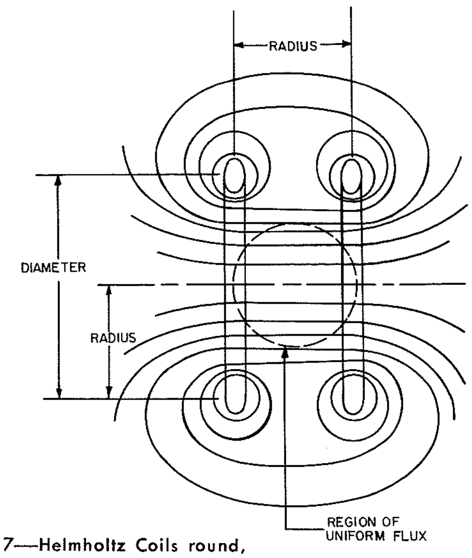


Fig. 7—Helmholtz Coils round, as originally conceived.

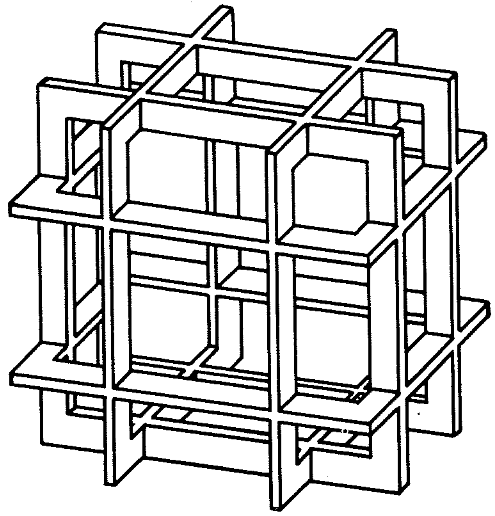


Fig. 8—Helmholtz Chamber—three pairs of square coils.

of the earth's field. In this manner, the purifying magnet corrects for two sources of disturbance.

It can be seen that the neck purifying magnet may be used to correct uniform errors only. It will correct the pre-deflection disturbances and the uniform components of post-deflection errors. If the 3-gun assembly is not perfectly aligned it is used to bring the beams back into line. The purifying magnet cannot be expected to compensate for the following items which cause non-uniform landing shift:

1. When the angle the deflected beam makes with a disturbing X or Y-field is 90° then the shift is greatest. Since the angle is other than 90° except for zero yoke current, then the shift magnitude varies with deflection;
2. Yoke errors (the effective length of a yoke varies with deflection angle; i.e., the electron path is shorter through the yoke at small deflections than at large deflections. As a result, the deflection center changes as a function of angle. Even though these effects have been corrected in the kinescope design,[4] the equalizer must still correct variations between yokes);
3. Metal near the beams, which can distort the terrestrial field;
4. The effect of dynamic convergence on purity;
5. Small variations in registration within the kinescope, as a result of established manufacturing tolerances;
6. The earth's field Z-axis component. The shift would be tangential and its magnitude would vary from zero at the screen's center to a maximum at the edge. This component may arise from a projected field which is predominately X or Y.

COLOR EQUALIZER

Since all six errors described above are non-uniform, they result in color changes which vary from one picture area to another. These errors are regional or "zonal" and are corrected to a practical degree by the color equalizer which is capable of affecting different zones independently.

The color equalizer (Fig. 9) utilizes a band fitted around the periphery of the kinescope face. On this band are mounted six magnets and appropriate pole pieces which pro-

4. "Improvements in Color Kinescopes Through Optical Analogy" by D. W. Epstein, Peter Kaus, D. D. Van Ormer, December, 1955, RCA REVIEW.

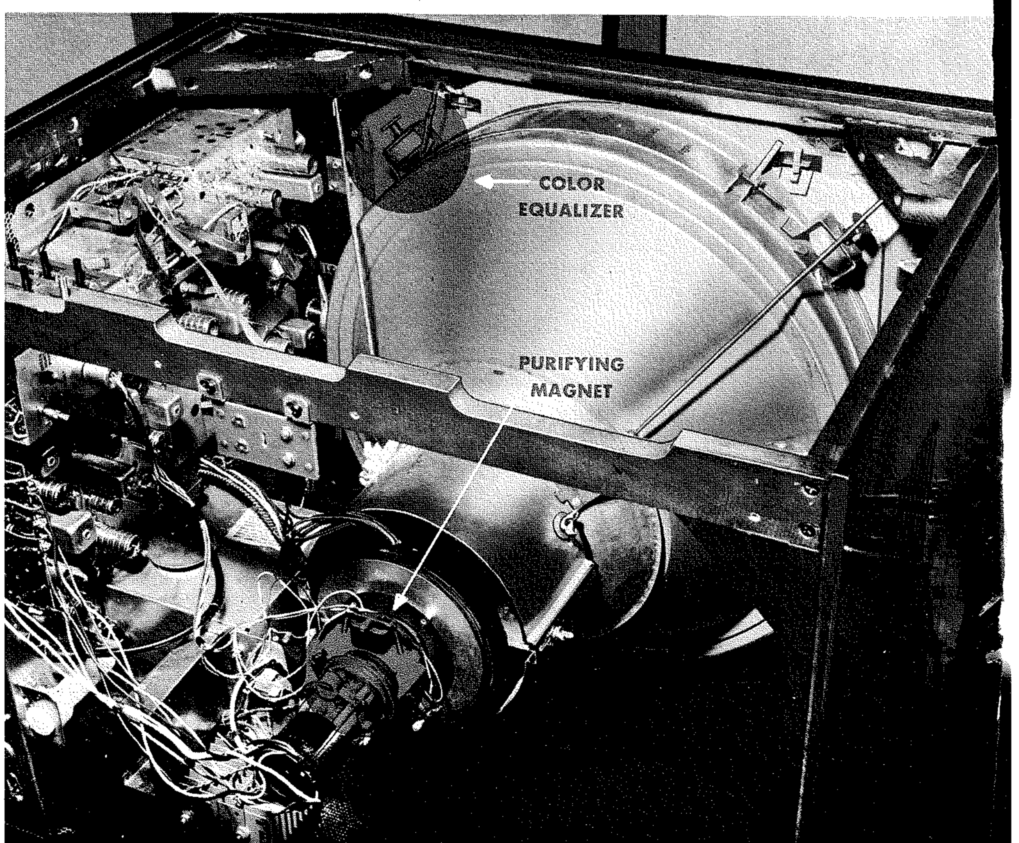


Fig. 9—The color equalizer and neck purifying magnet are shown in place on a 662 color receiver.

duce fields at the edge of the viewing screen, with a drop-off in strength toward the center. The field produced by each of the six magnets must cause either radial or tangential beam shift at the screen or both, and must be independently adjustable to give from zero to a maximum of ±7 thousandths of an inch tangential and ±5 thousandths radial shift at the picture edge. The field should extend only to the area requiring correction. It has been found that a division into six zones is a practical solution for adequate correction for the 21AXP22 kinescope. Ideally, an infinite number of zone compensating magnets would be desirable.

The requirements for equalizer correction can be found for a field of given direction by subtracting the vector for neck purity movement from the vectors representing actual error at representative points whether the errors are due to fields, dynamic convergence or kinescope errors. Any setting of the neck purifying ring causes a shift in approximately the same direction and amount for all areas on the kinescope face. Therefore, if in Figs. 10, 11, and 12, the vector on the center of the screen is used as a reference and is subtracted from all other vectors on the figure, the resultant vectors would indicate the required correction to be provided by the equalizer for that particular field. This technique is valuable in determining the exact requirements of purifying correctors for all directions of field.

Ferromagnetic shields were employed in the earlier CT-100 color receivers as a protection against the earth's flux and, although costly, were quite successful. Their success was largely due to the smaller deflection angle of the 15GP22.

One of the direct results of study and determination by measurement in the Helmholtz Chamber, however, is the conclusion that ferromagnetic shielding of color kinescopes against the earth's magnetic field is not the whole answer. The new color kinescope, type 21AXP22, because of its increased deflection angle is more sensitive to the effect of the earth's flux. Development effort has been exerted on the application of the color equalizer rather than on shielding to correct for the earth's magnetic field because no known method of shielding permits a practical solution. Shielding alone can not compensate for the kinescope errors due to manufacturing tolerances but a color equalizer can accomplish this, and at this state of the art is a requirement.

CONCLUSION

It may be concluded that the earth's magnetic field affects the color of the picture produced by a 21AXP22 kinescope to the extent that correction must be provided by the receiver. Shielding offers no satisfactory answer. Whatever form the color corrector takes, it should have separate adjustments for the different zones. The larger the vertical and horizontal deflection angles become, the more severe the requirements are for an equalizer. The Helmholtz Chamber generates the special fields required for producing and magnifying the errors to be corrected. The existence of the color equalizer and neck purifying magnets, apart from their primary function, permit less stringent tolerances to be used in manufacturing the kinescope thus lowering its cost.

REFERENCES

The preceding description covers some of the interesting and useful applications of the Helmholtz Chamber in the design of Color Television Receivers at Cherry Hill, N. J. At Lancaster, Pa., Tube Division engineers also apply the Helmholtz principle in the development of Color Kinescopes. The reader is referred here to design work devoted to the 21AXP22 Color Kinescope by several groups in RCA. The papers listed below describe some of the design problems and give solutions which helped to make this tube a practical reality.

GUN DEVELOPMENT OF THE RCA 21AXP22 COLOR KINESCOPE . . . by R. E. Benway and R. H. Hughes, Aug.-Sept., 1955, RCA ENGINEER.

DEVELOPMENT OF A 21" METAL ENVELOPE COLOR KINESCOPE . . . by H. R. Seelen, H. G. Moodey, D. D. Van Ormer, and A. M. Morrell, March, 1955, RCA REVIEW and April, 1955, ELECTRICAL ENGINEERING.

DEFLECTION AND CONVERGENCE OF 21" TRI-COLOR KINESCOPES . . . by M. Obert, March, 1955, RCA REVIEW.

IMPROVEMENTS IN COLOR KINESCOPES THROUGH OPTICAL ANALOGY . . . by D. W. Epstein, Peter Kaus, D. D. Van Ormer, December, 1955, RCA REVIEW.

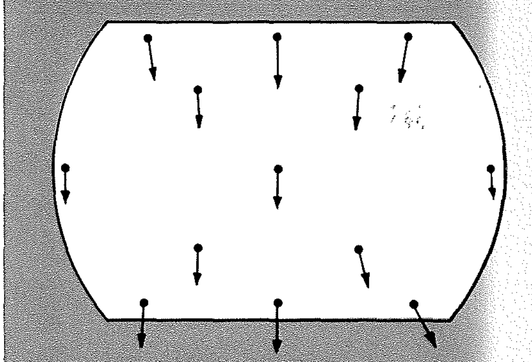


Fig. 10—(X-axis) Measured Relative Landing Shift due to magnetic field along X-axis.

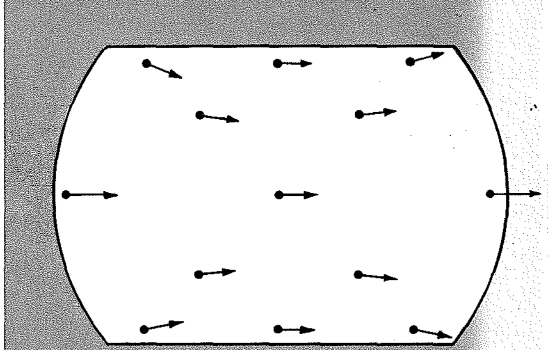


Fig. 11—(Y-axis) Measured relative landing shift due to magnetic field along Y-axis.

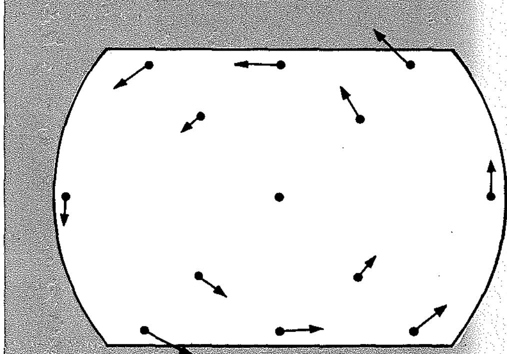


Fig. 12—(Z-axis) Measured relative landing shift due to magnetic field along Z-axis.

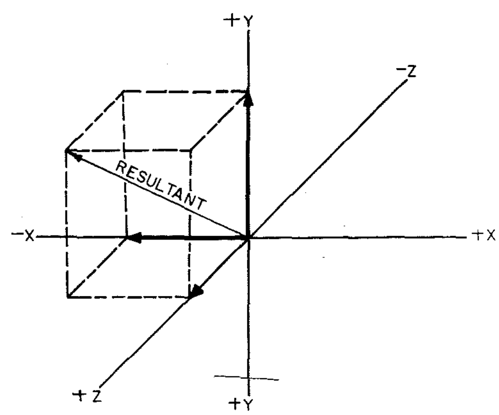
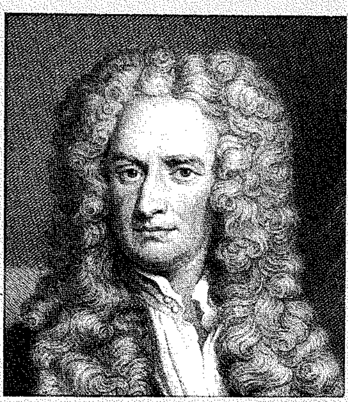


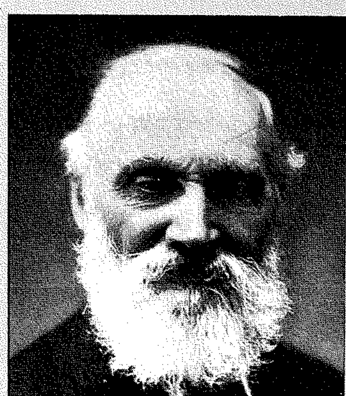
Fig. 13—Vector addition of X, Y and Z fields in Helmholtz Chamber to produce resultant field in a given direction.

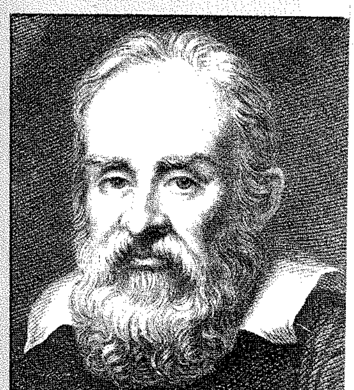
James Clerk Maxwell
1831-1879



Sir Isaac Newton
1642-1727

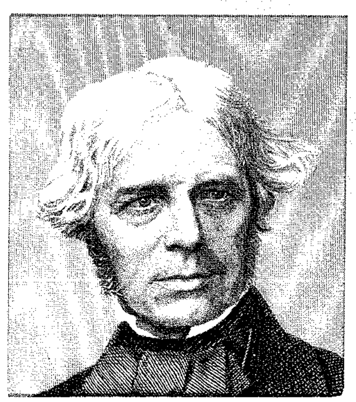
William T. (Lord) Kelvin
1824-1907





Galileo Galilei
1564-1642

Michael Faraday
1791-1867



SEMICONDUCTORS AND TRANSISTORS

By

DR. L. MALTER

Chief Engineer
Semiconductor Division
Harrison, N. J.

During the nineteenth century, primarily as a consequence of the discoveries of such individuals as Ampere, Volta, Faraday, Kelvin, and Maxwell, electricity developed into a force which subsequently changed not only our material world, but, in addition, reshaped our social and economic environment. The impact of these discoveries first made itself felt in enabling man to have conveniently at his disposal energy in quantities vastly in excess of that which was formerly available from his own efforts, from those of animals, or from crude applications of such natural sources as water power or the combustion of natural fuels. Concomitantly, or following closely upon the heels of the growth in the power field, came such new and revolutionary devices as the telephone, telegraph, and electric lighting. These devices immeasurably extended man's communications facilities and added to the possibilities for a fuller life. If one examines this burgeoning technology from the standpoint of the materials involved, it is apparent that its success was dependent upon the existence of two widely dissimilar types of materials, conductors and insulators. It was the existence of these two kinds of material and their proper marriage which made possible the family of electrical devices which we have acquired from the nineteenth century pioneering.

NINETEENTH-CENTURY CONTRIBUTION

In isolated instances during the nineteenth century, electrical phenomena were discovered which did not fit into the pattern of a universe made up exclusively of "pure" conductors and insulators. One such example is the phenomenon of photoconductivity wherein, under the influence of light, the electric conductivity of a material is altered. Other examples are the phenomena of phosphorescence and of thermionic emission and photoemission. One discovery, which at the time did not excite great interest, was of a class of materials whose properties lie somewhere between those of conductors and insulators. Their characteristics were such that they could not be used for any of the applications of either of those types. Furthermore, even insofar as electrical conductivity is concerned, some exhibited the anomalous behavior of decreasing in resistivity with increasing temperature. This characteristic was the exact converse of the behavior of conducting materials. These new materials were christened semiconductors, and have now become the basic raw material of a new science, technology, and industry which promise to have great, and, it is hoped, beneficial effects upon the future of mankind.

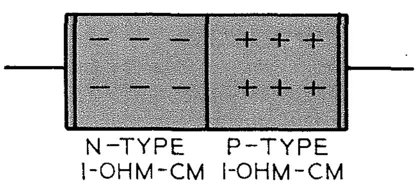


Fig. 1—P-N rectifier made by joining together p-type and n-type semiconductors.

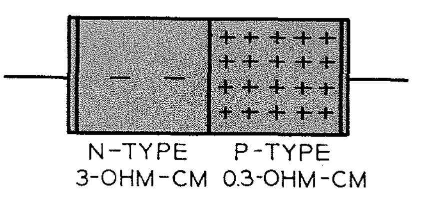


Fig. 2—P-N-P transistor formed by interposing n-type layers between two p-type sections.

During the early decades of the twentieth century the study of semiconductors increased. These studies were largely empirical because the physical nature of a semiconductor was still essentially a mystery. However, based upon the volume of empirical results obtained over the years, and with the aid of the powerful tool of quantum-mechanics developed during the 1920's, it finally became possible to arrive at a simple and meaningful picture of the nature of semiconductors during the 1930's.

ADVANCES IN THE "THIRTIES"

It is often the case in the natural sciences that theory and experiment, rather than going hand in hand, play leap-frog with each other to a considerable extent. This procedure has largely been the pattern in the field of semiconductors. The theoretical advances of the 1930's provided physicists with a relatively simple picture of the nature of semiconductors and their internal processes. With this tool in hand, it became possible for those concerned with the less esoteric and more material aspects of the natural sciences to devote themselves to the objectives of extending the boundaries of the application of electricity in the services of mankind by finding uses for these materials.

Within RCA the interest and activity in the broad field of electronically active solids, of which semiconductors are a special class, developed rapidly during the 1930's. In its early days this activity took the form primarily of research in a number of fields, among which were: (1) phosphors, a study enabling television to grow to its present magnitude and quality; (2) thermionic emission which has contributed greatly to the present stature of the hot-cathode electron tube, without which there would be little or no electronic industry; (3) phenomena such as photoemission, photoconductivity, secondary emission, and magnetism, which have served as a basis for the RCA development of secondary-electron multipliers, image orthicons, vidicons, signal-storage devices, and ferrites.

A tremendous impetus to activity in the semiconductor field proper was generated by the discovery of the transistor in 1948 by Bardeen and Brattain. RCA was quick to recognize the tremendous potential of this device and the role it was destined to play in the field of electronics. Research in the semiconductor area was increased even further and the beginnings were made toward develop-

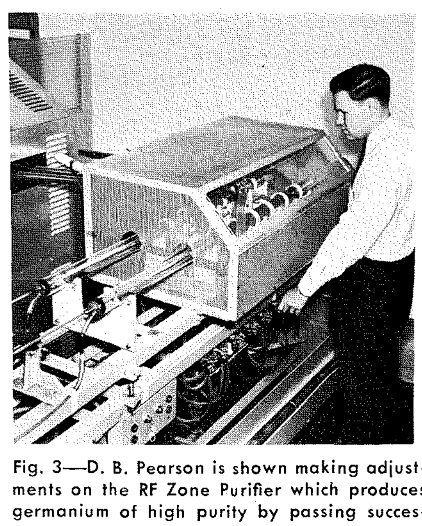


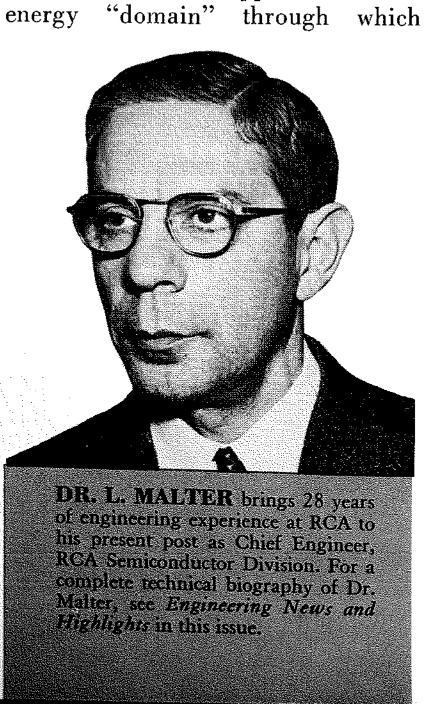
Fig. 3—D. B. Pearson is shown making adjustments on the RF Zone Purifier which produces germanium of high purity by passing successive molten zones through an ingot.

ing the technology needed to serve as the basis for an essentially new industry. The Advanced Development phase of this activity was started as an offshoot of Receiving Tube Engineering. By 1954 this activity had developed to the point where it was desirable that it exist as an independent entity, and so at that time the Semiconductor Operations Department was set up as a separate part of the Tube Division. Late in 1955, the Semiconductor Activity became a separate division of the Radio Corporation of America.

With this historical background laid, we can now attempt to present a picture of just what we are concerned with physically in semiconductors and particularly in the transistor, the semiconductor device which promises so dramatic an impact upon electronics.

SEMICONDUCTOR MATERIALS

Before an attempt is made to discuss the transistor as such, it may be well to present briefly a simple picture of the nature of semiconducting materials. In a conductor there are large numbers of "free" electrons. These electrons wander about in the material and can be impelled under the influence of an applied electric field to increase their energy and to take on a preferred direction of motion in the direction of the applied field. The energy "domain" through which these electrons "move," with average values determined by thermal conditions, is commonly referred to as the conduction band.



DR. L. MALTER brings 28 years of engineering experience at RCA to his present post as Chief Engineer, RCA Semiconductor Division. For a complete technical biography of Dr. Malter, see *Engineering News and Highlights* in this issue.

In an insulator the electrons contained within so-called valence bands have the property that the average energy of the electrons in these bands cannot be increased by small amounts. As a consequence, the electrons in the valence bands are essentially uninfluenced by an applied electric field, and thus do not contribute to the phenomenon of electrical conduction. The valence band is separated from the conduction band in which the electrons are free to move under the influence of an electric field, by a so-called "forbidden gap." No electrons can have energies corresponding to the values in the forbidden band. Under the influence of external forces, e.g., thermal energy, electrons can be raised from the valence band to the conduction band. For most insulators, however, the forbidden gap is so wide that very high temperatures are necessary in order to effect appreciable conductivity.

In the case of some materials, e.g., germanium and silicon, which are like insulators in having a valence band separated from a conduction band by a forbidden gap, it is found that the introduction of certain types of impurities causes a marked increase in conductivity. Such materials are referred to as semiconductors, and depending upon the nature of the impurities, they are referred to as n-type or p-type semiconductors. When they are essentially free of impurities they are referred to as intrinsic semiconductors. Most intrinsic semiconductors differ from good insulators only in having a smaller forbidden gap.

In an intrinsic semiconductor an increase in temperature results in an increase in the number of electrons, which are excited from the valence to the conduction band, and which are thus available for conduction. This effect accounts for the decrease in resistivity with temperature. In transistors no use is made of the thermally produced conduction; indeed, it is actually a detriment because it varies so markedly with temperature. Instead, it is the so-called n-type and p-type semiconductors which are used for transistors.

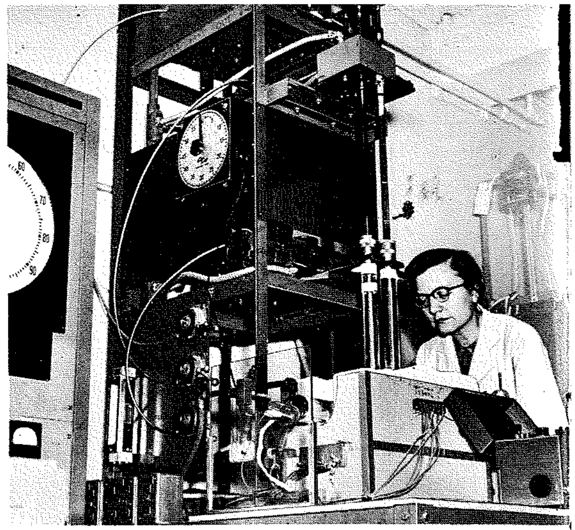


Fig. 4—P. Lintz is shown operating a vertical-type furnace for growing single-crystal germanium. Such factors as crystal-growth rate, rotational speed, atmosphere, temperature, and temperature gradients are carefully controlled. As single-crystal germanium is pulled from the melt, poly-crystalline high-purity material is fed into the crucible to maintain the liquid level and composition.

As has been said, in n- or p-type semiconductors the conduction is due primarily to the presence of impurities in the semiconductor material. If arsenic is introduced as a microscopic impurity into a semiconductor material such as germanium or silicon, a so-called donor level is set up in the forbidden gap. Its energy value is only slightly below that of the bottom of the conduction band, and thus, at room temperature, electrons from this donor level are thermally excited into the conduction band, providing what is called n-type conductivity. We see thus, that in n-type semiconductors the conductivity is provided for almost entirely by electrons excited from the donor level into the conduction band.

Conversely, if indium is introduced as an impurity into an intrinsic semiconductor, so-called acceptor levels are formed only slightly above the top of the valence band, and electrons can now rise out of the filled band into the acceptor levels as a result of thermal effects. Consequently there is a decrease in the number of electrons in the valence band. The absence of an electron in the valence band is referred to as a "hole." These "holes" behave very much like electrons, except that their sign is positive. They can "move" under the influence of electric fields, transfer charge, and in general contribute to conduction. The latter class of materials are referred to as p-type semiconductors, the conducting medium being holes.

It has been found that some of the materials in Column IV of the periodic table have semiconductor properties, that some of the materials in Column III can act as acceptor impurities, and that some of those in Column V as donor impurities.

RECTIFIERS AND TRANSISTORS

The simplest form of semiconductor device is the so-called p-n rectifier, made by joining together p- and n-type semiconductors as shown in Fig. 1. When a battery is connected so as to make the right-hand terminal positive, holes flow out of the p material into the n material. This connection is also just the condition which makes electrons flow out of the n material into the p material. Thus a large current flows across the junction (this mode of operation is referred to as "forward direction"). The ratio of current carried by holes to that carried by electrons is partly determined by the ratio of the p-type impurities to the n-type impurities in their respective materials. A reversal of the battery leads to almost no flow of charge away from the junction (reverse direction).

If we now form a device wherein a thin n-type layer is interposed between two p-type sections, we obtain a so-called p-n-p transistor (see Fig. 2). One of the p sections, let us say that to the left, is designated as the emitter, and the other as the collector, the interposed n region being designated as the base. In operation the emitter is biased in the forward direction with respect to the base, and the collector in the reverse direction. Under these conditions holes flow from the emitter into the base region. They then travel across the base region to the collector junction by the process of diffusion, and then readily cross the base-to-collector junction into the collector. This hole travel occurs because the reverse bias across this junction is in such a direction as to impede the flow of electrons from the base to the collector but so as to accelerate the flow of holes from the n-type base into the p-type collector. Small changes in the potential between the emitter and base result in large changes in the amount of injected hole current. On the other hand, changes in the potential difference between the base and collector result in virtually no change in the current flow. Thus we see that the transistor can function as an amplifier wherein a variation in potential between the emitter and base causes a corresponding variation in the current that enters the collector. The impedance between the emitter and base, i.e., the input impedance, is very low, whereas the output impedance, i.e., the impedance between the base and the collector, is very high, so that the device can, and in fact, does give considerable power gains. An outstanding advantage of this type of amplifier over previously almost universal thermionic-cathode types is that no outside source of energy is required to generate the charge carriers necessary for the amplification process. The fact that no "cathode" power is required results in a great decrease in the over-all power requirements and also minimizes problems with regard to available emission and life.

For good transistor operation, the electron flow out of the base region into either the emitter or collector should be as small as possible. This objective is effected by making the resistivity of the p-type emitter and collector low in comparison with that of the n-type base material.

By alloying n-type impurities into p-type material, one can make an n-p-n transistor. The effective charge carriers in this case are electrons.

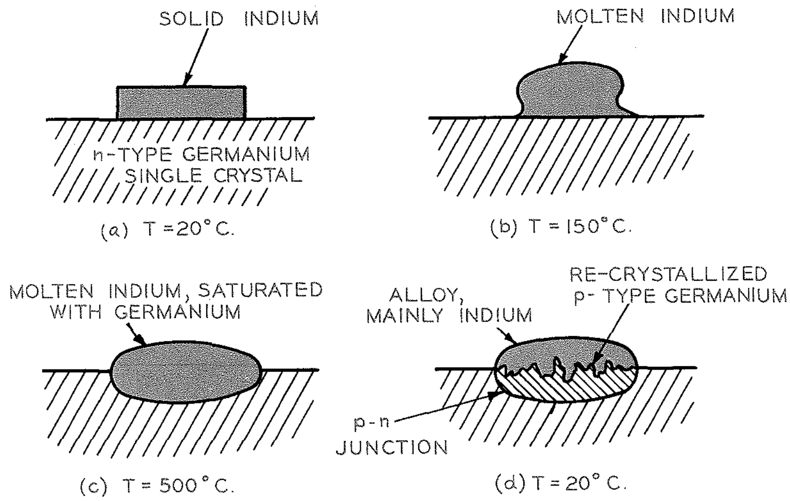


Fig. 5—Various steps in the formation of an alloy junction.

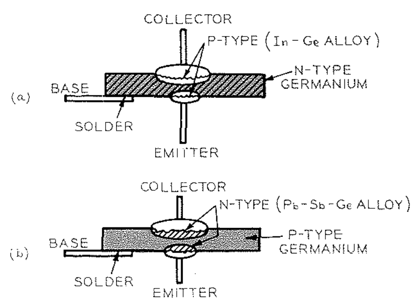


Fig. 6—p-n-p and n-p-n transistors in which junctions are formed on opposite sides of a thin base layer.

TEMPERATURE CONSIDERATIONS

The width of the forbidden gap is of great importance in determining the temperature range over which a transistor will operate. The relationship follows from the fact that as the temperature is increased the number of the electrons in the conduction band, which are produced thermally by excitation out of the valence band, increases. These thermally generated electrons are generally undesirable, and thus set an upper limit to the operating temperature of a device made from a particular semiconductor material. In germanium, which is the most commonly employed semiconductor material, the width of the forbidden gap is 0.72 volts. The other common semiconductor material, sili-

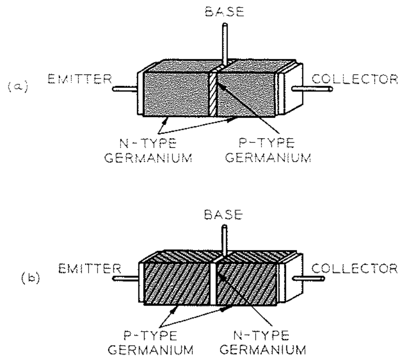


Fig. 7—Grown-junction n-p-n and p-n-p transistors.

con, has a forbidden-gap width of 1.1 volts. It is because of this difference that silicon is the chosen material for higher-temperature applications. Unfortunately, insofar as other quantities of prime importance in transistor behavior are concerned, that is, the so-called electron and hole mobilities, silicon is considerably inferior to germanium. The mobilities, which are a measure of speed with which the charge carriers drift through the material under the influence of an electric field, are of prime importance in determining the frequency behavior of the transistor. As a consequence of the lower mobilities in silicon, it is, in general, inferior to germanium for high-frequency operation (provided that the geometry of the two transistors is identical).

TECHNIQUES

For the manufacture of transistors, it is first necessary to obtain a semiconductor of extremely high purity. This requirement is now effected by a so-called zone-purifying technique wherein molten zones are moved through a bar of solid material, advantage being taken of the fact that impurities concentrate in the molten zones and are thus moved toward one end of the bar. A photograph of a zone purifier, wherein the moving molten zones are produced by radio-frequency techniques is shown in Fig. 3. As a subsequent step it is necessary to introduce controlled amounts of impurities of the proper type into the essentially pure or intrinsic semiconductor.

Single crystals of the resultant n- or p-type materials are then produced in one of various ways. Fig. 4 is a photograph of the equipment used in the Czochralski technique, wherein a crystal seed is dipped into a molten semiconductor and then withdrawn slowly, pulling with it a single-crystal bar of germanium or silicon. These single crystals having controlled impurities content can now be used as the raw material for making transistors, for example, by the "alloy-junction technique." In this procedure, in its most common form, small dots of indium are alloyed into a thin wafer of n-type germanium from opposite sides. The various steps can best be understood by reference to Fig. 5. As we proceed from Figs. 5a to 5c, the molten indium dissolves germanium within itself, and is always in a saturated state. As the assembly is permitted to cool, germanium re-crystallizes out of the melt, but with included indium as a p-type or acceptor impurity. This process results in the formation of a p-n junction between the original n-type germanium and the recrystallized p-type germanium.

Fig. 6a shows the assembly of a p-n-p transistor wherein the junctions have been formed at opposite sides of a thin base layer. In Fig. 6b is shown an n-p-n transistor wherein an n-type recrystallized region is formed in contact with a p-type base layer.

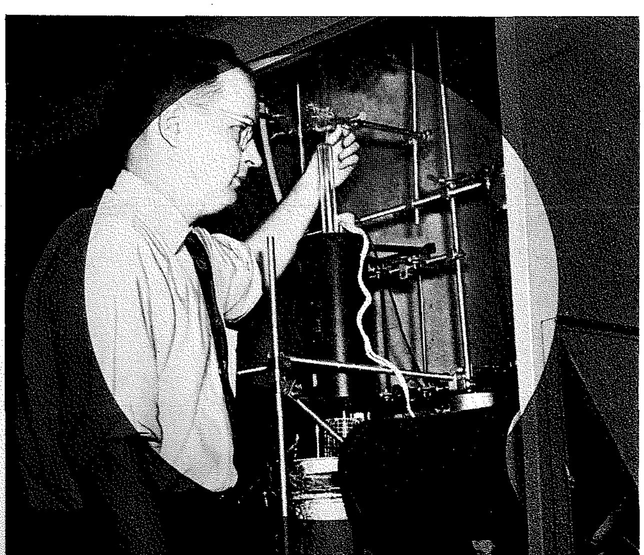
Many other techniques for making junction transistors have been developed. Fig. 7 shows a so-called grown-junction transistor. In this type of transistor the desired types of conductivity are obtained by varying the composition of the melt while a single crystal is being pulled, or by changing the rate of pulling in the case of a melt which contains impurities of both types.

Another technique for making p-n junctions is by the diffusion of impurities into the semiconductor under the influence of high temperature. The impurities may initially be in the form of a deposited layer on the surface of the semiconductor or in the form of a surrounding atmosphere.

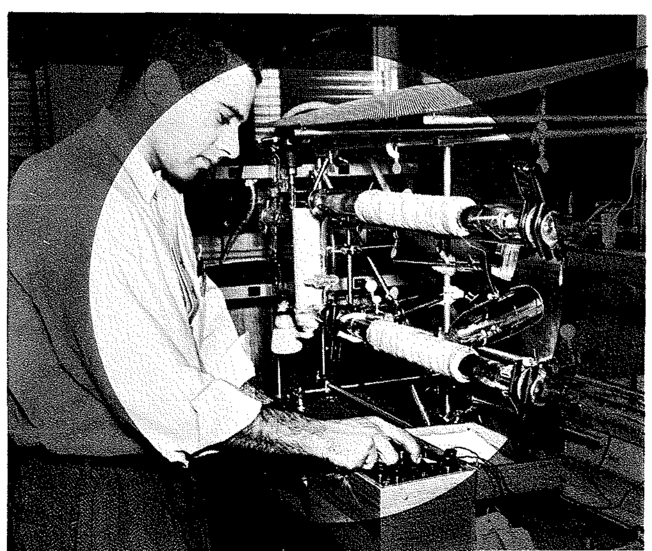
STATE OF THE ART

Many commercial transistors have been developed and announced to date. The majority of these are for audio applications. This situation is what might be expected because, as in the case of tubes, the technical problems become more difficult as

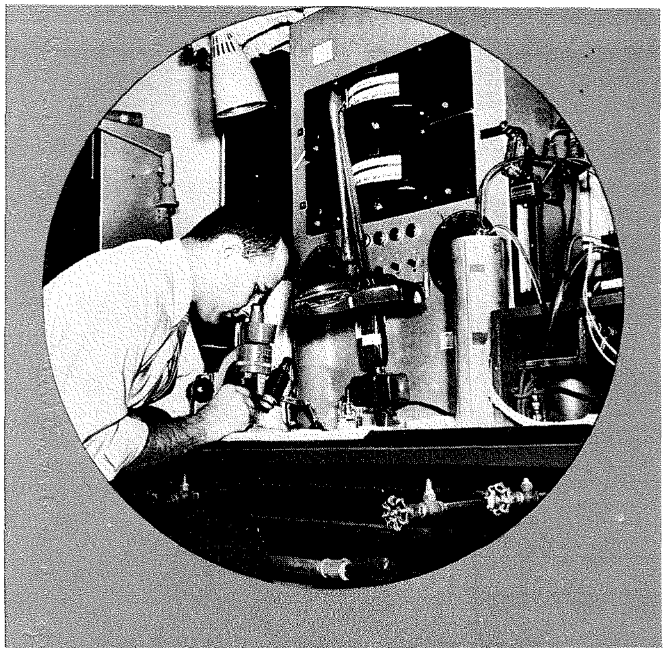
E. Jordan is shown aligning furnaces for the preparation of impurity alloys for transistors. Alloys must be homogeneous and accurate in composition in order to obtain proper semiconductor device characteristics. These materials are developed and produced in the Advanced Materials Group.



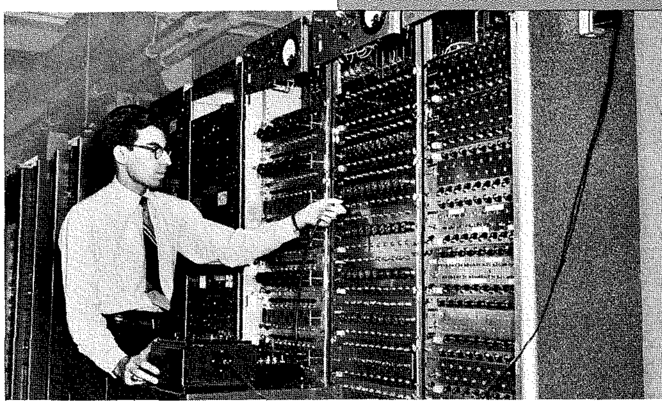
An alloying furnace for silicon power rectifiers is shown being operated by H. R. Meisel. Alloying junctions to silicon requires extreme cleanliness and is presently accomplished in this vacuum furnace. New devices and fundamental device technology are studied in the Advanced Devices Group.



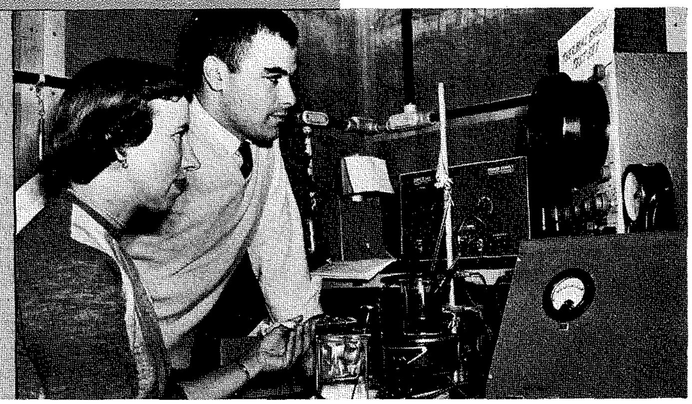
A. Peldunas is shown examining an alloy boat for alloying of transistors in the Laboratory. Temperature gas controls are shown on the center panel, the alloy furnace is at the right. Gas purity and temperature conditions are held to tight limits to assure uniformity of transistor parameters. This operation is a part of the Methods and Process Laboratory where devices for Engineering tests are fabricated.



Operating life-test conditions are shown being checked by M. Berkowitz of the Test Engineering Laboratory. Performance of new devices as well as of factory product is thoroughly evaluated on both high- and low-dissipation operation life tests to obtain predictions of field service.



S. Simons is shown with Technician A. Fertal observing curve presentation of transistor during Thermal Shock test. Noise characteristic levels of transistors are tested over a wide temperature range to assure satisfactory operation at the extremes of temperature normally encountered in commercial equipment. Tests such as this are performed in the Test Engineering Lab.



frequency is increased. In the audio field of application a considerable amount of specialization is already taking place. Thus, there are now types designed for small-signal and for large-signal applications, as well as for varying ranges of power output. In addition, as a consequence of their outstanding potential as regards signal-to-noise characteristics, low-noise transistors are now available for the "head" end of critical audio equipment. Audio transistors are available in both silicon and germanium. To date the former are more difficult to make and, as a consequence, are considerably more expensive. For some time their use is likely to be limited to special requirements, largely in the military field, where temperature considerations are paramount.

Transistors are beginning to move into higher frequencies. Commercial types now exist which are suitable for the i-f and converter stage of broadcast receivers. Experimental units are available for still higher frequencies, the upper frequency limit attained to date with a transistor oscillator being in the neighborhood of 1200 megacycles per second.

A basic limit on the high-frequency operation of transistors is set by the time it takes for charge carriers to diffuse across the base layer. One can gain in this respect by making the base layer thinner, and this design is one direction in which effort is being directed. However, when one realizes that the base-layer thickness in the case of present i-f transistors is already less than 0.001 inch, it can be seen that the technical problems involved are not inconsiderable.

If an electric field is established across the base region, it results in a speeding up of the charge carriers through that region. This effect results in a considerable extension in the upper frequency limit of operation of transistors. This drift transistor, as well as other types of transistors designed to extend the upper frequency limit of operation, is described in an article by H. Johnson, Vol. 1, No. 4 of the RCA ENGINEER.

FUTURE TRENDS

Looking ahead for the next few years, one sees extensions in the boundaries of transistor performance capabilities as regards power, frequency, and temperature. It is expected that these steps forward will be taken not only by exploiting the means already discussed, but by the development of new materials whose limitations as regards forbidden-gap and mobilities are less severe than those in germanium and silicon. Considerable effort is under way in many laboratories throughout the world in exploring other semiconductors, largely synthetic, in the hope that from this work will come the "dream" materials of the future.

Other areas for application of semiconductors are already being explored actively. Many of these are certain to result in new and exciting products which will affect us at work and at home. Among these are such devices as phototransistors; light amplifiers of the form described by D. W. Epstein in Vol. I, No. 1 of this magazine; solar batteries, which are already serving to convert solar into electrical energy; and so-called Peltier Coolers, wherein refrigerating action can be achieved by passing electric currents through suitable semiconductor materials.

EIGHT RCA ENGINEERS ELECTED IRE FELLOWS

LOY E. BARTON
"For contributions to Radio Engineering, including inventions in Class-B Amplification"

ALAN M. GLOVER
"For contributions to the development of Photo Tubes"

NATHANIEL I. KORMAN
"For contributions in the field of Radar Fire Control and Missile Guidance"

HUMBOLDT W. LEVERENZ
"For contributions to the field of Luminescence as applied to electronic devices"

GEORGE McELRATH
"For contributions in the development of broadcasting and television operating practices and techniques"

WALDEMAR J. POCH
"For contributions in the development and design of television studio equipment"

EDWIN E. SPITZER
"For contributions and leadership in the design of Power Tubes"

WILLIAM A. TOLSON
"For invention and development in the field of television receivers and military target tracking"

Early in 1956 The Institute of Radio Engineers announced the election of eight RCA engineers to the Fellow Grade. Diplomas will be individually presented at local Section meetings, banquets, and special gatherings, and a formal ceremony for the recognition of the 1956 IRE Fellows will be included in the Annual IRE Banquet to be held on Wednesday evening, March 21, 1956, in the Grand Ballroom of the Waldorf-Astoria Hotel in New York City during the 1956 IRE National Convention. A list of the RCA engineers, together with the award citation, is included here.

The IRE Fellow Grade was established in 1915, three years after The Institute of Radio Engineers was founded in 1912.

LOY E. BARTON received the B.E.E. degree in 1921 and the E.E. degree in 1925 from the University of Arkansas. He served as an instructor in Mechanical Engineering at the University from 1921 to 1925 and returned as an Associate Professor from 1927 to 1929 after a two year student training course at the General Electric Company. He has been employed by the Radio Corporation of America as a Radio Engineer since 1929, except for the period from 1936 to 1939 when he was with the Philco Corporation. At the RCA Victor Division at Camden he served in various capacities as a radio engineer and engineering supervisor until 1946. He was transferred to the David Sarnoff Research Center at Princeton in 1946 as a member of the technical staff. Many patents on radio devices have been issued to Mr. Barton, some of which pertain to class B audio amplifiers. Other patents pertain to Sonar, Radar, Air Navigation Systems, Color Television and Transistors.

Mr. Barton received letters of commendation from the Navy for his work at the Naval Research Lab.

ALAN M. GLOVER graduated from the University of Rochester in 1930 with the degree of A.B. and continued his studies to obtain the graduate degrees of M.A. and Ph.D. in Physics. He joined RCA in 1936 and worked in the development of phototubes at Harrison. From 1941 to 1950 he acted as Manager, Gas Tube and Phototube Engineering, first at Harrison and later at Lancaster, Pa.

Dr. Glover is largely responsible for the development of a large line of phototubes and multiplier phototubes. During the war, electrostatically focused multiplier tubes were very useful for radar jamming; since the war, a good sized market has developed in headlight dimming. As an extension of the multiplier work, Dr. Glover was active in the development of multipliers with large photo-sensitive surfaces that could be coupled closely to a fluorescent crystal. This combination is the well known scintillation counter which has been so useful in nuclear physics.

In 1954 he became Manager, Semiconductor Operations Department of the Tube Division and recently was named General Manager of the newly created RCA Semiconductor Division.

NATHANIEL I. KORMAN received his B.S.E.E. in 1937 from Worcester Polytechnic Institute, where he was graduated with "highest distinction." As an undergraduate at Worcester Polytechnic Institute, he was elected first, as an associate member of Sigma Xi and later, as a full member. He received his M.S.E.E. from the Massachusetts Institute of Technology in 1938, where he studied as a Charles A. Coffin Fellow.

He joined RCA in 1938 as a student engineer. In his early years at RCA, he worked on advanced development of FM transmitters and microwave components, particularly as they apply to television and radar. During this period, he made contributions of fundamental importance with his microwave work.

Mr. Korman has held positions of increasing responsibility and authority after being promoted to supervision in 1945. At the present time, he is Manager of Missile and Radar Systems Engineering. In this capacity, he directs the systems work on a wide variety of radar and missile projects. In recognition of his work, Mr. Korman was awarded the 1951 RCA Victor Award of Merit for extraordinary service to the company.

Mr. Korman, besides being the author of numerous technical articles, has twenty-eight domestic and foreign patents to his credit and currently has sixteen patents pending. In addition, he served the Department of Defense for a number of years as chairman of the Surface Borne Surveillance Radar, Subpanel of the Research and Development Board.

HUMBOLDT W. LEVERENZ graduated from Stanford University in 1930 with a B.A. degree. He studied Physics and Chemistry as an exchange fellow of the Institute of International Education at the University of Muenster, Westphalia, Germany, from 1930 to 1931. He joined the Electronic Research Group at RCA in Camden, N. J. as a chemicophysicist in 1931. In 1938, he transferred to RCA in Harrison, N.J., and in 1942 to RCA Laboratories at Princeton, N. J., where he has been in charge of research on electronically active solid materials such as phosphors, scotophors, ferromagnetic spinels, semiconductors, photoconductors, and secondary-electron emitters.

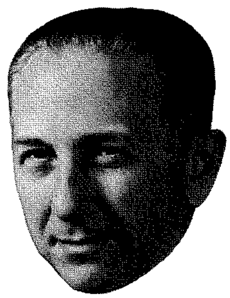
Mr. Leverenz has been very productive in the origination of U. S. and foreign patents and is the author of a book and a score of technical papers. He is a Fellow, American Physical Society; a Member, American Chemical Society, Optical Society of America, as well as member of several other Professional Societies. He was an Associate Editor of the Physical Review and is now an Associate Editor of the Journal of the Optical Society of America. Mr. Leverenz was recipient of the 1940 "Modern Pioneer" award of the National Association of Manufacturers and the F. P. Brown medal from the Franklin Institute in 1954.

GEORGE McELRATH has been active in Radio and Broadcasting since 1917. He first served as a Radio Operator in the U. S. Navy and in 1922 became Studio, Transmitter and Field Engineer at WEAF. In 1927 he became Field Supervisor for WJZ technical operations and in 1928 was Engineer-in-Charge for WRC, Washington.

Mr. McElrath later became Operating Engineer, NBC, New York, where he supervised technical operations and maintenance for Red and Blue Networks including Standard and International transmitters at all locations. In 1945, he was appointed Manager of Engineering Department for NBC and in 1950 Director of Radio Network Technical Operations. In 1952 Mr. McElrath became Director of Technical Operations, NBC, and is responsible for all television, radio, and sound effects operations and maintenance for NBC Networks, including New York and Hollywood, also International shortwave transmitters in New Jersey and California.

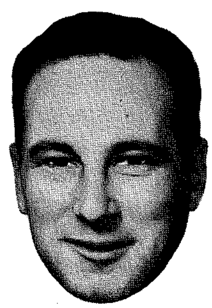
Mr. McElrath is a member of the Radio Pioneers and a Fellow Member of IRE.

WALDEMAR J. POCH graduated in 1928 from the University of Michigan with a B.S. degree in Electrical Engineering and in 1934 received his M.S. degree from the University of Pennsylvania. In 1928, he worked as a Student Engineer at General Electric Co. and in 1930 transferred to RCA in Camden, N. J., as a Receiver Development Engineer. In 1931, he was assigned to the Research Department in the TV Receiver field. His work in this department included development of video amplifiers, AGC systems, sync separation circuits and receiver test equipment. In 1938, he

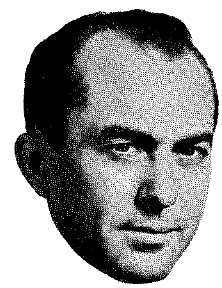


LOY E. BARTON

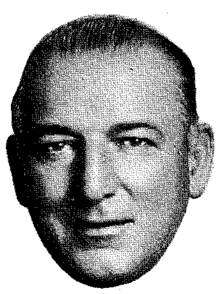
ALAN M. GLOVER



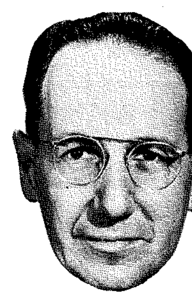
NATHANIEL I. KORMAN



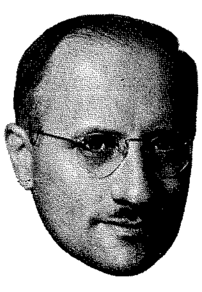
HUMBOLDT W. LEVERENZ



GEORGE McELRATH



WALDEMAR J. POCH



EDWIN E. SPITZER

WILLIAM A. TOLSON

developed transportable TV pickup equipment. During the war his work included development of lightweight portable TV pickup and transmitting equipment for the military services. In 1944, he worked as Unit Supervisor for Television Terminal Equipment Development. He later became a Group Supervisor of engineers working on Studio Equipment and in 1950 became Section Manager of Broadcast Studio Equipment Engineering. In this capacity he was responsible for a group of approximately 80 engineers.

In 1955, Mr. Poch was appointed to the post of Administrator, Technical Analysis, Product Planning. Mr. Poch has numerous U. S. and Foreign patents to his credit and is author of many technical papers dealing with television. He is a Member of SMPTE, Sigma Xi, and IRE. He is active on a number of Industry Committees, and was Chairman of the 1955 IRE Color Television Symposium of the Philadelphia Section.

EDWIN E. SPITZER received his B.S. in Electrical Engineering from the Massachusetts Institute of Technology in 1926 and his M.S. in Electrical Engineering in 1927. During the period from 1927 to 1933, he was employed as engineer on design and development of transmitting tubes at General Electric Co.

He became associated with RCA in 1933 at Harrison, N. J., and aided in setting up the power tube activity. He carried on pioneer work in the study of properties of graphite as an anode material for transmitting tubes. He became Section Head of Power Tube Design and Development and was responsible for many successful tube developments for radar during the war. In 1943, Mr. Spitzer transferred to the RCA Lancaster Plant where he was Section Supervisor and Manager of the Power and Gas Tube Development group which brought out several outstanding new tubes. Mr. Spitzer was responsible for simplified methods of calculating transmitting tube design factors and establishment of principles for rating tubes. In 1954, he was appointed Manager of Power Tube Engineering which includes design and development of Power, Large Power, Gas, Microwave, Photo, Pickup and Oscilloscope tubes.

Mr. Spitzer has had numerous technical papers published. He is a Registered Professional Engineer in Pennsylvania, a Fellow of the IRE and is active on IRE and government committees.

WILLIAM A. TOLSON received his B.S. in Electrical Engineering from Texas A. & M. College in 1923. As a student, he built and helped operate the school radio station. Following two years of military science, he became a student engineer at the General Electric Co. in Schenectady. He worked as development engineer and Section Head on Carrier Communications and later became Section Head of Television Development.

In 1930, Mr. Tolson became Section Head of Television Advanced Development for RCA Victor at Camden, N. J. From 1932 until 1952, he was active as Senior Research Engineer, RCA Laboratories, Camden and Princeton, N. J.

During World War II he did excellent original work on military projects, including automatic target tracking and gun control by radar. He invented and developed many improvements in television, including (a) the blocking oscillator used for television deflection; (b) distributed-winding deflection yoke; (c) use of non-linear amplifier to linearize saw-tooth wave for deflection; (d) use of triode for damping horizontal deflection; (e) Sync separator using grid current for clipping; and (f) operation of television at 60-cps field frequency to reduce power supply interference to interlace.

Mr. Tolson is presently engaged as Senior Research Engineer in military projects for the U. S. armed forces at RCA Laboratories, Princeton, N. J. He received the "Modern Pioneer" award from the National Association of Manufacturers in 1940.

INTRODUCING YOUR ENGINEERING EDITORS

P. R. BENNETT
Engineering Editor
RCA Victor Radio
& "Victrola" Division
Cherry Hill, N. J.

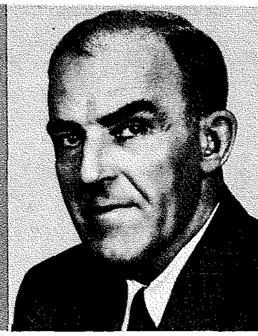
Paul R. Bennett joined the A. Atwater Kent Radio Manufacturing Company in 1928 and was active in the field of test equipment design and maintenance engineering until 1936. In 1936, Mr. Bennett transferred to the Philco Radio and Television Corporation working first with test equipment, later on sound systems, and finally, in the Radio Engineering Section on the design of battery powered farm and portable receivers. In 1939, Mr. Bennett came with the RCA International Division and was assigned the position of Chief Engineer of RCA Victor Argentina in Buenos Aires, which position he held for 4½ years. Following his return to the U. S. A. in 1943, he has held various posts in the RCA Home Instrument Engineering Department and recently was made Section Manager of the Radio and Phonograph Engineering Section of the Radio and "Victrola" Division.

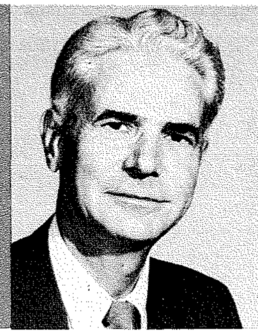
Mr. Bennett serves as Engineering Editor on the staff of the "RCA ENGINEER" and assists with planning, writing, approval, expediting, and scheduling articles submitted by the Radio and "Victrola" Engineering Division. This work is coordinated with W. S. Skidmore, Engineering editorial representative of the same Division, who is a member of the Cherry Hill Editorial Board.

R. S. BURNAP
Engineering Editor
Tube Division
Harrison, N. J.

Robert S. Burnap received the S.B. degree from the Massachusetts Institute of Technology in 1916, and continued as a Research Assistant for the next year. From 1917 to 1918, he was employed as an engineer at the Edison Lamp Works of the General Electric Company in Harrison, N. J. After serving with the U. S. Army Signal Corps Mr. Burnap returned to the Edison Lamp Works as assistant to the manager responsible for type C lamp development. Mr. Burnap spe-


P. R. BENNETT


R. S. BURNAP


J. B. DAVIS


C. A. MEYER


C. M. SINNETT

cialized in the design of projection lamps, and obtained several patents in this field. From 1925 to 1930, Mr. Burnap was Manager of the Commercial Engineering Section of the Edison Lamp Works. Since 1930, he has been Manager of Commercial Engineering for the RCA Tube Division.

Mr. Burnap, throughout his career, has been active in the writing field, having published articles in professional and trade journals and house organs. He has carried on extensive work in the field of standardizing in such organizations as the SMPTE, AIEE, IRE, ASA, and JETEC. Mr. Burnap was secretary of the SMPTE in 1929 and elevated to fellow in 1934. He was also elected Fellow of the IRE in 1947 and of the AIEE in 1951.

As Manager of Commercial Engineering, one of Mr. Burnap's major responsibilities is to supply the right kind of technical information on all Tube Division products and thereby promote their sale. Another major responsibility of Commercial Engineering is to handle the processing and editing of technical papers submitted by other engineering functions of the Tube Division. In addition, Mr. Burnap cooperates with the editors of the RCA ENGINEER and the Tube Division Editorial Representatives in stimulating the preparation of papers for the RCA ENGINEER.

J. B. DAVIS
Engineering Editor
Defense and Commercial
Electronic Products
Camden, N. J.

J. Burgess Davis, who is Engineering Editor for Defense and Commercial Electronic Products, attended Bloomsburg State Normal School and Albright College. He has been closely affiliated with radio and television for more than thirty years (twenty-three with RCA), serving consecutively as technical advisor in extension courses with RCA Institutes; as technical writer and lecturer for RCA Service Division, and technical writer and editor for Special Apparatus and Engineering Products Divisions.

In his duties as Engineering Editor, Mr. Davis is responsible for scheduling technical papers and for rendering editorial assistance to authors. He is supported in this work by an Editorial Board representing all engineering activities in Defense and Commercial Electronic Products. The editor and members of the Board work together with the authors in producing papers for presentation before technical societies and industrial conventions as well as for publication in RCA ENGINEER, ENGINEERS DIGEST, RCA REVIEW and the Records and Proceedings of technical societies. Mr. Davis is also responsible for administering the standard procedure for control and approval of technical papers, for the engineering departments of all product and service divisions of the Company, under the direction of Dr. G. L. Beers.

Mr. Davis serves as an Engineering Editor on the Editorial Staff of the RCA ENGINEER; is Editor of Engineers Digest; Editor of the IRE Bulletin, Philadelphia section; and a member of the New Jersey Industrial Editors' Association.

C. A. MEYER
Engineering Editor
Tube Division
Harrison, N. J.

Charles A. Meyer received the B.A. degree from the University of Chicago in 1937 and the M.A. degree in English from Harvard in 1939. During World War II, after intensive training in electronics, he served as a radar and communications officer in the Army Air Corps. Part of this service was at MIT Radiation Laboratory on a guided missile project. In 1946, upon leaving the military service, Mr. Meyer joined Commercial Engineering, RCA Tube Division at Harrison, N. J. In 1954 he was appointed to his present position as Manager, Commercial Engineering Technical Services. As part of his Commercial Engineering duties, Mr. Meyer helps with the approval procedures for papers originating within the Tube Division and provides editorial and drafting assistance to the authors. Mr. Meyer cooperates with the editors of the RCA ENGINEER and the Tube Division Editorial Representatives in stimulating the preparation of papers for the RCA ENGINEER.

Mr. Meyer is a member of Phi Beta Kappa and a Senior Member of the IRE.

C. M. SINNETT
Engineering Editor
RCA Victor Television Division
Cherry Hill, N. J.

C. M. Sinnett received his B.S. in E.E. from the University of Maine in 1924 and joined the Engineering Department of the Westinghouse Electric and Manufacturing Company in July of that year. In November, 1929 he was transferred to Camden, N. J. as Manager of the Phonograph Development and Design Section of the RCA Manufacturing Company and later became Manager of the Loudspeaker and Phonograph Section.

In 1945 Mr. Sinnett was appointed Manager of the Home Instrument Advanced Development Section, which position he still holds in the RCA Victor Television Division. He was Chairman of the Philadelphia Section of the IRE in 1952 and was elected IRE Fellow in 1955. He is a member of Tau Beta Pi and has 30 patents to his credit in the fields of audio and acoustics.

Mr. Sinnett, who represents the Television Division, Cherry Hill, serves as an Engineering Editor on the Staff of the RCA ENGINEER. He assists authors in the planning, writing, scheduling and securing approvals of technical papers. Mr. Sinnett serves as Chairman of the Cherry Hill Editorial Board and coordinates all work with the Editorial Representatives who are members of the Cherry Hill Editorial Board.

HOW RCA ORGANIZATION IS PLANNED TO MEET CHANGING NEEDS

by
J. L. MASTRAN, *Administrator Organization Planning*

MANY ENGINEERS throughout RCA must wonder and ask questions about the significant organization structure changes that have taken place in our Corporation during the past several years. What were the circumstances that made these changes necessary? Why and how was the new type of organization structure established?

We are all aware that RCA's business has undergone a great change in the past ten years. Our sales have increased over 300 per cent during this period. We have developed new products, new markets and expanded our engineering and manufacturing operations in many areas. The organization changes that have been made, because of these changing conditions, were necessary in order to operate our business more effectively, and to keep it profitable and competitive.

This article is written to explain the overall organization philosophies and procedures that are being followed in making organization changes throughout RCA.

DECENTRALIZATION PHILOSOPHY

Basically, the organization structure changes taking place are the outcome of RCA's adoption of the philosophy of decentralizing the responsibility for operations. This philosophy may be further defined as the delegation of responsibility and authority to individuals for the profitable conduct of the business operations of integrated units within the Corporation. By integrated unit is meant one having all of its own functions, such as engineering, purchasing, manufacturing, marketing, and any others necessary to manage a particular product line or lines. Such a unit becomes the responsibility of one person.

The philosophy of decentralization of organization is not peculiar to RCA. Many other large companies that have grown bigger and more diversified in their operations have found it necessary to decentralize their organization in one form or another.

In order to understand properly the reasons for decentralization and the organization trend being followed by our Company, it may be well to turn our memories back to 1944-1945 and review the circumstances that caused the RCA Victor Division to decentralize at that time.

RCA VICTOR DIVISION—1944-1945

In 1944 the organization structure of the Victor Division was basically functional (see Fig. 1); that is, each of the major functions, such as sales, manufacturing, etc., performed in the Victor Division was the responsibility of a functional executive who reported directly to the chief executive officer of the Victor Division. In the case of Engineering there was a Chief Engineer of the RCA Victor Division, who had functional responsibilities for all engineering activities. Direct product engineering was a responsibility of the Plant Managers. The General Manager of Manufacturing, for example, was responsible for the engineering and manufacturing of all products—tubes, records, and special electronic products. In the same manner, the General Sales Manager was responsible for selling all RCA Victor products.

RCA VICTOR DIVISION (1944)

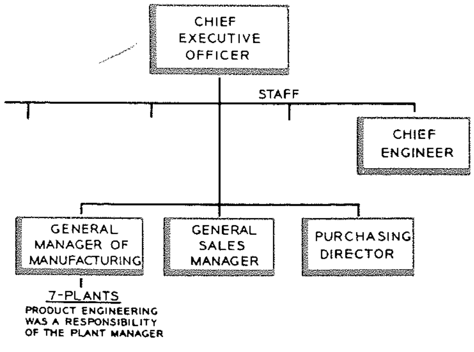


Fig. 1—This chart illustrates the basically functional organization employed in 1944.

RCA Victor in 1944, in surveying the future, could foresee many things that were about to happen—reconversion to peacetime products; tremendous pent-up consumer demand heralding increased volume of business encompassing new products, new markets, and television. Was the existing functional organization the best one to capitalize on this favorable forecast? The answer was "NO" for these essential reasons:

Product Leadership Divided

Product responsibility for each of the products made was scattered under the functional organization structure. There was no *one* person that the chief executive officer could hold fully responsible for engineering, manufacturing, and marketing any particular product line.

Coordination Difficult

No effective method was available to coordinate essentially widely different businesses; *special electronic* products were sold to industrial and government markets and consisted mainly of high-cost, custom products produced mostly in small lots. *Home Instruments* were sold to the consumer market and were produced with mass production techniques and were highly merchandised; *record* operations saw attention focused on artist relationships, hit song problems, and the 45 rpm project pending; *tubes* with particular marketing problems, were low cost and mass produced on highly specialized equipment.

Administrative Load Heavy

The administrative load on the chief executive officer and on each of the top functional executives reporting to him was very heavy, i.e., the General Manager of Manufacturing was responsible for engineering and manufacturing widely-diversified products; the General Sales Manager was responsible for selling *all* Victor products with their many different markets and sales problems and so on for the other functional heads. All decisions covering two or more functions had to be made by the chief executive officer.

Profit Responsibility Difficult to Delegate

It was not possible to delegate profit responsibility effectively to any one person below the Chief Executive Officer himself because no other person had responsibility for *all* functions such as sales, engineering, manufacturing, purchasing, etc.

Future Outlook Indicated Continued Growth

The outlook for the future was that the Victor Division with seven plants was going to grow in size and complexity. In such a future, the problems of a functional organization could only become more complex.

1945 DECENTRALIZATION INTO FOUR PRODUCT ORGANIZATIONS

In 1945, after a major organization survey was made, the reorganization of the RCA Victor Division took place, resulting in a top structure consisting of four major manufacturing product units as shown in Fig. 2. With this new alignment there was established below the chief executive officer of the Victor Division a general manager over each of the RCA Victor major businesses; i.e., tubes, home instruments, records, and engineering products. As already explained, each of these businesses was essentially different and was large enough to be set up independently.

Each of these General Managers was responsible for all functions necessary to engineer, produce, and market his product profitably as well as the required financial, accounting, and other staff functions.

FUNCTIONAL ORGANIZATION WEAKNESSES OVERCOME

With the adoption of this new form of organization, the chief executive officer of the RCA Victor Division was able to overcome the major weaknesses of the functional organization; i.e., product leadership for each of the Victor Division major product lines was established; the coordination of the various functions necessary to engineer, make and sell a particular product was now reduced and confined to a product unit; the administrative load on the chief executive officer of the Victor Division was lightened; profit responsibilities could be delegated to each of the product unit general managers; and each of the four product units was organized so that future growth and expansion was more easily possible.

TEN-YEAR GROWTH

As we all know, the great growth predicted for the Victor Division took place. The sale of products expanded more than three-fold, the number of plants grew from seven to twenty-five in nineteen separate localities, and the number of employes more than doubled.

The great growth of the RCA Victor Division and other businesses of RCA caused organization structure changes to take place at the top management level of the Corporation. The RCA Victor Division, as an organization entity, was dissolved in January, 1954. Group executives were established to direct major segments of RCA's profit-making divisions and subsidiaries. The RCA Victor Division staff organization was integrated with that of the RCA Executive Offices. The new realignment enabled RCA's chief executives to keep in closer contact with the RCA major operating units.

Each of the four major product units established in 1945 in the Victor Division had grown tremendously. Three of the units—Tubes, Home Instruments, and Engineering Products—*each* became as large, from the standpoint of sales volume, as the entire Victor Division was in 1944.

FURTHER DECENTRALIZATION INDICATED

During the years of this growth, each of these product units made organization structure changes, to keep abreast of changing conditions—i.e., new products, markets, etc. Each had begun to experience organization structure problems that were similar in nature to those the Victor Division had experienced in 1944 and 1945.

During the past several years, many changes have taken place. The Home Instrument organization was separated into two divisions—Television Division and Radio and "Victrola" Division. With this change the new Television Division management could devote its complete time and attention to the building and expanding of its product line. At the same time a new integrated Radio and "Victrola" organization was established under the leadership of a general manager to devote its complete time and attention to making its product line a more profitable unit of the Corporation.

ENGINEERING PRODUCTS GROWS FIVE-FOLD

The Engineering Products Division which had grown more than five times in size since 1950 has recently been divided into two major organization units — Defense Electronic Products and Commercial Electronic Products. As each of these two essentially different types of businesses grew since 1950, it became increasingly difficult to administer and manage them effectively. Since the future outlook was continued growth, it became necessary to establish each as a major self-contained, integrated unit with its own general manager.

JOHN L. MASTRAN was graduated from the University of Virginia in 1942, and the Harvard Graduate School of Business Adminstration in 1943. He came to RCA in July, 1943, where he worked on the staff of the General Manager of Manufacturing. Since that period, he has held the following positions: Systems and Organization Analyst, RCA Victor Division; Assistant to the General Plant Manager, Tube Division; Assistant to the Vice President, Tube Division; and in June, 1953, was appointed Administrator, RCA Organization Planning.

Mr. Mastran is a member of the Advisory Council on Organization Planning of the National Industrial Conference Board and is a guest speaker for courses conducted by the American Management Association. He is a member of Beta Gamma Sigma, National Honorary Business Fraternity, and Alpha Kappa Psi.

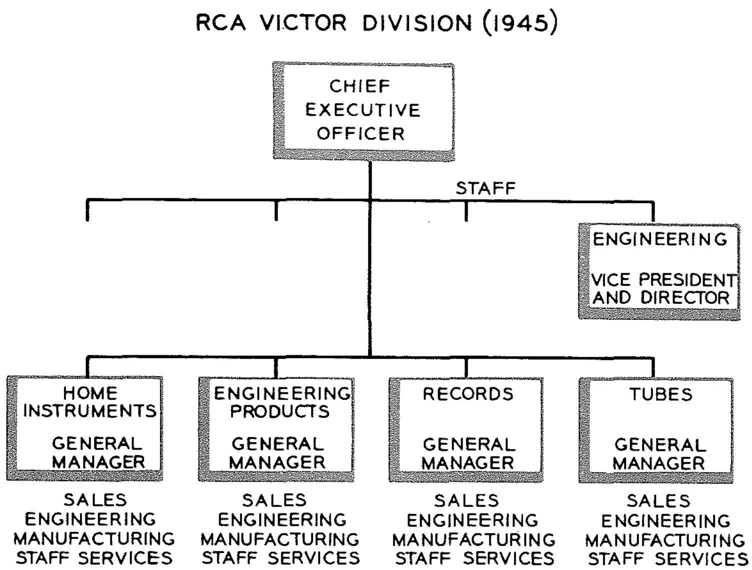


Fig. 2—As shown above, the 1945 realignment resulted in four separate product organizations.

The Tube Division in the Fall of 1953 realigned its functional organization into product marketing and product operations departments. In October, 1955, plans were announced that contemplated the expansion of the Tube Division into three operating divisions — Tubes, Semiconductors, and Component Parts. On December 1, 1955, a separate Semiconductor Division was established.

DEFENSE ELECTRONIC PRODUCTS ORGANIZATION

In order to explain in more detail the organization structure of a decentralized unit, it may be well to outline, as an example, the structure of the newly established Defense Electronics Products unit.

In January 1956, the Defense Electronic Products organization established a top structure as shown in Fig. 3. Two of the departments in this organization, namely, West Coast Electronic Products Department in Los Angeles, and the Missile and Surface Radar Department in Moorestown, N. J., are virtually self-sufficient businesses; two departments, namely, Airborne Systems Department and Surface Communications Department are semi-autonomous in that each receives certain line services from the Defense Production and Defense Engineering Departments because of their common location in Camden. The Chief Engineer of Defense Electronic Products is responsible for providing overall engineering guidance, coordination, and common engineering services that are so necessary in achieving most effective engineering effort for the four decentralized engineering units. The other activities reporting directly to the Vice President and General Manager also provide staff services to the entire Defense organization.

In this organization alignment, the Vice President and General Manager of Defense Electronic Products has delegated to specific managers, the authority and responsibility to manage major integrated segments of his responsibilities. For example, the West Coast Electronic Products Department Manager is responsible for the engineering, purchasing, manufacturing, and marketing of specific products assigned to him. All functions in this organization on the West Coast have been brought together for the first time under one manager who can provide the leadership and direction to mold these functions and managers into an effective and profitable unit for Defense Electronic Products and RCA. Now, positive action can be taken and operating decisions made on the spot on the West Coast.

ADDITIONAL CHARACTERISTICS OF DECENTRALIZATION

The success of setting up self-contained decentralized organization units has been well demonstrated during the past decade in RCA. However, it must be pointed out that when a Corporation decentralizes, it also must establish a qualified central staff organization to guide, coordinate, and advise the decentralized units effectively. This overall staff is needed to assure that the individual unit's objectives and operations are in accord with overall objectives of the Corporation.

This central staff must prevent wasteful duplication and assure that the efforts of all units are integrated to produce a product or service that is competitive and profitable. For example, in the development of RCA's color television system, it was necessary for a central engineering staff to coordinate the engineering effort of almost every product group within the Corporation (receiving tubes in Harrison, components in Camden, kinescopes and camera tubes in Lancaster, receiver circuits in Cherry Hill, broadcast studio and transmitter equipment in Camden, etc.)

When the RCA Victor Division was reorganized in 1945, the definite need for a central staff was emphasized and established. Later in January, 1954, when the Victor Division staff was integrated with the staff in the RCA Executive Offices, the resulting RCA Staff was made an integral part of the new organization. As an example, in engineering today there is a Vice President in charge of Engineering Services. This organization includes a Vice President, Product Engineering, responsible for providing information and advice to RCA's top executives on product engineering matters, for solving critical and difficult engineering problems especially those involving more than one product division, and for providing leadership for product engineering groups.

Another aspect of decentralization is the requirement that high caliber business managers must be available to administer adequately the decentralized units. Also, in decentralizing, additional costs are generally incurred since some functions are duplicated. However, frequently a newly established function can more than offset its initial costs by contributing to greater overall efficiency. A Corporation which has outgrown its functional organization structure can make the transition profitably to a decentralized operation despite some additional duplication of facilities and functions.

Decentralization creates additional opportunities, product leadership, team spirit, closer coordination and more cooperation because all persons working on one product line can be brought together as an organization unit. This concentration of effort on a single product or product line makes maximum use of the specialized talents available in a particular area of the business. It creates an organization structure that permits the achieving of peak performances in all functions; engineering, manufacturing, marketing, and administration. These features more than offset the disadvantages of decentralization.

INCREASED OPPORTUNITIES

One of the most important results of the great growth of the Corporation's activities has been the marked increase in the number of opportunities in the form of more responsible positions that have been created. For example, in the field of engineering, two new Chief Engineers' positions have been created in the past two months, one in each of the following organizations: Commercial Electronic Products and Semiconductor Division. In addition, many more responsible engineering development, design, and services positions have been established. Many of the people in these postions are now closer to the operating management and thus have greater opportunity to become more proficient and rounded in performing their duties.

Not only are the opportunities increased many fold in all engineering functions, but RCA engineers are contributing importantly in all levels of management—Executive, Administrative, Research, Sales, Marketing, and others. In the past several months a significant number of the top level management positions that were established in RCA's product units were filled by people with engineering backgrounds. For example, the following are a few of the positions filled by engineers: General Manager, Semiconductor Division; Manager, West Coast Electronic Products Department; Manager, Surface Communications Department; and Manager, Missile and Surface Radar Operations.

OTHER RCA ACTIVITIES

Although this article is confined to product divisions, it is appropriate to point out that the organization philosophy already explained applies equally well to the National Broadcasting Company, Inc.; RCA Service Company, Inc.; RCA International Division; RCA Laboratories; and other RCA major operating units. Each of these RCA activities has grown greatly in the past ten years, and each has had to make organization changes in order to continue to manage and administer its operations more effectively.

CONTINUOUS ORGANIZATION PLANNING

When one realizes that throughout RCA there are approximately 6,000 managerial and administrative positions and ten levels of organization between the President of RCA and the first supervisory level in some units, one can appreciate the great and constant need to institute organization structure changes carefully and wisely.

Organization Development Administrators are located in all organization divisions, subsidiaries, and plants of RCA to assure that the best organization structure is being utilized. Each Administrator assists and advises management personnel whenever organization changes are contemplated. These Administrators consult with each manager contemplating structure changes and assure that the proposed changes are in accordance with sound organization planning practices and RCA organization policies. A straightforward objective approach is taken, and changes made are consistent with the operating objectives of the unit.

Studies are being made by Organization Development Administrators in analyzing and developing new ideas and theories in organization structure. More effective ways for organizing, managing, and administering are being made. As much care and attention must be given to "engineering" our organization structure as to engineering our products.

As an example, the recent realignment of the Engineering Products Division was undertaken only after a comprehensive study extending over a two-year period. Many managerial and key administrative personnel in EPD and elsewhere in RCA were interviewed and detailed analyses of all aspects of EPD's business, both current and future, were completed before the final recommendation was reached.

CONCLUSION

In summary, it is RCA's policy to analyze and plan its organization carefully so that necessary changes may be made that are consistent with both short and long range objectives. Organization structure changes properly planned and implemented are important not only to the business as a whole, but also to the most important asset of the Corporation—its people. The recent growth of RCA in sales, products, and services has necessitated organization changes that have resulted in making more positions of greater responsibility available in almost all functions and at all levels.

DEFENSE ELECTRONIC PRODUCTS ORGANIZATION (1956)

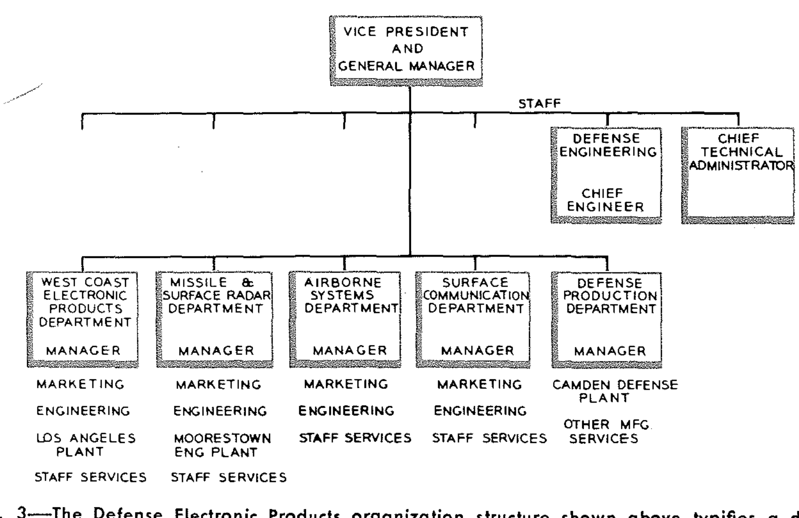


Fig. 3—The Defense Electronic Products organization structure shown above typifies a decentralized unit.

MECHANICAL ENGINEER'S ROLE IN DEVELOPMENT OF ELECTRONIC EQUIPMENT

by **L. JACOBS, Mgr.**
Mechanical Engineering
Missile and Surface Radar
Defense Electronic Products
Moorestown, N. J.

IN AN EARLIER issue of the RCA ENGINEER (Vol. 1, No. 2), T. G. Greene and P. C. Harrison described "The Role of the Mechanical Engineer in Electronic Equipment Design." They traced the development of Electronics from the "dawn of the era" when the inventor was not only a combination mechanical and electrical engineer, but also a draftsman, model maker and production engineer, to today's multi-billion dollar business where, due to the vast increase in complexity of the product, a high degree of specialization has evolved. They described many of these complex technical problems and revealed the important part the mechanical engineer plays in solving them.

It is the purpose of this article to further illustrate the role of the mechanical engineer in the electronics industry by describing his function in the *development* of electronic equipment. It is expected that future papers will appear in the RCA ENGINEER which will describe additional activities including specific design techniques.

MECHANICAL DEVELOPMENT DEFINED

In the electronics industry we think of design engineering as the process of creating a new product using known techniques, parts and materials. The design engineer is creative in the manner of the architect who, working on the design of a skyscraper, conceives the basic plan, makes the stress calculations and, with the aid of draftsmen, prepares the drawings from which construction may proceed. The building industry is an old one and the techniques, parts and materials have developed slowly. An architect rarely comes across a problem during the course of design that may stop the job competely or alter the plans radically.

However, in the new field of electronics, frequent changes are to be expected. A new product could hardly compete in today's market if it did not include many ideas that are basically new. Not only must new arrangements be provided, but frequently new concepts are necessary, new materials must be developed, and new techniques discovered. It is in facing these hitherto unsolved problems that the mechanical engineer assumes the initiative in further development work.

Webster's dictionary uses these apt phrases in defining the word *develop:* ". . . to unfold more completely; to evolve the possibilities of . . ." The mechanical engineer does just this!

In a particular design, it may not be possible or practical to achieve the desired end product with existing techniques. The television tuner is a good example of this, inasmuch as it does not employ conventional broadcast receiver design. While ease of operation and high reliability are essential in the end product, low cost and simplicity of manufacture are also required to maintain our position in today's highly competitive market, and here again the mechanical engineer has large responsibilities.

Another aspect of the development problem faced by the mechanical engineer is the implementation of new electrical or mechanical principles into practical operating devices. When the research laboratories developed magnetic tape, the mechanical engineer started his own development program. We see the results today in tape recorders for sound and soon we shall see the tape recorder for video. Mechanical development problems already solved for constant speed control in the audio recorder are now increased many times in the video version.

COMPONENT DEVELOPMENT

Aside from the ever-present problem of developing parts that are simpler to make and cheaper to buy, the mechanical engineer has to meet the increasingly stringent requirements of the armed services specifications. Greater reliability is the "number-one" requirement. For the mechanical engineer working on component development, this means material analysis, selection, standardization, and performance testing to assure reliable operation under varying temperature, humidity, and corrosive atmospheric conditions. It means development of accelerated tests to simulate wear, varying load conditions, shock, vibration, and mishandling. In addition, he is constantly striving to develop lighter and smaller parts that will operate over a wider temperature range.

The electromagnetically operated clutch is a typical product in which all these development parameters are met. This device is available in many forms; toothed, dry friction, dry powder, magnetic fluid, and hysteresis types. The development of these clutches for rapid start-and-stop applications with high-inertia loads on the one hand, and continuous slipping under constant torque conditions for speed control on the other, represent the two extremes of the application. Varying duty cycles and load conditions dictate widely different clutch requirements. The chief development problems are those brought on by heat and wear. In servo system applications, a linear relationship between slip torque and actuating current is important.

An example of such a clutch development at RCA is one used in an airborne communication equipment where rapid, remote tuning over a wide-frequency range was required (see Fig. 1). About six years ago, at the time development was started on the equipment, the principle of the magnetic fluid clutch was announced. It was found that a magnet, placed in a suspension of fine iron particles in oil, caused this suspension to adhere to the magnet and "freeze." The clutch, in principle, consisted of an iron rotor moving in the field of an electromagnet with the iron in oil suspension filling the air gap. Slip torque was found to be almost a linear function of exciting current and independent of rotational speed. High torque-to-inertia ratio, low operating power, low wear and smooth operation made this clutch appear most promising for this tuning application. But the first clutch built for this equipment quickly failed. Starting and stopping the relatively high-inertia tuning device at the required

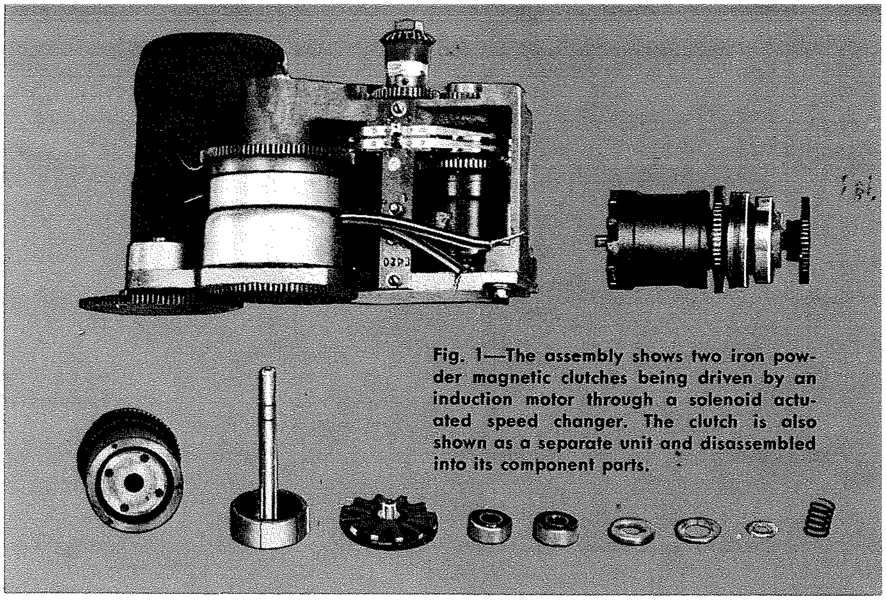


Fig. 1—The assembly shows two iron powder magnetic clutches being driven by an induction motor through a solenoid actuated speed changer. The clutch is also shown as a separate unit and disassembled into its component parts.

frequent intervals created so much heat in the clutch that the oil evaporated and decomposed, the iron particles oxidized, and the insulation on the wire of the energizing coils deteriorated; iron particles got into the bearings and quickly ruined them. A development program was undertaken to provide a clutch that would more rapidly dissipate heat, and to find fluids and magnetic powders that would be more stable at high temperature. Oils of all kinds, particularly the silicones, were tested for stability at high temperatures. Iron powders of many different alloys were tested to find one that would not oxidize so readily even at the expense of some reduction in permeability. A setup was prepared to test clutches under accelerated life conditions. With a representative inertia load attached, the clutch was made to drive and then reverse periodically. Tests were run at the temperature extremes.

Back at his desk with his sketch pad, the engineer worked on designs to reduce the hot-spot temperature and improve heat dissipation. He also investigated means for preventing the iron powder from getting into the bearings. Seals made from felt and synthetic rubber, as well as from precision graphite and hardened steel, were tried. Labyrinth and magnetic traps were also employed.

Out of this investigation came one very surprising but gratifying result—dry iron powders could be used just as well as those suspended in oil. This eliminated one series of problems but introduced another one. The dry iron powder had a tendency to pack. Further investigations revealed that one particular type, with consistency as fine as talcum powder, had properties approaching that of a fluid and would not pack. The problem of iron particles in the bearings was solved principally by using a design in which the clutch was so orientated in the operating position that the bearings would be above the level of the powder. During transportation and storage, when the shaft is not rotating, standard seals proved adequate to keep the iron out of the bearings.

HEAT TRANSFER EQUIPMENT

To the mechanical engineer just out of school, heat transfer is associated with boilers, condensers, home and industrial heating systems, and various chemical processes. It is also related to internal combustion engines, turbines and other power generating equipment. However, he is rarely aware that it is very much a part of the development of electronic equipment. In this field, heat is generally an undesirable by-product. The mechanical engineer must remove the heat with a minimum of increased size, weight, and cost to equipment. In high-power broadcast transmitters, some tubes are cooled by high-velocity air flowing over copper fins. Others are cooled by water circulating in a jacket around the tube. The cabinets containing the low-powered tubes and other components are cooled by forced air circulating through them. These are relatively straightforward design problems and there is a minimum of development work associated with them. This is far from true in many other cases, particularly in military electronics. Let us consider some of these.

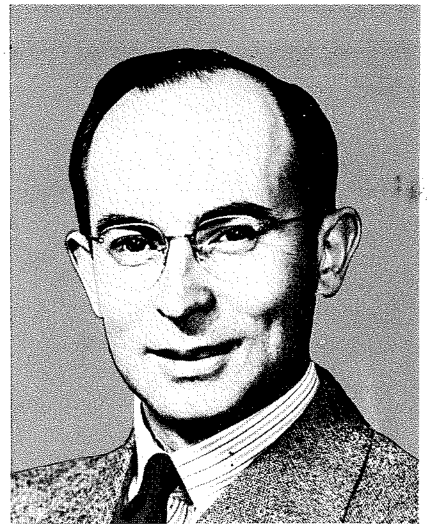
AIRBORNE COMMUNICATION — In rarefied atmosphere the spacing required between high-voltage points and ground becomes so large that it is frequently impossible to design an equipment, cooled by low-pressure air, that is of practical size and weight. Therefore, in developing electronic equipment for operation at very high as well as low altitudes, it is often necessary to enclose the chassis in a case that can be pressurized. Boxing up this power in a small volume would create damagingly high temperature unless means were provided to remove the heat, with an air-to-air heat exchanger, that would operate well at both high and low altitudes. Since compactness and low weight are of prime importance in airborne equipment, the heat exchanger was designed as an integral part of the pressurized case. Basically, this design consists of three concentric aluminum cylinders with very thin aluminum corrguations brazed between them. The center cylinder forms part of the pressurized case. Hot internal air is forced between the corrguations connecting the inner and center shells. Because of the large surface area exposed to the high-velocity air and the high thermal conductivity of aluminum, heat is transferred to the corrugation separating the center and outer shells with a relatively small temperature drop. Outside air is forced between the center and outer cylinder to remove the heat. This required the development of a blower that would provide, automatically, the larger volumetric flow needed at high altitudes to compensate for the poor heat-removing qualities of low-density air.

MOBILE AND PORTABLE COMMUNICATION—A mobile communication equipment, say for a jeep, is often made up of a number of small units mounted together on a shock-absorbing frame. This allows rapid interchangeability and versatility. Units can be interchanged for operation at different frequency bands, and it is easy to rearrange them to fit another vehicle or for a different configuration. Since space is at a premium, high heat-dissipating parts are packed close together. Water-tightness is generally a specification requirement, so ventilation is impossible. Heat exchangers of the type described above are impractical because of the small size of the units. An approach to the solution of this problem is to transfer the heat by metallic or liquid conduction to the case, where normal convection currents or a conveniently mounted fan can do the rest of the job. While considerable work has been done on this problem, the surface has only been scratched. The problem is complicated by the fact that good heat transfer from a heat-dissipating component to a metallic conducting medium is dependent upon intimate contact between the two. This condition is difficult to achieve since the means of achieving it are not compatible with those essential to quick and easy replacement of defective parts.

RAM AIR COOLING—In a project recently completed, there was no room in the plane for some new electronic equipment. It was decided to build it into a streamlined pod and suspend it from the wing. Here also pressurization was required. But a different approach was taken to supplying the external cooling air. Instead of providing a blower capable of handling the large quantity of external low density air, advantage was taken of the fact that the pod was exposed to high-velocity air. The ram principle was used to compress the air and supply it into a heat exchanger that was much smaller and lighter than could be possible by operating directly with low-density air.

MICROWAVE SYSTEM DEVELOPMENT

The transmission of microwave energy from the transmitter to the antenna and back again to the receiver, as required in every radar and communication link equipment, is done through waveguide (rectangular transmission line). In the course of its travels, the energy passes through and is operated upon by many specially designed, critical, complex, and precise microwave components. While these are essentially electronic devices, their performance is vitally affected by mechanical configurations. Development of such components requires close coordination between groups. Microwave



L. JACOBS—Mr. Jacobs, a graduate of Columbia University, received his B.S. in M.E. in 1937 and his M.S. in I.E. in 1938. He joined RCA in 1939 as a time and motion study standards engineer, and in 1942 began work on the development of manufacturing processes for components used in electronic equipment. In 1944 he joined the Engineering Division and became associated with radar in the mechanical designing of electronic units. He became mechanical design project engineer in 1946. This work in the specialized electromechanical field included the direction of the mechanical design of highly intricate systems for height finder radars and air search radars as well as automatic tracking radar systems and missile guidance systems. He continued as project engineer until 1952 when he was appointed Manager of Mechanical Engineering for the Missile and Radar Section.
Mr. Jacobs represents Missile and Radar Engineering on the Engineering Department Mechanical Coordinators Committee which resolves problems on mechanical standards, shop and drafting practices, design, and new products and procedures.

"plumbing" developments such as rotating joints, tunable cavities and rotating and nutating feeds are representative of projects confronting the mechanical engineer in this area. An example of the close teamwork between the electronics engineer and the mechanical engineer is the development of a new rotating feed. The electronics engineer recently completed testing his "breadboard" version of this feed, which exhibits exceptionally good electrical properties and much higher power-handling capacity than any of its predecessors. Now, the mechanical engineer must develop this into a practical device for tactical equipment and he has some real problems. The insulating material most desirable electrically has a high coefficient of thermal expansion but it must be in intimate contact with metal which has a relatively low coefficient of expansion. The configuration is such that ordinary machining techniques cannot be used. The location of the added masses to maintain dynamic balance under high rotating speeds is severely limited because of the probable interference with the microwave beam. None of these problems is insurmountable, but heavy developmental effort will have to be applied before a practical feed is available.

ANTENNAS

In the field of radar antennas (see Fig. 2), the mechanical engineer finds limitless development opportunities. In search-radar applications we have large structures—some in excess of sixty feet, rotating constantly—on the alert to detect enemy aircraft or surface vessels. The antenna may tilt to search a broader expanse of sky. It may be mounted on a stabilized platform, for naval vessel installation, to maintain a precise vertical reference in spite of the ship's rolling and pitching motion. Once the target is located and designated, the tracking radar takes over. Its precision antenna tracks the target automatically while the radar's computer directs guns or missile launchers to the optimum firing position. These antennas must take a terrific beating from the elements and yet continue to provide accurate information to the radar system.

ANTENNA REFLECTORS—A radar antenna generally consists of a microwave feed source directed into a reflector that is usually made as a paraboloid or some variation of it. The electrical engineer specifies the equation of curvature with permissible tolerances and general configuration. Maximum size openings in the reflecting surface are also given, but the rest of the job is up to the mechanical engineer. The antenna must be designed for low weight, low inertia, and high resistance to corrosion, shock and vibration. Rotational forces due to wind load must be reduced to a minimum. Structural analyses to determine natural frequencies of vibration, deflection, and stress concentrations are made. Analytical and graphical techniques have been developed to predict wind forces and double checks are made with scale models in wind tunnels or full size models in open road truck tests. Servo-power equipment to rotate antennas is large and costly and accurate prediction of driving torques is essential.

ANTENNA DRIVE PEDESTAL — Greene and Harrison, in their introductory paper, covered many problems with which the mechanical engineer is faced in the design of antenna pedestals and now I should like to describe several development problems that appeared in the course of design. One of these was slip rings. For a particular antenna pedestal, the number of slip rings required was so large that, with conventional construction, the pedestal base would have been disproportionately large and accessibility to the slip rings for servicing would have been poor. A new concept, perceived by others outside RCA but never put into practice, was considered. This device, known as the Segmented Slip Ring Assembly, consisted of 1) an insulated disc with the required number of contact segments mounted on the periphery, fixed with respect to the pedestal base, 2) another insulated disc and contact segment assembly fixed with respect to the rotating turntable that carried the antenna and 3) an arrangement of interconnected brushes, placed between and in contact with both segmented discs, and caused to rotate at half the speed of the turntable. A reduced scale model was made to test this principle and determine the bugs. Brushes of various materials and contact pressures were tried; and contact segments and insulating supports of different materials were also studied. Measurements were made of contact resistance, current-carrying capacity, wear, noise, ripple, cross-talk and pick-up. Simulated life tests were run. It was discovered that, with the arrangement of the three major components described above, the brush assembly was fragile, accessibility to the brushes was poor, and proper alignment was virtually impossible. Another model was made with one brush assembly stationary on the base, another rotating with the turntable and the segmented discs rotating at half speed. Double instead of single brushes were used to overcome some contact problems. Life tests on the final design proved it to be a highly reliable device. Because of the compactness of this design it was readily possible to remove the slip ring assembly for servicing (See Fig. 3).

Another development associated with an antenna pedestal is a low-friction seal for a sixty-inch diameter bearing. Conventional seal techniques would have introduced intolerably high friction, particularly at

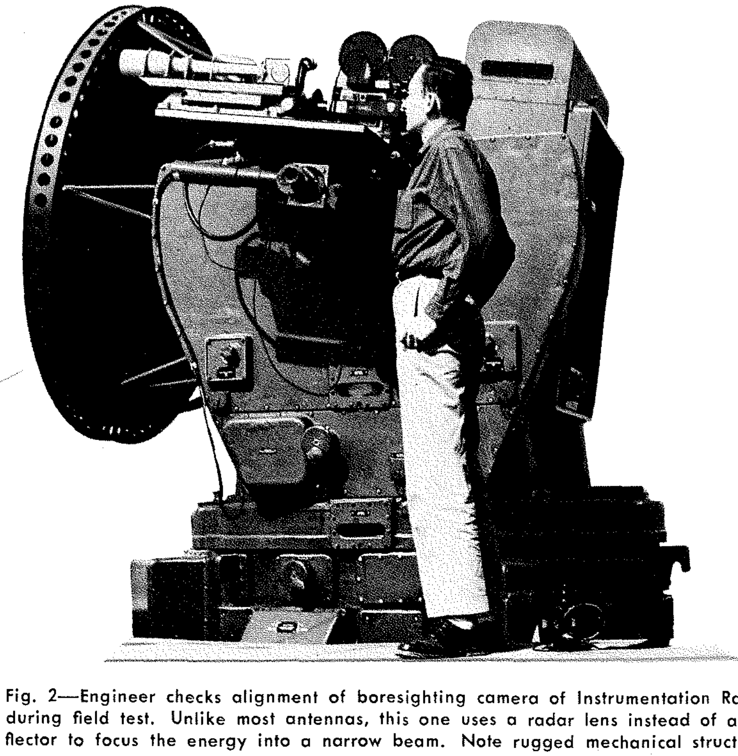


Fig. 2—Engineer checks alignment of boresighting camera of Instrumentation Radar during field test. Unlike most antennas, this one uses a radar lens instead of a reflector to focus the energy into a narrow beam. Note rugged mechanical structure.

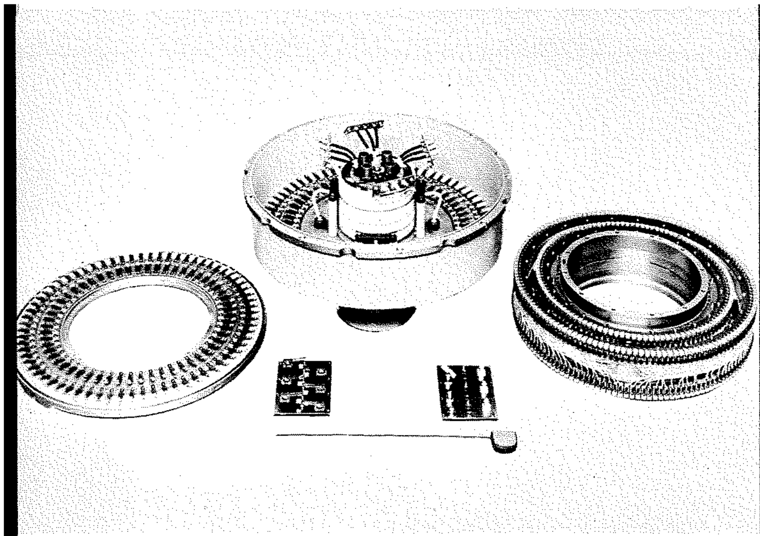


Fig. 3 — This novel slip ring assembly, utilizing a system for switching through segmented disk assemblies, permitted a much more compact design than would have been possible with conventional slip ring techniques.

low temperatures. While the unique design finally used looked good in principle when first put on paper, many detail features had to be determined with the aid of a laboratory model. Test apparatus was rigged up to simulate severe desert sand storms and long and varied tests were run before the final seal design was established. Sand is, of course, sure death to any bearing and it was essential that none get into this one, since it is very expensive and difficult to replace.

RADOMES—To reduce the problems of high-wind load and severe icing conditions on antennas, many radar installations are being made with the antennas operating in radomes. These are of two general types: 1) inflatable, made like a big balloon and under constant air pressure to keep it from collapsing, and 2) rigid, made from plastic materials and built something like an igloo. The inflatable type has been used for about five years and the many problems encountered in its development have not been fully solved. New high-strength fabrics must be developed to make the radome light enough for true portable applications; simpler erection equipment, and simpler anchoring techniques must also be developed.

The rigid radome presents problems in insulating materials and structures. Microwave signal losses in rigid radomes are quite high and the mechanical engineer, working with plastics specialists, must develop this type of radome considerably further before the inherent advantage of having a nice rugged house for the antenna can be realized.

POWER DRIVES — While electric motors have been largely used to drive antennas, there are many applications where hydraulic drives are better suited. This is particularly true in the high-power range where there is a significant weight advantage. Hydraulic servo drives also have more rapid response than the electric motor and are being used where such performance is of prime importance. Recent development in servo valves have made hydraulic drives particularly desirable (see Fig. 4). Mechanical engineering development of these components and their systems is considerably broadening the scope of the mechanical engineer's responsibility for electronic systems. This is particularly true of guided missiles.

In a particular application of hydraulic drives to a rapid fire anti-aircraft gun system, the effect of indexing the magazine was considered to be a possible troublesome factor. The force required to keep the gun tracking the target smoothly was small compared with the "kick" from the high-inertia magazine. Due to the non-linear nature of the disturbing force, analytical treatment was not practical. An experimental set-up was prepared to get the answer. (See Fig. 5.) The same hydraulic components to be used in the product design were set up on the hydraulic test bench and caused to drive a mechanism to simulate the inertia, compliance, backlash and friction of the gun mount and fire control system. In addition, means were provided to simulate the "kick" of the indexing magazine. Typical tracking runs were made, using a closed loop servo system, and the response measured. The results indicated that the proposed hydraulic system was practical for this application.

OPTICS*

Some fire control systems use electronics for range-finding purposes and for computation, but still depend upon optics for angle tracking. While the glass requirements are generally determined by an optics man who is usually a physicist, the development of the precision mechanisms to support, adjust, and control the glass parts is a mechanical engineer's problem. He develops techniques for presenting cathode-ray-tube images in the same field of view with the optical image and for superimposing radar pictures on maps. He is also working in the vast new field of color television where the division of light into its primary colors, and later recombination into one image, offers many challenging development problems.

SHOCK AND VIBRATION

Military electronic equipment is generally used in environments where commercial equipment would not operate or would fail after short service. Some of the toughest of these environmental conditions are those of shock and vibration. Shipboard gear should be designed to withstand any shock, short of that which would sink the ship. Unbalance in the ship's propeller creates continuing high amplitude vibration capable of damaging sensitive components in short order. Army field equipment must withstand rough handling, high drops from the tailboard of a truck, and long truck rides over rough roads with inadequate precautions taken to lash the gear. Airborne equipment is subjected to continuing vibration over a wide frequency range. There are also landing shocks and high acceleration under rapid maneuvering conditions. The two examples which follow will illustrate the range of development problems created by these environmental conditions.

STABLE LOCAL OSCILLATOR — Under operating conditions, the local oscillators in certain radar receivers are adversely affected by even very small vibratory forces. Therefore, it is necessary to mount such oscillators through vibration isolating systems

*See "Optical Engineering at RCA," by G. L. Dimmick, Vol. I, No. 2 Issue of RCA ENGINEER.

that provide a low natural frequency of vibration. However, it is also necessary for these relatively delicate components to withstand high shock forces incurred from rough handling and road transportation. Soft mounts would bottom under shock and the oscillator would receive high impacts that might cause severe damage. The mechanical problem centers about developing an inherently rugged oscillator structure and a low natural frequency vibration isolating system with built-in snubbing devices capable of absorbing shocks when excursions exceed the practical limits of the vibration mounts.

MISSILE-BORNE ELECTRONIC GEAR—Some of the present limitations to reliability in missiles are created by the damaging effect of vibration. The propulsion system creates vibrations covering a wide frequency range, 2-2,500 cps. This is far in excess of the 60 cps found in propeller-driven aircraft and the 500 cps of the jets. Since we are dependent upon meager telemetered information for the magnitude and frequency at different locations on the "bird," it is very difficult to design for it. Much more experimental and analytical work must be done to fill in the gaps of our knowledge. Even with more information, the problem would be great because, with such a broad frequency band, it is impossible to design the structures to avoid all resonances. One trend is toward the development of materials and then structures, with inherently high damping coefficients. This area of development is just now being opened up.

OTHER DEVELOPMENT FIELDS

Due to space limitation, this paper treats only a few representative development problems with which the mechanical engineer is concerned in electronics. Some others, not previously described, but also requiring concerted mechanical development are: 1) UHF and VHF Television Tuners, 2) Automatic Record Changer Mechanisms,* 3) projectors with emphasis on intermittent mechanisms for film drives, 4) card punching and sorting machines for business type computers, 5) high-speed devices that convert electronically coded signals to printed characters, 6) automatic machinery (see Fig. 6) that fabricate printed wiring boards, assembles and solders the components and then tests the final product, and 7) automatic machinery for the manufacture of color kinescopes.

SUMMARY

Aside from primary power generation, there is hardly a basic course of study in the mechanical engineer's education that he does not apply in the development of electronic equipment. Even his knowledge of the power field is occasionally called upon to aid in the selection of primary power supplied for mobile fire control gear and fixed station self-contained missile guidance systems. He is concerned with raw materials, their processing, properties, availability, and cost. He is concerned with a wide range of fabrication techniques and is constantly looking for new ones to make his parts better and cheaper and to do things in ways hitherto impossible of accomplishment. On specific designs he develops structures, housings, precision mechanisms both small and large, and applies statics and kinematics where required to obtain the desired results. At first glance, fluid dynamics seem far removed from electronics, but actually there are important applications in lubrication and hydraulic drives. Thermo-dynamics is used for many and varied heat transfer problems on all electronic equipment. Optics, too, while more limited in application, is an extremely important part of certain special electronic equipment. Mathematics is, of course, the universal tool of all engineers and the mechanical engineer, well versed in the subject, is much better equipped to handle the development problems with which he is faced. However, the mastery of these subjects is only one factor in the successful role of the mechanical engineer in the design and development of electronic equipment. Other major ones are: 1) the ability to visualize new concepts, 2) the ability to apply practical knowledge properly, and most important, 3) the ability to work in close team fashion with other engineers.

*See "New Slide-O-Matic Victrola Attachment," by E. S. Maris; RCA ENGINEER, Vol. I, No. 2.

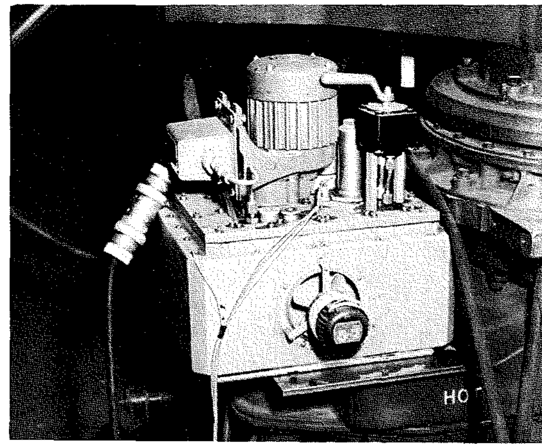


Fig. 4—An experimental hydraulic servo drive unit is shown attached to an antenna pedestal normally driven by an electric servo system. The characteristics of this hydraulic system will be determined by extensive laboratory tests.

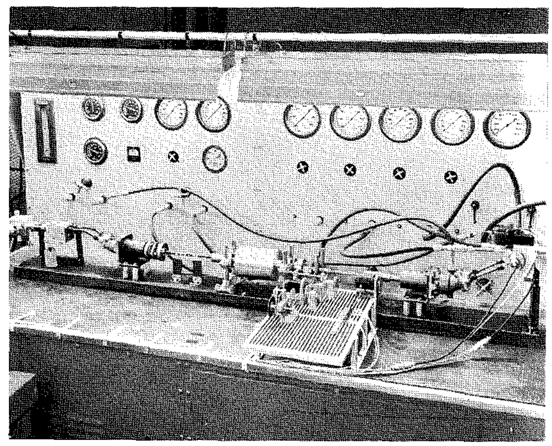
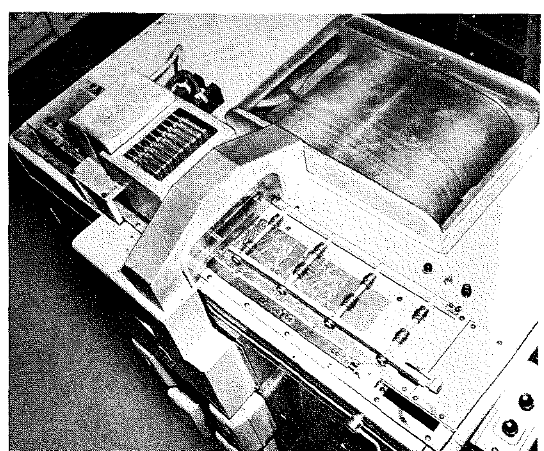


Fig. 5—This typical hydraulic power drive test setup includes the servo valves and hydraulic motors that will be used in the final product design. Driven by the motor are devices to simulate inertia, compliance, friction, backlash and certain nonlinear actuating forces that will occur in the final product.

Fig. 6—The machine illustrated here was developed to punch holes in a printed circuit board, automatically, in accordance with the intelligence supplied by a perforated tape. Any pattern can be punched, within the size limitation of the machine, provided spacing is in increments of .100 inches.



The author in the process of producing an experimental printing plate via the techniques described in this article.

RCA ELECTROFAX IN THE GRAPHIC ARTS[1]

by
M. L. SUGARMAN, JR.
RCA Laboratories
Princeton, N. J.

IN THE PAST few years rapid strides have been made in the new field of electrophotography, or electrostatic photography. Practical achievements thus far promise to furnish valuable supplements to silver halide and other photosensitive materials now used in continuous tone photography, office copying and duplication, photo-engraving and other photo-resist applications, and in many other fields. The best known systems until recently have been "Xerography",[2] which utilizes a photoconductive selenium coated plate as the photosensitive element, and "onset" or "smoke" printing[3] in which the electrostatic image is created by light falling on a thin metallic film under the influence of a strong electric field.

The electrophotographic printing system known as "Electrofax", developed at the RCA Laboratories in Princeton, was first publicly described in the December, 1954 issue of the *RCA Review*.[4] This initial paper covered the fundamental Electrofax printing process, particularly as it applies to direct photographic reproduction on specially coated paper.

The present article will review briefly the characteristics and operation of the basic Electrofax process as described in that paper and will present some additional experimental applications of the system to the production of high speed photo-offset (lithographic printing) plates, letterpress (relief printing) plates, photographic transparencies, and other graphic arts embodiments.

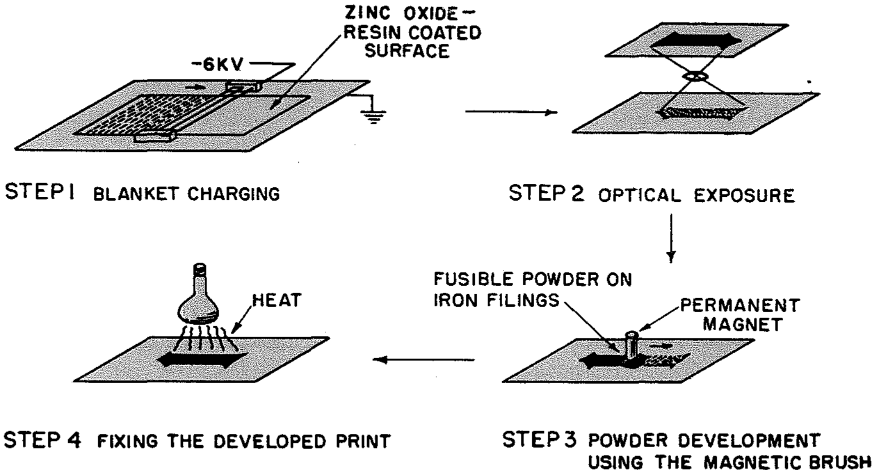


Fig. 1—Electrophotographic printing by the Electrofax process.

The basic Electrofax process for producing fused resin images is the same for all applications described below. The photo-sensitive element is a photoconductive coating consisting of a special zinc oxide in a resin binder. This film may be handled freely in ordinary room light or daylight until electrically charged, but attains high optical sensitivities suitable for either contact or projection printing after a simple electrical charging operation. All essential materials are relatively inexpensive and easily obtainable. The image may be comprised of any material capable of being converted to a powdered or granular form, but is usually a fusible pigmented resin composition. Images may be produced in any color. The process of producing the printed image is completely dry and takes only a few seconds. Both coatings and images are extremely stable, possessing indefinite shelf life both before and after printing.

Fig. 1 outlines the simple steps involved in producing a print. These steps are the same regardless of the base material on which the zinc oxide-resin mixture may be coated.

A uniform electrostatic charge is first placed on the surface of the photoconductive zinc oxide-resin coating, using an array of fine wires at about 6000 volts d-c under which the coated surface is passed in the dark or under suitable safelight conditions. A grounded plane is normally established on the reverse side of the coated surface. This operation is illustrated in Fig. 2.

Next the charged surface is exposed to an image of the material to be reproduced. The charge flows away in each area of the surface in proportion to the amount of incident light, thus leaving a continuous-tone electrostatic image corresponding to the dark areas of the original.

The negative charge image is now developed by dusting with a positively charged powder. Several methods are possible for charging and applying the powder. In the preferred Electrofax

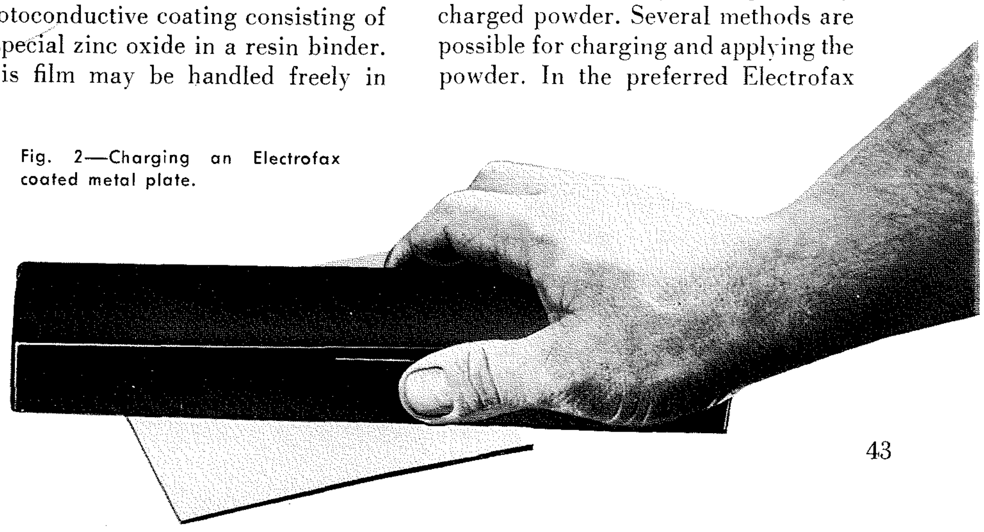


Fig. 2—Charging an Electrofax coated metal plate.

[1]Based on a paper presented at the seventh annual meeting of the Technical Association of the Graphic Arts, Boston, Massachusetts, May 9, 1955.

[2]R. M. Schaffert and C. D. Oughton, "Xerography, A New Principal of Photography and Graphic Reproduction", Jour. Opt. Soc. Amer., Vol. 38, pp. 991-998, December 1948.

[3]William C. Heubner, "Progress in Pressureless Printing", TAGA, Proc. of the Fourth Ann. Tech. Meeting, pp. 31-36, May, 1952.

[4]C. J. Young and H. G. Greig, "Electrofax"—Direct Electrophotographic Printing on Paper, *RCA Review*, Vol. XV, No. 4, Dec. 1954.

RCA ELECTROFAX

continued

method, a so-called "magnetic brush" is simply rubbed across the exposed surface to create the image, as shown in Fig. 3. This "magnetic brush" consists of "bristles" of powdered iron particles (following the magnetic lines of force from a bar magnet) carrying a special thermoplastic developing powder so compounded as to acquire a positive electrostatic charge upon contact or friction with iron. The strong attraction of the negative latent electrostatic image attracts the positive developer powder from the iron surface in proportion to the amount of charge in a given area of the zinc oxide-resin coated surface, forming a continuous tone positive-to-positive image of the original. The iron carrier remains on the parent magnet.

Photographic reversal (in which black areas of the original appear as white on the Electrofax print, and vice-versa) is possible by several techniques, such as use of a powder which acquires a negative charge upon contact with iron.

As a final step, the developed powder image is normally fixed by heat fusing. Alternate methods, such as solvent vapor softening of either the powder image or the photoconductor binding resins, or both, may be used for fixing. The heat fixing operation does not destroy the electrophotographic properties of the coating, thus allowing additional Electrofax printing at any time.

PHOTOGRAPHIC CHARACTERISTICS

The sensitivity and contrast of Electrofax coatings processed as above are about equivalent to a relatively high contrast silver halide photographic printing paper. Resolution obtained with a 200 mesh developing powder is of the order of 1000 lines per inch. This high resolution with a relatively coarse developing powder is attributed to an automatic selection of the finer powder particles by a high resolution charge image. The residual charge after a given optical exposure correlates closely with the measured reflection density of the developed image, as is shown in Fig. 4.

The intrinsic sensitivity of the white zinc oxide coating is primarily in the ultraviolet. Addition of certain dyes in preparing coating formulations will result in the appearance of an additional sensitivity region in the visible. Fig. 5 illustrates this effect.

Approximate exposures for Electrofax printing with various light sources are indicated in Fig. 6.

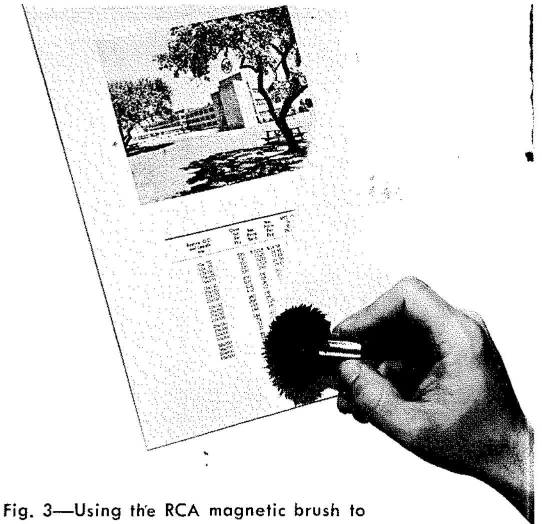


Fig. 3—Using the RCA magnetic brush to develop the latent electrostatic image.

LITHOGRAPHIC DUPLICATING MASTERS

Any Electrofax print may be converted to a lithographic offset duplicating master. Lithographic printing is based on the fact that water and grease are mutually repellent. On a lithographic offset duplicating plate, or master, background (non-printing) areas are made water-receptive and grease-repellent whereas image areas carry the greasy lithographic ink, transferring an ink replica first to rubber "offset" blanket, and thence to the surface to be printed. Among the well known office duplicators using this principle are the "Multilith" and "Davidson" machines.

In a normal Electrofax print, both the resin forming the base for the fused powder image and the resin binder in the zinc oxide-resin coating appearing in background areas are wetted by lithographic inks. The successful use of such a surface as a lithographic plate depends on the conversion of background areas of the print to a sufficiently hydrophilic (water-receptive) character to enable them to function as non-printing areas, while at the same time maintaining the grease-receptive character of the image areas, allowing the latter to carry and transfer grease-based inks. Several successful techniques have been developed to accomplish this conversion.

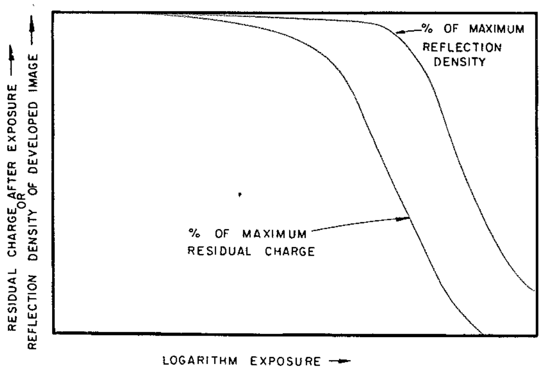


Fig. 4—Correlation between reflection density of a completed Electrofax print and charge values in the latent electrostatic image before development.

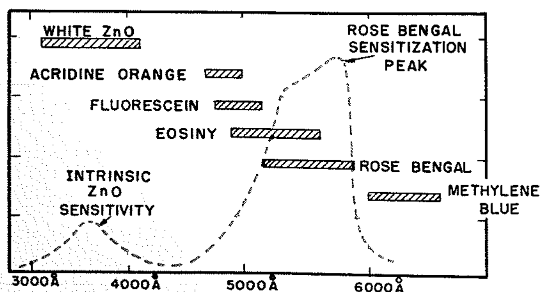
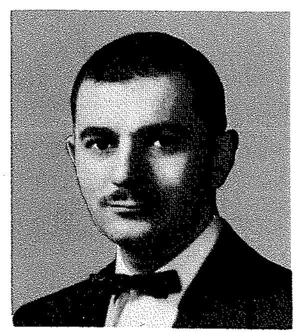


Fig. 5—Sensitivity regions added to Electrofax coatings by various dyes. Dotted curve represents the tungsten response of a typical rose bengal sensitized coating.

MEYER L. SUGARMAN, JR. received the B.S. degree in Chemistry from the University of Florida in 1939 and the M.Sc. in Physical Chemistry from Ohio State University in 1940. He served as a Field Artillery Officer, United States Army, from December 1940 to December 1945, attaining the grade of Major. He was recently promoted to Lt. Colonel, Chemical Corps Reserve.

After release from active duty, Mr. Sugarman worked in color photographic research at the Kryptar Corporation, Rochester, N. Y. from 1945-1948, and then at the Eastman Kodak Company, Rochester, as senior research chemist, infra-red photoconductors and filters from 1948-1952. Since March, 1952, he has been a research engineer, at the David Sarnoff Research Center, Princeton, working on photoconductive picture-forming devices and applications of the Electrofax process. Mr. Sugarman was the recipient of RCA Laboratories Achievement Award for 1954 for outstanding work in Research. He is a Member of Sigma Xi, the Technical Association of the Graphic Arts, and the Reserve Officer's Association.



LIGHT SOURCE	EXPOSURE CONDITION	TYPICAL EXPOSURE TIMES FOR A SATISFACTORY PRINT	
		UNSENSITIZED ZnO PAPER	ROSE BENGAL SENSITIZED PAPER
TUNGSTEN 100W BULB 2FT. FROM EXPOSURE PLANE	CONTACT THROUGH POSITIVE TRANSPARENCY	1/2 SEC.	1/50 - 1/25 SEC.
BLACK LIGHT TWO 4W FLOURESCENT TUBES 2FT. FROM EXPOSURE PLANE	CONTACT AS ABOVE	1/10 SEC.	1/10 SEC.
ELECTRONIC FLASH UNIT 10FT. FROM EXPOSED PLANE	CONTACT AS ABOVE	SINGLE FLASH 10^{-6} TO 10^{-5} SEC.	SINGLE FLASH 10^{-6} TO 10^{-5} SEC.
BRIGHT DAYLIGHT	ADAPTED CAMERA - LENS AT f4.5	1/2-5 SEC.	1/10 - 1/2 SEC.

Fig. 6—Approximate exposure requirement for Electrofax printing under various conditions.

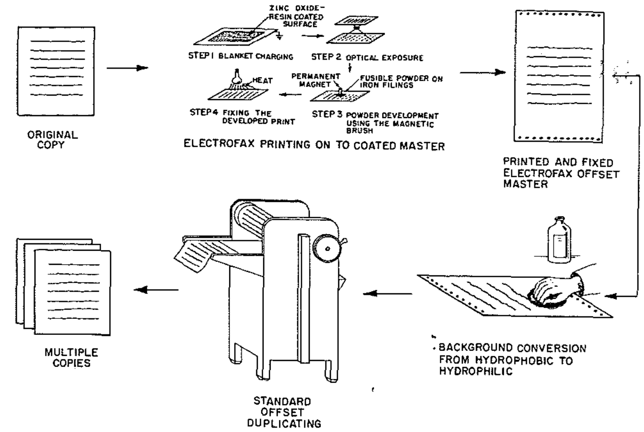


Fig. 7—Electrofax direct printing offset duplicating masters.

Ordinary Electrofax prints on a low wet-strength, light-weight low cost paper base material have produced over 1000 excellent ink-printed copies on a standard offset duplicator, using a simple swabbing operation to effect the background conversion as shown in Fig. 7. Coatings on thin metal stock or on a special wet-strength paper base also function well in this system.

Since continuous tone images are made up of discrete powder "dots", continuous tone offset reproduction is possible without auxiliary half-tone screening.[5]

A second method for producing lithographic plates is described below.

HIGH SPEED PHOTO-RESIST

In photoengraving operations, such as the making of relief printing plates (letterpress plates), engraved name plates, aperture masks such as the shadow mask in color kinescopes and the like, the etch resistant pattern used to mask desired areas of the surface to be engraved during the etching operation is normally produced by light-hardening of a specially sensitized glue, gum or resin coating, which is rendered insoluble by exposure to intense ultraviolet radiation. Official exposures normally are of the order of minutes to arc lights, with the coated surface exposed through contact printing with a specially prepared high-contrast film in a vacuum printing frame. After exposure, the unhardened coating is washed off in non-hardened areas. Similar photographically hardened coatings are used for other masking operations, such as in photolithography or the making of silk screens. Such operations are termed "photo-resist" systems.

If the Electrofax coating is applied in a thin layer to a suitable substrate and electrophotographically printed with an image comprised of a resin having different solvent characteristics from that used as the binder in the photo-conductive layer, the combination may form the basis for a high speed photo-resist technique, as outlined in Fig. 8. This method has been used successfully for the rapid production of relief and lithographic printing plates, silk screen stencils, printed circuit boards and many other items.

This Electrofax resist system possess light sensitivities of the order of 10,000 to 100,000 times those of dichromate or diazo-sensitized coatings normally used in photo-resist formulations, allowing exposures directly on pre-coated plates in a copying or process camera.

All the usual characteristics of Electrofax coatings including indefinite shelf life and insensitivity to light until electrically charged are maintained in these presensitized plates.

LETTERPRESS (RELIEF) PRINTING PLATES

Good quality relief printing plates have been produced using the photo-resist method outlined above. These include both line cuts (copy or illustrations comprised of line work, printed text, or solid areas only) and halftones on zinc, copper, and magnesium. A photograph of an experimental plate and a proof from this plate appears in Fig. 9. Fig. 10 is an actual impression from an experimental plate.

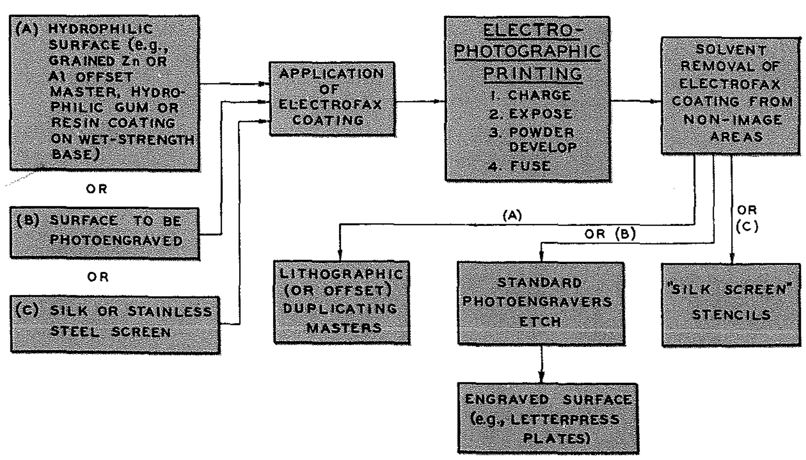


Fig. 8—Steps involved in use of the Electrofax high-speed photo-resist method in several typical applications. Similar techniques may be used for many other masking operations.

[5] "Half-tone screening" is the process of breaking up an image into dots of various sizes to enable reproduction of intermediate shades of gray or color in a printing process.

PRINTED CIRCUIT BOARDS

Printed circuit boards may be prepared quickly and easily by the Electrofax photo-resist method. In this case, a thin layer of the Electrofax photoconductor-resin sensitizer is applied to the surface of the usual copper-clad laminate (about 1 mil of copper cemented to a phenolic base), the circuit pattern is exposed onto the charged Electrofax coating by contact or projection, and the image developed with an acid resistant powder and fused in place, just as for other photo-resist applications. After removing the photoconductor resin coating in non-image areas by differential solvent action, the exposed copper film is dissolved away completely in these areas, leaving conducting paths only where the copper is protected by the fused Electrofax images. The etch-resistant image may finally be washed

Fig. 9—Zinc line-cut plate produced by projection printing from a 35mm microfilm original with a one-second exposure.

off with a second solvent, leaving an etched circuit pattern comparable with those produced by conventional slow-speed resist techniques.

By use of the above method, either experimental or production circuit units may be produced in a matter of minutes, with an enlargement or reduction if desired. No intermediate photographic transparencies are needed, as the resist image may be laid down by contact pointing from an actual size pencil or an ink drawing on a transparent or translucent base. If enlargement or reduction is desired, or the drawing is on an opaque base, projection exposure may be used.

Fig. 11 is a photograph of an etched circuit board produced by this method.

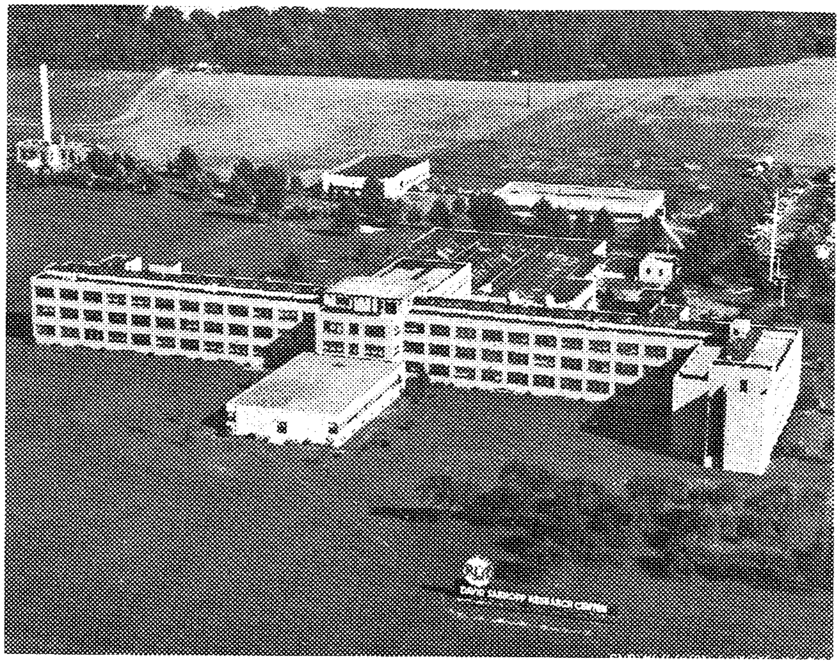


Fig. 10—Newspaper type (coarse screen) halftone printed from a metal plate produced using the Electrofax high-speed resist system. Fine screen reproductions suitable for magazine use are also possible.

ELECTROPHOTOGRAPHIC TRANSPARENCIES

If the Electrofax photoconductor-resin coating is coated on a transparent base, lantern slides, photographic films, or other transparencies may be produced therefrom by several techniques.

One obvious method of producing transparencies is the removal of both resin and photoconductor from background areas as described earlier. In an alternate method which has given excellent results, the zinc oxide is dissolved out of the fused powder printed photoconductive layer by use of a suitable reagent mixture, leaving the black or colored fused resin image on a transparent background composed of clear photoconductor binding resin.

SUMMARY AND CONCLUSION

The "Electrofax" system of dry photography furnishes a new set of tools for use in the graphic arts, capable of application to improvement and diversification of present techniques, as well as to development of completely new methods and materials. Effective photographic speeds are many thousands of times those available with present techniques and materials in the same cost range. A few typical proposals for practical use of this system have been outlined here. Many additional applications are easily visualized and are under investigation by the RCA Laboratories and by a number of other companies working under licenses based on RCA inventions in electrophotography.

ACKNOWLEDGMENT

The author gratefully acknowledges the fundamental contributions of C. J. Young, H. G. Greig, E. C. Giaimo, R. G. Olden, and others at the RCA Laboratories toward the work described in this article.

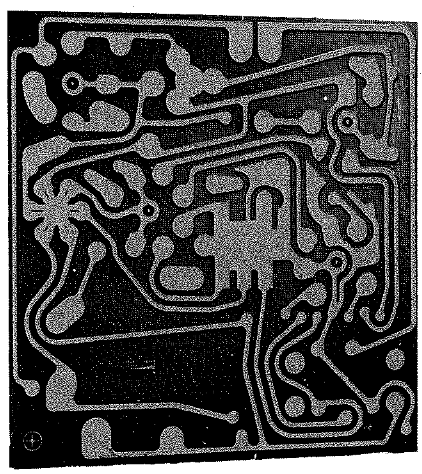


Fig. 11—A typical point-to-point etched wiring board produced by the Electrofax high-speed photo-resist technique.

HYBRID "POCKET" RADIO RECEIVER

By

KEITH E. LOOFBOURROW AND JOSEPH E. STOLPMAN

Semiconductor Division
Harrison, N. J.

THE HYBRID pocket or portable radio receiver represents an attempt to capitalize upon the advantages offered by transistors and at the same time to utilize vacuum tubes fully whenever they offer advantages.

The greatest problem in employing transistors in an all-transistor receiver is the relatively high cost of present commercially available transistors, especially the high-frequency types. Although considerable progress has been made to reduce the cost of the high-frequency transistors, such transistors are not as yet fully competitive with tubes on a cost basis. Those who are familiar with the technical problems involved in the design and use of i-f and converter transistors will realize that the hybrid receiver design has attractive interim possibilities. When the price of transistors approximates that of tubes, the portable hybrid set will then probably disappear. However, the hybrid pocket set can offer considerable engineering improvement as compared to the pocket tube set, particularly with respect to the battery power requirements.

POWER REQUIREMENTS OF PORTABLES

Analysis of the power requirements of a typical all-tube portable radio receiver indicates that approximately 75 per cent of the relatively expensive B battery power and 40 per cent of the less expensive A battery power is consumed by the output stage. The power amplifier stage of the "pocket"-type all-tube receiver uses approximately 60 per cent of the B battery power and 25 per cent of the A battery power, as indicated in Fig. 1.

The maximum power output of the all-tube pocket-type portable is 20 milliwatts versus 75 milliwatts of the hybrid version. Because of the relatively high percentage of power consumed in the filament circuit, full advantage cannot be realized from class B operation of tubes in the output stage. The transistor, however, may be used to full advantage in such an application. Because the filament power requirements are eliminated, the idling power requirements of a class B transistor output circuit are practically nil.

When transistors are used in the output stage of a portable receiver, a considerable savings in battery power can be obtained as shown in Fig. 1. It should be noted that the power for the transistor output is obtained from the A battery supply. The battery-drain figure given for the receiver using transistors is higher than that which would occur in normal operation because the power consumed by the output stage in class B operation varies with the signal level. The figures given represent continuous operation of the receiver at maximum power output under sine-wave conditions. Under conditions of normal speech and music, the average power consumption would be reduced to the values indicated by the dotted lines.

DESCRIPTION OF HYBRID PORTABLE

A circuit diagram of a hybrid pocket radio receiver is shown in Fig 3. The tube filaments, which are usually connected in parallel, are connected in series. Series connection permits the use of a common supply for both the transistor output stage and the tube filaments of the other stages of the radio receiver. It should be noted that no resistors are employed to maintain equal filament voltages because of the negligible battery current drain of the three remaining tubes. The oscillator-mixer tube is deliberately placed at the negative end of the series string so that the oscillator will continue to operate as the battery approaches its end point. The audio amplifier-detector stage is placed in the middle of the series string to facilitate the use of automatic volume control of the oscillator-mixer

KEITH E. LOOFBOURROW received his B.S. degree in Electrical Engineering from the Oklahoma Institute of Technology, Oklahoma A & M College in January, 1950.

Upon graduation, Mr. Loofbourrow joined the Application Engineering Laboratories of the RCA Tube Division, at Harrison, N. J. His work there included circuit development in the VHF and UHF regions. In 1953, he became a member of the Semiconductor Applications Laboratory, and since March 1955, he has been Manager of the Semiconductor Test Engineering Laboratory.

JOSEPH E. STOLPMAN received the B.S. degree in Electrical Engineering from Fenn College in Cleveland, Ohio in 1951. After graduation, he spent two years with Federal Telephone and Radio Corporation as an applications engineer on microwave communications. He joined RCA in June, 1953 as a member of the Application Engineering Laboratory of the Semiconductor Engineering activity in Harrison, N. J. He is currently in charge of applications engineering on commercial transistor types.

stage. A bypass capacitor is added to provide decoupling in the filament circuit.

The audio amplifier circuit is redesigned to provide for transformer coupling to the output stage and to provide adequate driving power for the transistor output stage. These requirements have caused the increased B-battery power consumption of this stage, as shown in Fig. 1. The sensitivity of the resulting audio system is equivalent to that of receivers using a subminiature output tube.

The transistor output stage necessitates the use of class B driver and output transformers. The design con-

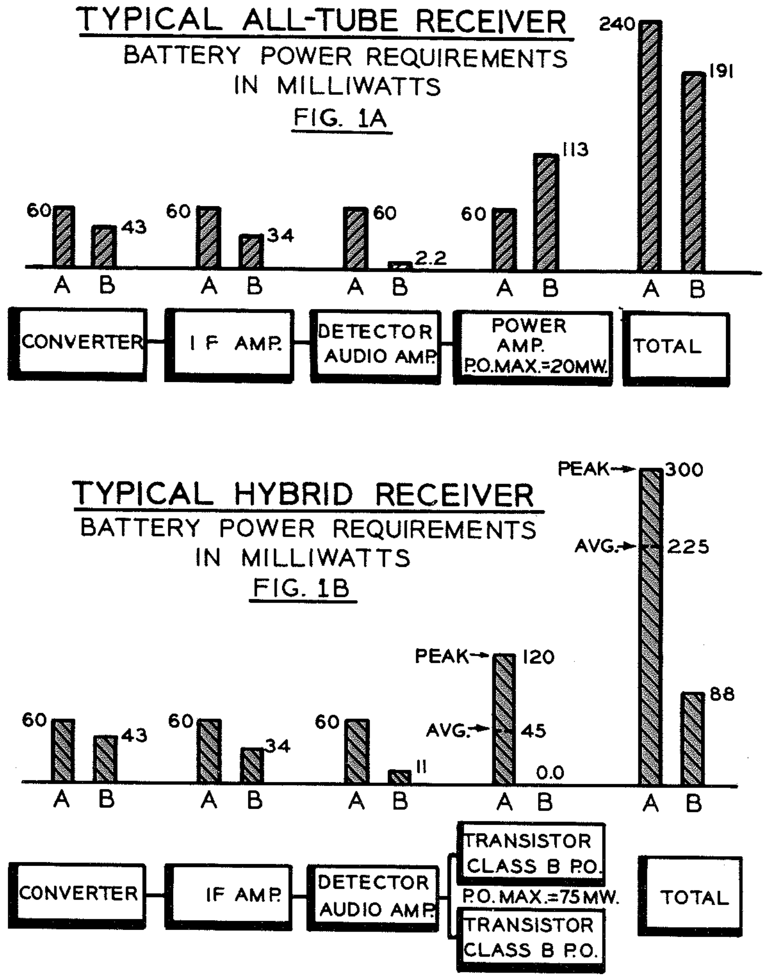


Fig. 1—Battery power requirements for a typical all-tube pocket receiver compared with battery requirements of typical hybrid pocket receiver.

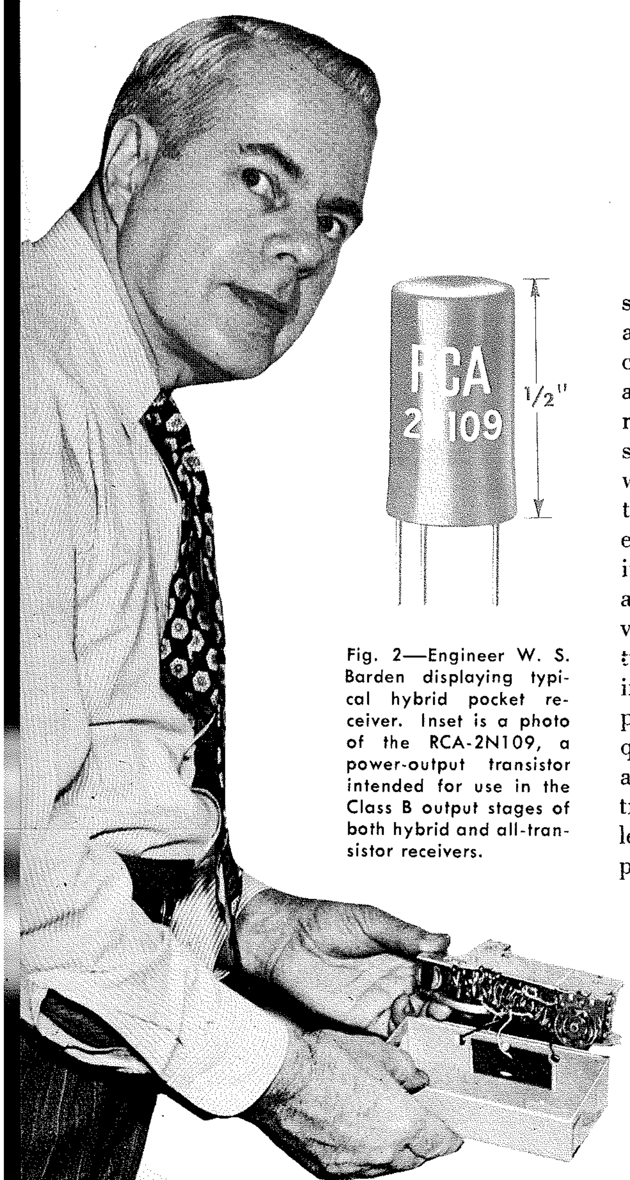


Fig. 2—Engineer W. S. Barden displaying typical hybrid pocket receiver. Inset is a photo of the RCA-2N109, a power-output transistor intended for use in the Class B output stages of both hybrid and all-transistor receivers.

siderations of a class B transformer are more exacting than those of a class A transformer. In order to achieve the same efficiency, the d-c resistance of a centertapped winding should be half that of a single-ended winding. This reduction is caused by the fact that the a-c impedance of each half of the centertapped winding is only one-fourth of the total a-c impedance, since a-c impedance varies as the square of the number of turns. Because of the high output impedance of the pentode audio amplifier tube circuit, the design requirements of the driver transformer are rather stringent. The output transformer, however, offers no problem. Because of the low output impedance of the transistor stage, the primary requires far fewer turns than an equivalent class A tube output transformer.

CLASS B OUTPUT STAGE

The operating point of the class B transistor output stage is determined by the 100-ohm and 3000-ohm resistors which provide a base bias voltage of approximately 0.15 volt. In this circuit the idling current per collector is approximately two milliamperes, and the idling power consumed by the transistor output stage is approximately 28 milliwatts. This value includes the 10 milliwatts consumed in the base bias network. Because of the temperature sensitivity of transistors, it is generally recommended that some form of temperature compensation be used in the bias network of many circuits using class B transistor stages. However, due to the relatively low-voltage, low-power dissipation involved in this

Editor's Note: In the new products section of Engineering News and Highlights two new transistors are announced and briefly described. One is for i-f stages and the other for converter stages of all-transistor radios.

particular circuit, and the cost of such a device, the elimination of the temperature compensation in this particular application can be justified both technically and economically. Distortion at low signal levels will vary inversely with temperature. A capacitor is connected across the input terminals of the output transformer. This capacitor limits the high-frequency response of the transistor output stage and also minimizes cross-over distortion.

OUTPUT STAGE PERFORMANCE

The transistor output stage has a power gain of approximately 30 db and has a maximum power output of approximately 75 milliwatts. The low-level distortion is somewhat greater than that found in class A circuits, but is considered commercially acceptable in this application. The high-level distortion is improved over that found in class A amplifiers.

The use of a class B transistor output stage in a "pocket" portable radio receiver using subminiature tubes effects a considerable savings in battery power consumption, provides sensitivity and selectivity equal to that of an all-tube pocket receiver, increases maximum power output, and improves distortion characteristics at high signal levels. Although the total cost of the receiver is increased due to the use of two transistors to replace one tube and the use of an additional transformer, the increase in cost is somewhat off-set by the improved performance and the longer battery life.

Although the hybrid set costs slightly more than the tube set, it costs much less than an all-transistor set.

ADVANTAGES OF HYBRID RECEIVER

By incorporation of the transistor output stage in the pocket receiver, the B battery consumption has been reduced from 191 milliwatts (4.25 milliamperes at 45 volts) to 88 milliwatts (1.95 milliamperes at 45 volts). The A-battery consumption has been reduced from 240 milliwatts (160 milliamperes at 1.5 volts) to 225 milliwatts (50 milliamperes at 4.5 volts). The total power consumption of the tube-version pocket portable radio receiver is 431 milliwatts. The total power consumption of the hybrid version pocket portable radio is 313 milliwatts. The difference of 118 milliwatts represents a reduction of 27 per cent in total power consumption, but note that the relatively expensive B battery power has been reduced 54 per cent.

The savings in battery consumption can be used in either of two ways: (1) the receiver can be designed to have smaller size and less weight through the use of smaller batteries compatible in size with the reduced battery power requirements; or (2) the receiver can be designed to use conventional battery sizes to provide substantial improvements in battery life and a sizable reduction in operating costs per hour.

One manufacturer of such a pocket-portable has taken the following approach. The original B battery has been retained, thereby increasing the life by a factor of at least three. The operating costs per hour of this battery has therefore been reduced to a value one-third of the original cost. The inexpensive A battery has been replaced by a more expensive mercury-type battery in order to triple the voltage and yet retain the same space requirement and current capacity. This change has increased the A-battery operating cost per hour, but due to the lower B-battery operating cost per hour has kept the total operating cost per hour of the pocket portable radio receiver the same. The apparent sacrifice of savings on the basis of operating cost per hour is justified because the original cabinet and mechanical design has remained the same and also because the original A battery life had been extremely short. The hybrid set has been sold on the basis of greatly increased battery life and power output.

The hybrid set also offers a distinct although less obvious advantage to the radio industry in that it has hastened the development of and made more economical the all-transistor pocket portable sets which are now beginning to appear on the market. The class B transistor circuit used in the hybrid set is also used in the transistor sets. Through use of this circuit in the hybrid set, the industry has not only familiarized itself with the use of transistors, but has proved the reliability and performance of transistors in actual field service. The value of this experience cannot be expressed in terms of dollars.

The hybrid set has also aided the transistor manufacturers immensely. Although transistors have become the standard of the hearing-aid industry and have been employed to a limited extent in special military applications, the hybrid set is the first application to provide a high-volume market in the home-entertainment field. Such expanded use of transistors has encouraged transistor manufacturers and is rapidly increasing their manufacturing "know-how."

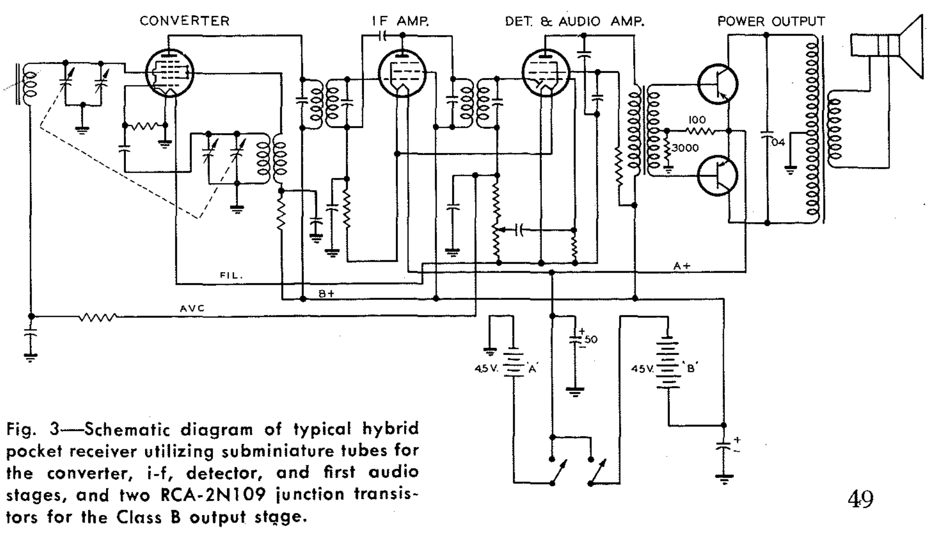


Fig. 3—Schematic diagram of typical hybrid pocket receiver utilizing subminiature tubes for the converter, i-f, detector, and first audio stages, and two RCA-2N109 junction transistors for the Class B output stage.

GRAPHICAL SOLUTION OF SIMPLE LENS PROBLEMS

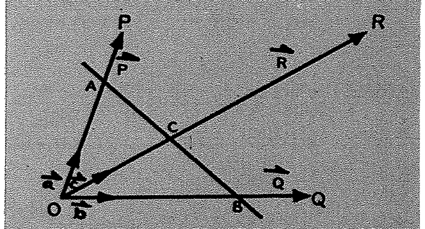


Fig. 1—Vectors P, Q and R act at O and lead to the relation

$$\frac{OP}{OA} + \frac{OQ}{OB} = \frac{OR}{OC}$$

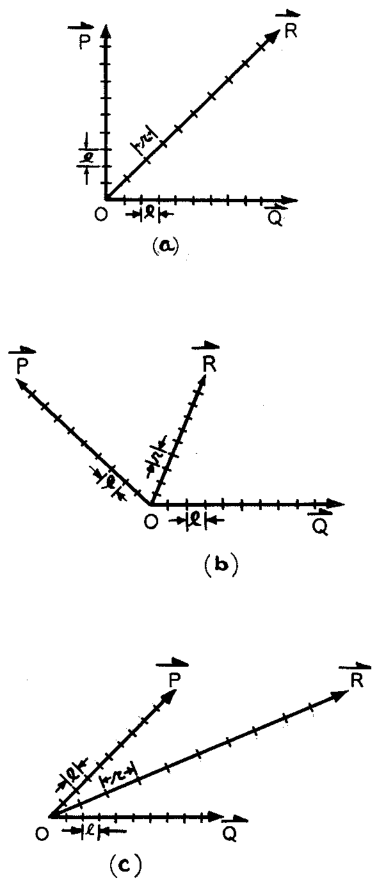


Fig. 2—Three examples showing the relation of unit lengths, l, to resultant lengths, r.

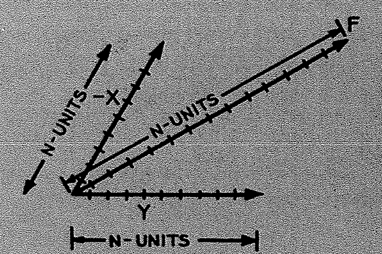
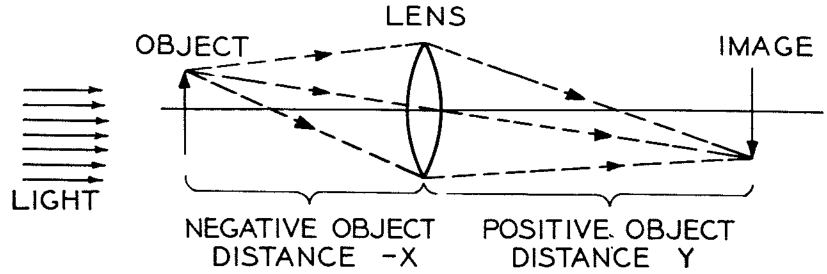


Fig. 3 — Vectors representing focal length, f; object distance, x; and image distance, y are shown operating at O.



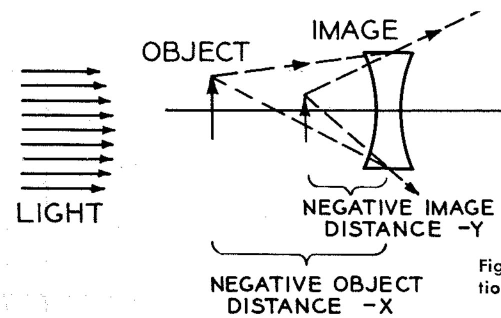
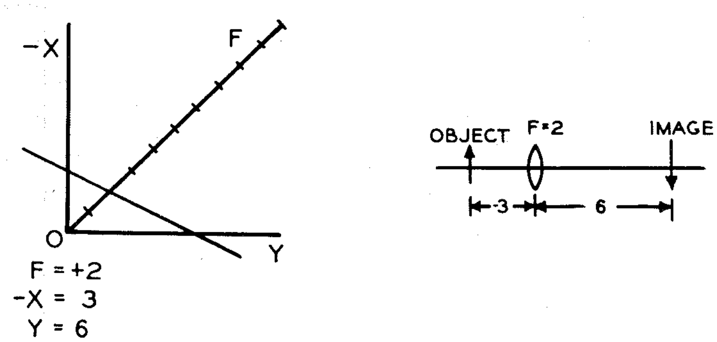
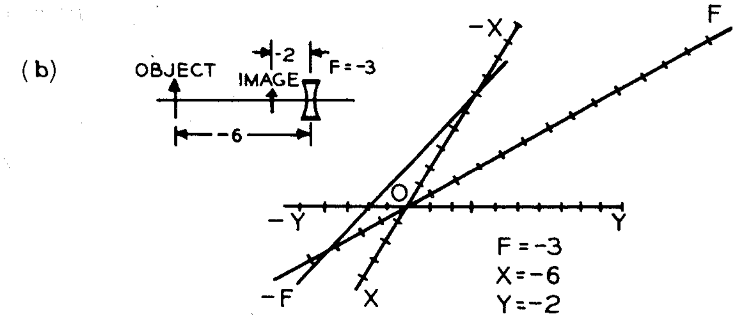


Fig. 4—Illustrating the sign convention used in this article.





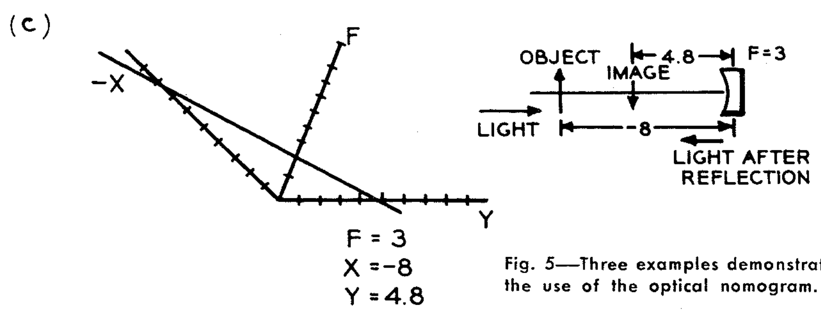


Fig. 5—Three examples demonstrating the use of the optical nomogram.

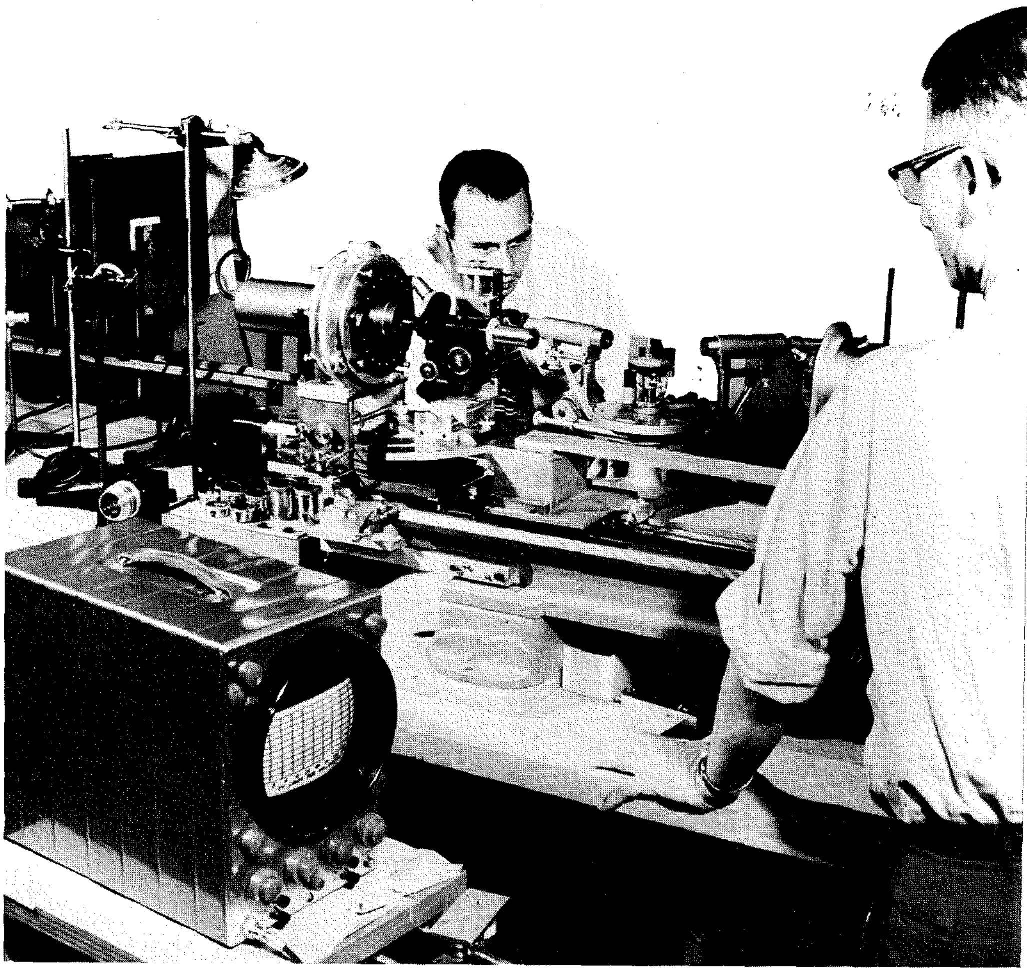
by

E. KORNSTEIN

General Engineering Development
Defense Electronic Products
Camden, N. J.

WITH THE ADVENT of complex electro-optical-mechanical systems such as television, fire control systems, missile tracking and guidance systems, to mention just a few, the relationship between optics and mechanics and especially optics and electronics has become unusually close.

Some rather simple optical relationships are available which permit the electrical or mechanical engineer to obtain approximate or first order solutions to lens problems. A first-order solution can provide preliminary data on anticipated overall length, number of elements, required focal lengths of components, and orientation of the images in the system and in general, indicate the feasibility of the system.



A view demonstrating some of the equipment presently in use in the optics laboratory. The author (in background) and J. F. Price, Project Engineer, are utilizing the RCA developed electronic lens tester to evaluate optical lenses.

BASIC RELATIONSHIPS

It will be recalled from elementary physics courses that a relation between the object distance, image distance, and focal length of a lens can be derived. This equation has the form $\frac{1}{y} - \frac{1}{x} = \frac{1}{f}$ for objects and images that are located in vacuum, or for most practical purposes located in air. (Index of refraction of air is about 1.00029). In the above equation, which is known as the Gaussian equation for reasons of ancestry, the object distance is x, the image distance is y, and the focal length is represented by f. The Gaussian equation is valid for "thin lenses", lenses theoretically so thin that they can be represented as planes, and objects and images very small compared to the lens parameters so that the lens is covering an exceedingly small field. Even though these conditions are not met in practice, application of this equation permits a useful first-order approximation. A better approximation can be made by assuming normal, thick lenses and taking into account the principal planes of the lenses. The principal planes can be found by computation or by direct measurement on a lens. The object and image distances are then measured from these planes.

It can be shown that if vectors (vector quantities represented by $\rightarrow$) $\vec{P}$ and $\vec{Q}$ act at 0 and have a resultant $\vec{R}$ (see Fig. 1), and if a transversal cuts their lines of action at A, B, and C respectively, the following relation can be derived:

$$\frac{OP}{OA} + \frac{OQ}{OB} = \frac{OR}{OC}$$

This relation would look very much like the Gaussian equation if $\vec{P}$, $\vec{Q}$ and $\vec{R}$ could be reduced to unity.

If the original vectors $\vec{P}$ and $\vec{Q}$ had been unit vectors, then the vector $\vec{R}$ could be considered as a vector of "unit resultant" length. That is, measurement of length along the resultant $\vec{R}$ is modified and calibrated in terms of "resultant" length. Fig. 2 perhaps clarifies this point. Three examples are shown. In all cases the vectors $\vec{P}$ and $\vec{Q}$ are of equal lengths and $\vec{R}$ is the resultant. The vectors $\vec{P}$, $\vec{Q}$ and $\vec{R}$ in all these examples are 10 units long, but the units measured along the resultant $\vec{R}$ are not the same length as those along $\vec{P}$ and $\vec{Q}$. The units along $\vec{R}$ can be called "resultant units." In other words, one unit along $\vec{R}$ is equal in length to the resultant of one unit along $\vec{P}$ and an equal unit along $\vec{Q}$. In this way the above equation can be written as

$$\frac{1}{OA} + \frac{1}{OB} = \frac{1}{OC}$$

where distances along OC are "resultant units." This equation now has essentially the same form as the Gaussian thin lens equation.

$$\frac{1}{y} - \frac{1}{x} = \frac{1}{f}$$

SIGN CONVENTION

It seems appropriate at this point to establish a sign convention to avoid confusion. In the optical group of General Engineering Development, the following sign convention has been found to be most satisfactory. As shown in Fig. 4, if light from a source reaches the object or image surfaces before it reaches the lens,

SOLUTION OF LENS PROBLEMS

continued

the object or image distance is negative. If light from a source reaches the lens before it reaches the object or image surfaces, the object or images distances are positive. Converging lenses and concave mirrors have positive focal lengths. Diverging lenses and convex mirrors have negative focal lengths.

OPTICAL NOMOGRAM

Two vectors of equal length, originating from the same point and making any acute or obtuse angle are shown along with their resultant as in Fig. 3. If each of the original vectors are "n" units long, the resultant is divided also into "n" equal units. Units along the original vectors represent object and image distances and units along the resultant represent focal lengths. In order to maintain the sign convention, positive image distances "y" and negative object distances "—x" are located along the two original vectors and positive values of focal length "f", marked off along the resultant.

In order to use the nomogram, any two of the three variables, y, x or f must be known. A straight line is drawn connecting the values of the two known variables and the value of the unknown variable is found by its intersection with this straight line.

Several examples of the operation of this nomogram are given in Fig. 5. The angle between the object and image vectors can be arbitrarily chosen as a matter of convenience. Since rectangular graph paper is most common, 90° is perhaps as good a choice as any and then units of focal length will be $\sqrt{2}$ times as large as units of object and image distance as in Fig. 6.

It is hoped that this nomogram will prove useful to engineers requiring first order data relating object and image distances with focal lengths of lenses and mirrors. It also serves to illustrate how some interesting relations can be found using simple vector techniques.

EDWARD KORNSTEIN graduated from New York University in January, 1951 with a B.A. degree, majoring in Physics and Mathematics. In 1955, he obtained an M.S. degree in Physics from Drexel Institute of Technology through the RCA Tuition Refund Plan. Mr. Kornstein came to the Optics Group at RCA in February, 1951 and has been associated with optical projects since that time. He has worked on color television optical systems, motion picture and television projection optical systems, optical gunsights, telescopes, cameras, and reconnaissance systems. Mr. Kornstein is an associate member of the Optical Society of America and the Society of Motion Picture and Television Engineers.

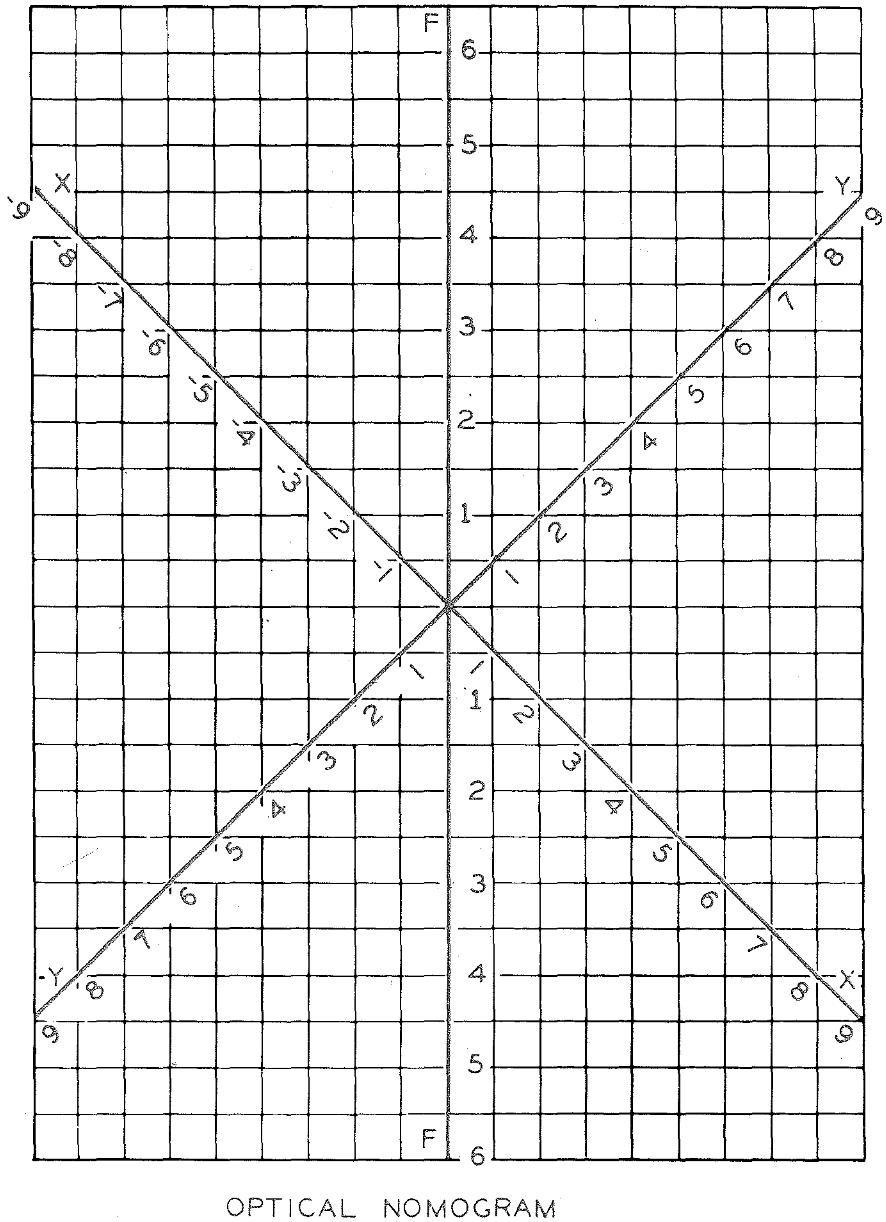
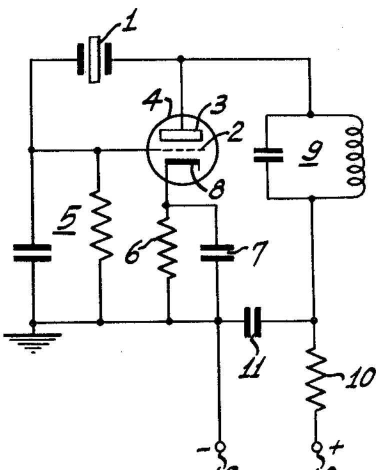


Fig. 6—Optical nomogram relating focal length and object and image distances for simple lenses.

Patents Granted
TO RCA ENGINEERS

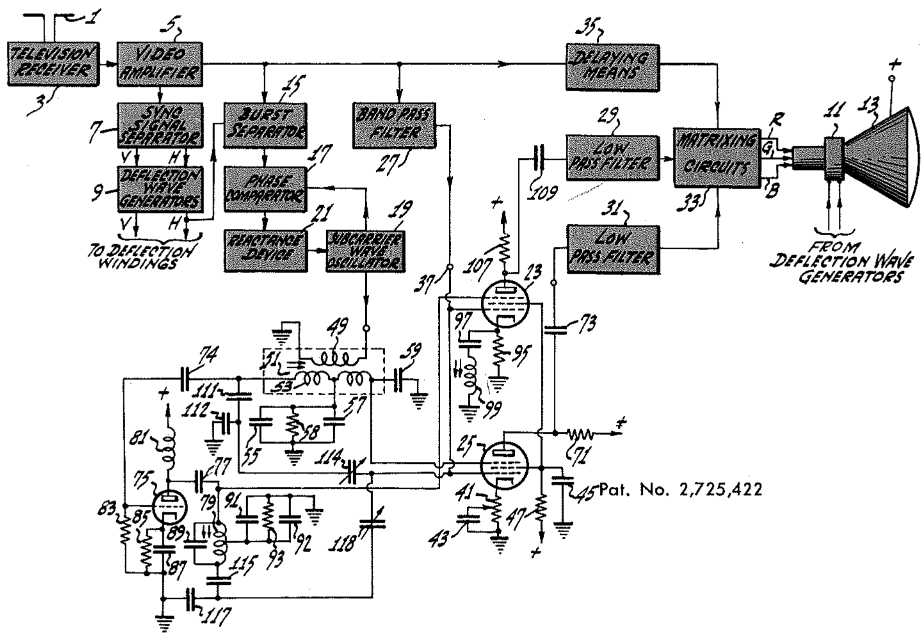
Based on Summaries Received over a period of about two months



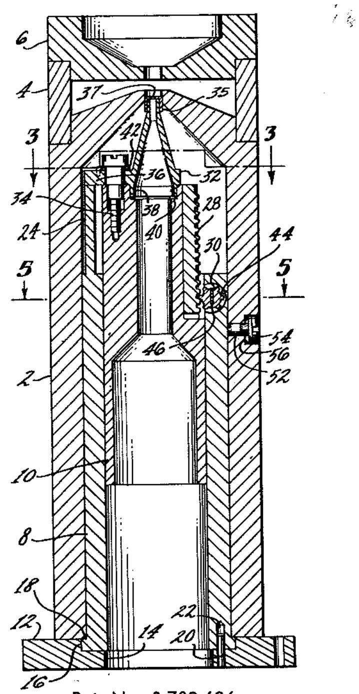
Pat. No. 2,724,777

AMPLITUDE-STABILIZED CRYSTAL OSCILLATOR (Patent No. 2,724,777)—granted November 22, 1955 to F. M. Brock, Commercial Electronic Products, Camden, N. J. In Pierce crystal oscillator having cathode resistance, a portion of a.c. voltage across this resistance is rectified and resulting d.c. is applied to oscillator grid with a polarity such as to oppose the normally high negative bias of tube. Tube thus constrained to operate toward Class B limit.

COLOR TELEVISION RECEIVERS (Patent No. 2,725,422)—granted November 29, 1955 to J. Stark, Jr. and G. E. Kelly, RCA Victor Television Division, Cherry Hill, N. J. In a demodulator in a color television receiver wherein interelectrode capacitances inadvertently couple the demodulating signal to the chroma signal electrode, a neutralizing circuit couples a prescribed polarity and magnitude of demodulating signal to that electrode to neutralize the inadvertent signal developed there.

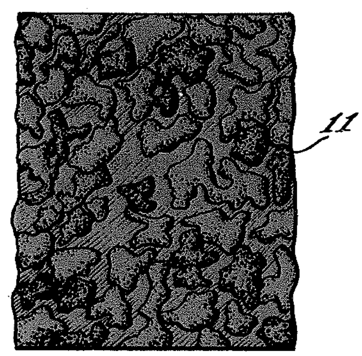


Pat. No. 2,725,422



Pat. No. 2,720,606

ELECTRON MICROSCOPY (Patent No. 2,720,606)—granted October 11, 1955 to E. G. Dornfeld, Commercial Electronic Products, Camden, N. J. This structure includes a telescoping pair of sleeves positioned within the lower pole piece of the microscope. The aperture plate is carried by a holder which is pivotally mounted on the inner sleeve. Longitudinal motion of the telescoping sleeves is caused by a rack and pinion. A cam surface on the outer sleeve engages a tongue on the aperture plate holder and causes the holder to pivot. The position assumed by the aperture plate and holder is, then, out-of-the-way of the electron beam.

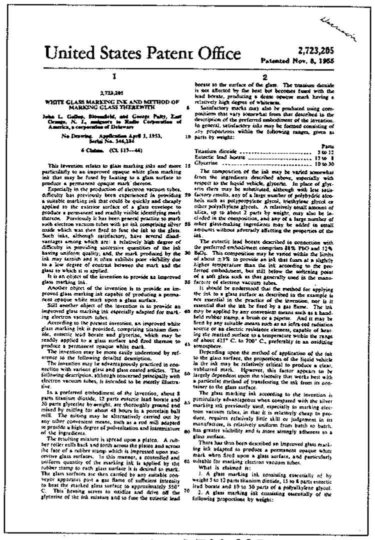


Pat. No. 2,719,355

CARBONIZING METAL AND METHOD OF MAKING IT (Patent No. 2,719,355)—granted October 4, 1955 to J. B. Diffenderfer, Tube Division, Harrison, N. J. A sheet metal structure comprising a metal base (10) has sintered thereto a plurality of nickel particles (12) to form a matrix (11). The particles each have a plurality of pores (13) and define additional pores (15) between the particles. The pores (13, 15) are of capillary size so that a carbon coating (17) is readily absorbed by the pores for anchoring the coating to the matrix. The coated sheet metal may be formed to desired shape without loss of coating.

PATENTS GRANTED

continued


United States Patent Office 2,723,205 Patented Nov. 8, 1955

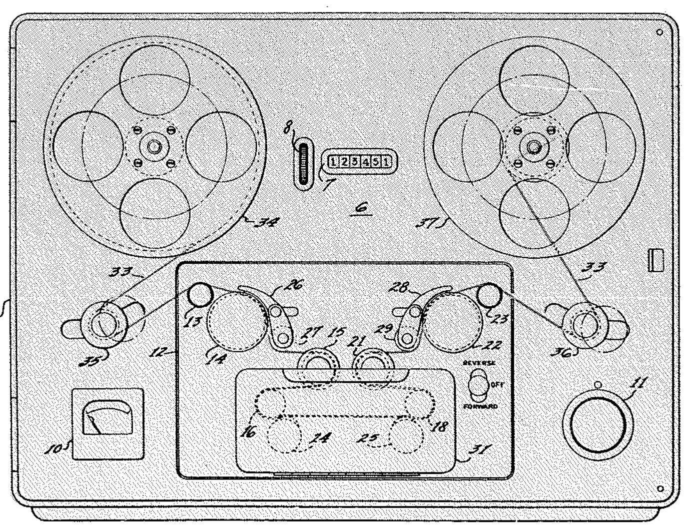
WHITE GLASS MARKING INK AND METHOD OF MARKING GLASS THEREWITH

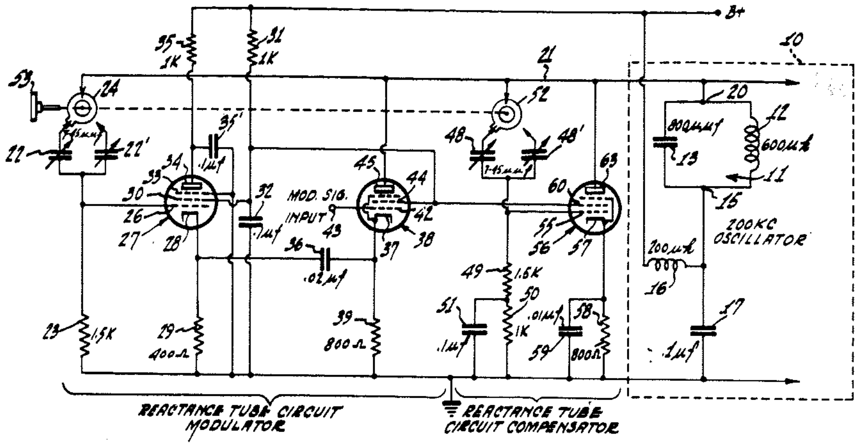
Pat. No. 2,723,205

WHITE GLASS MARKING INK AND METHOD OF MARKING GLASS THEREWITH (Patent No. 2,723,205)—granted November 8, 1955 to J. L. Gallup and G. Palty, Tube Division, Harrison, N. J. Marking ink for glass consisting essentially of 5-12 parts by weight titanium dioxide, 8-15 parts eutectic lead borate and 10-30 parts polyalkylene glycol. The ink is fixed by heating to about 425°-700°C.

FILM DRIVE AND CONTROL MECHANISM (Patent No. 2,725,200)—granted November 29, 1955 to H. C. Ward, Defense Electronic Products, Los Angeles, Calif. Sensing rollers are provided in film loops to vary the friction of clutches driving or holding back film to maintain substantially constant tension in the film loops.

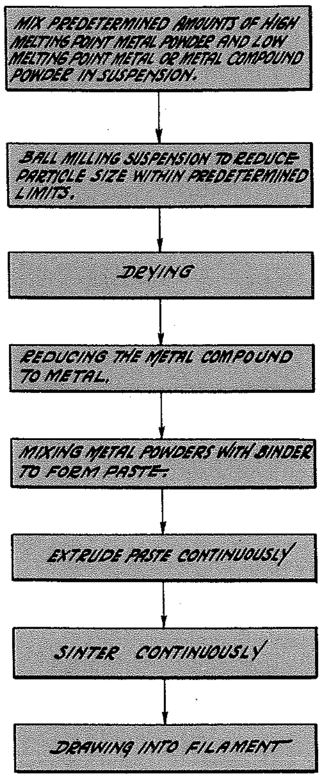
Pat. No. 2,725,200





Pat. No. 2,724,802

FREQUENCY MODULATED OSCILLATOR (Patent No. 2,724,802)—granted November 22, 1955 to E. F. Oschmann, Radiomarine Corp. of America, New York. Two reactance tube circuits are connected to the oscillator tank. The modulating signal is applied to one circuit including tube 38 and cathode follower 27. The second reactance tube circuit includes tube 56 arranged to compensate for the effects of aging in the tubes.

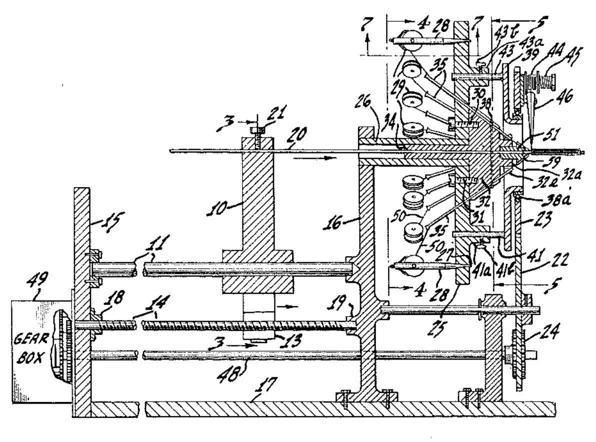


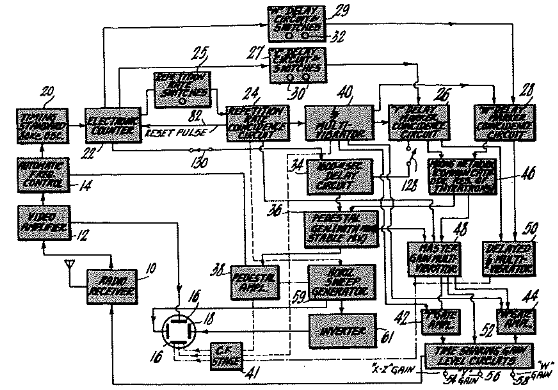
Pat. No. 2,719,786

METHOD OF MAKING A TUNGSTEN-NICKEL ALLOY FILAMENT (Patent No. 2,719,786)—granted October 4, 1955 to M. N. Fredenburgh, Tube Division, Harrison, N. J. For making a tungsten-nickel filament by a continuous technique, a method is provided whereby paste 12 of tungsten and nickel powders of particular size and in predetermined relative amounts, is continuously extruded. The extrusion 11 is self-supporting and is passed through a sintering furnace 13 wherein the nickel particles are alloyed with the tungsten particles.

APPARATUS FOR MAKING MESHED GRIDS (Patent No. 2,719,544)—granted October 4, 1955 to Julius Hirmann, Tube Division, Harrison, N. J. A machine for making a plural side rod grid, includes a plurality of reels (29) of side rod stock supported in a relatively large radius array, and a conical nosepiece (51) having a relatively small radius and grooves in the outer surface thereof for feeding side rock stock from the reels (29) to a mandrel (20).

Pat. No. 2,719,544

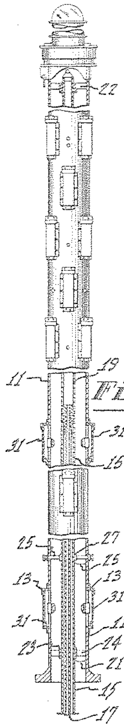




Pat. No. 2,724,829

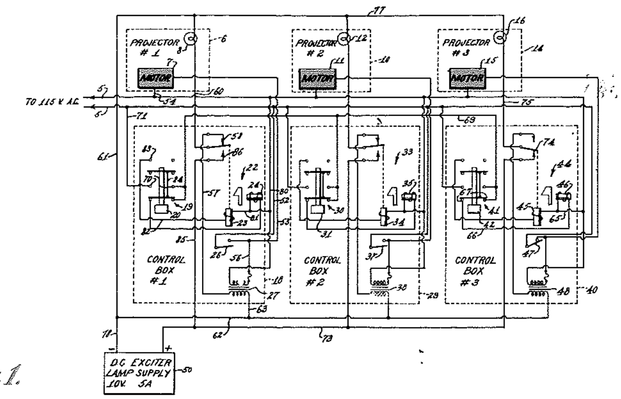
GAIN CONTROL SYSTEM (Patent No. 2,724,-829)—granted November 22, 1955 to J. P. Eugley, Defense Electronic Products, Camden and N. A. MacInnes, Defense Electronic Products, Moorestown, N. J. The receiver of this invention is useful in a loran system in which 4 received pulses (2 from the master station and 1 each from 2 different slave stations) are simultaneously displayed. The gain control circuit permits independent adjustment of the receiver gain during the periods of reception of the two master pulses and during the periods of reception of the two slave pulses.

AUTOMATIC GRID WINDING AND SWEDGING APPARATUS (Patent No. 2,719,543)—granted October 4, 1955 to P. W. Maurer, Tube Division, Harrison, N. J. A machine is provided for simultaneously winding grid wire on side rods and swedging end portions of the side rods to provide reference surfaces having utility in mounting the finished grid on a mica. The machine includes a head having conventional notching and peening rollers (43, 45) and two opposed swedging hammers (60, 61) spaced a critical distance from the rollers referred to provide swedges at desired portions of the side rod stock.



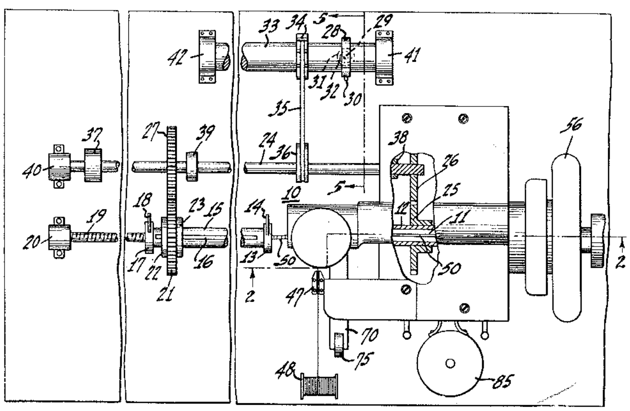
Pat. No. 2,724,774

SLOTTED CYLINDER ANTENNA (Patent No. 2,724,774)—granted November 22, 1955 to O. O. Fiet, Commercial Electronic Products, Camden, N. J. An antenna consisting of a hollow tubular conductive member having a plurality of longitudinally extending slots therein. Energy is fed to the interior of the tubular member. Coupling loops extend from the sides of each of the slots into the tubular member to couple energy from the interior thereof to the slots from which the energy is radiated into space. The coupling loops include a lumped reactance in the form of a capacitor.

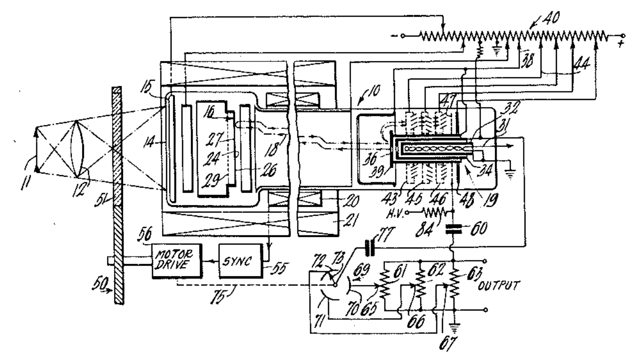


SOUND CHANGEOVER SYSTEMS (Patent No. 2,722,570)—granted November 1, 1955 to J. F. Byrd and J. D. Phyfe, Commercial Electronic Products, Camden, N. J. To select a projector from a plurality of projectors without pre-setting and pre-heating the incoming exciter lamp, the incoming motor switch connects power from the motor power source as it connects the motor to the source. When any changeover switch is actuated, a direct current source is connected to the incoming exciter lamp and disconnected from the outgoing exciter lamp by releasing a relay. The motor is then disconnected by the changeover switch.

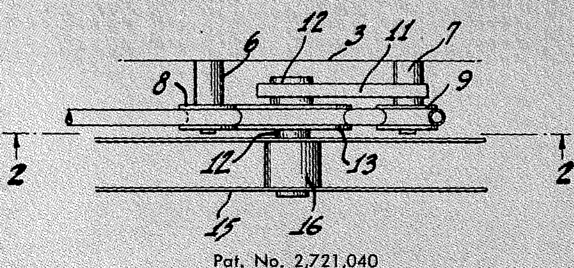
COLOR TELEVISION (Patent No. 2,710,308)—granted June 7, 1955 to O. H. Schade, Tube Division, Harrison, N. J. A portion of the individual component color signal outputs of a color camera will feedback to control elements of color pickup tubes to provide color balance by controlling the sensitivity of the color pickup tube to each of the separate component colors.



Pat. No. 2,719,543



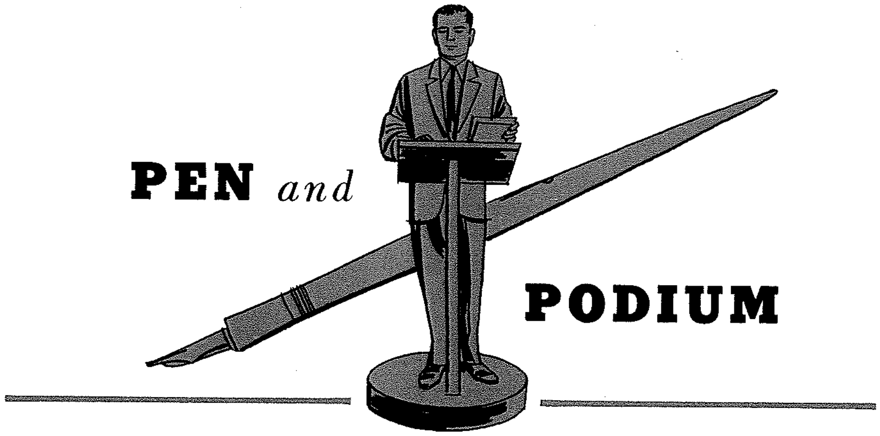
Pat. No. 2,710,308



Pat. No. 2,721,040

TAKE-UP FILM REEL DRIVE (Patent No. 2,-721,040)—granted October 18, 1955 to V. M. Grantham, Defense Electronic Products, Camden, N. J. To obtain an economical reel drive which increases the torque with film roll size, the drive spindle pulley is pivotally mounted and permitted to increase its frictional contact with the drive belt by both increasing the pressure between the belt and pulley and the amount of belt contacted by the pulley.

PEN *and* PODIUM



BASED ON REPORTS RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

INCREASING AUTOMATION IN INDUSTRY IS NECESSITY FOR ECONOMIC GROWTH . . . By Dr. E. W. ENGSTROM, SENIOR EXECUTIVE VICE PRESIDENT. Presented at the Centennial Symposium of Engineering at the University of Pennsylvania. Dr. Engstrom described automation as a process of growing beyond "the limitations of humans in decision-making and control" through the entire industrial and commercial process from raw material to consumer.

In a discussion of its effects in the future, Dr. Engstrom declared that automation will bring about "new and broader patterns in the use of labor" and creation of "a large group of managers of a new type."

"With automation, we shall no longer have large groups of people who are themselves part of a production machine," he said. "Instead, we will have many persons employed to design, to build, to service, to control, and to make decisions. This will call for greater skills and far more training and education. It will mean a general upgrading of personnel. Assuredly, this will mean continual adjustment and re-alignment of personnel. Management and labor must tackle with reasonableness the growth processes involved, in order to lighten transitional burdens and insure maximum mutual gains."

Discussing the role of management, Dr. Engstrom predicted that "in the work of the administrators of business will be the real revolution of automation."

A NEW LOW-POWER SINGLE-SIDEBAND COMMUNICATION SYSTEM . . . By E. A. LAPORT, RCA INTERNATIONAL DIVISION, New York City, and K. L. NEUMANN, RADIOMARINE CORP., New York City. Published in RCA REVIEW, December, 1955. A new single-sideband high-frequency telephone system is described for simplex or duplex operation. It is usable for telephony, manual telegraphy, and teleprinter operation over short and medium distances. It is primarily intended for suppressed-carrier operation, but can also be operated with carrier and one sideband for intercommunication with existing amplitude-modulated stations on the same working frequency. The system is adapted for use by non-technical personnel for many of the simpler telecommunication requirements around the world, with utmost spectrum conservation.

"SHIPS THAT SEE IN THE NIGHT" AND "RADIO AND THE SMALL BOAT" . . . By C. E. MOORE and G. G. BRADLEY, RADIOMARINE CORP., New York City. The speakers addressed members of the Marine Trades Association of New York at their recent meeting at Fraunces' Tavern. Mr. Bradley spoke on "Radio and the Small Boat," covering the fundamentals of radio-telephone installation and operation. Mr. Moore showed the RCA Radar sound film entitled "Ships That See In The Night." He also discussed the need for radar, its reliability and described its operation.

FUTURE DEVELOPMENTS IN ELECTRONICS . . . By C. C. OSGOOD, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented November 2, 1955 before the Pennsgrove Catholic Men's Club, Pennsgrove, N. J. Mr. Osgood showed slides of Princeton Laboratories and described the "dream" house and office of the future. Slides were used to help illustrate comparison between vacuum tubes and transistors. Transistorized portable radios, and TV receivers were also illustrated. Other subjects described were Microwave Relaying, Bizmac, Magnetic Tape, Industrial TV, Portable TV, Electron Microscope, Beverage Inspection and Atomic Battery.

HIGH FIDELITY AND HOW IT IS AFFECTED BY PHONOGRAPH RECORD MANUFACTURING . . . By H. I. REISKIND, RCA VICTOR RECORD DIVISION, Indianapolis, Indiana. Mr. Reiskind presented his talk before 60 members of the Indianapolis Section of the American Institute of Electrical Engineers in the late fall of 1955. The talk consisted of recording and manufacturing techniques used in the manufacture of phonograph records. It was concluded with a demonstration of a stereophonic recording.

THE CONTRIBUTION OF ELECTROPLATING TO HIGH FIDELITY RECORDS . . . By Dr. A. M. MAX, RCA VICTOR RECORD DIVISION, Indianapolis, Ind. On October 5, 1955, the talk was presented before 50 members of the St. Joseph Valley Branch of the American Electroplaters Society, Mishawauka, Indiana. On October 7, 1955, the talk was presented before 200 members of the Detroit Branch of the American Electroplaters Society at the Statler Hotel, Detroit, Michigan. The talk reviewed record matrix operations from lacquer to stamper and the changes which have been made in the past 10 years and their contributions toward improved or quieter surfaces and longer stamper life.

Some of the factors in quality control were also discussed such as control of impurities necessary to obtain consistent physical properties of electroformed deposits.

IMPROVEMENT IN COLOR KINESCOPES THROUGH OPTICAL ANALOGY . . . By D. W. EPSTEIN, P. KAUS, RCA LABORATORIES, Princeton; and D. D. VANORMER, RCA TUBE DIVISION, Lancaster, Pa. Published in RCA REVIEW, December, 1955. In color kinescopes wherein the phosphor dots are deposited by the conventional optical exposure, the movement of the deflection center with deflection angle causes a radial misregister between the phosphor dots and electron spots. This misregister has been eliminated by interposing a thin aspheric lens between the light source and the aperture mask during exposure of the phosphor screen in the manufacture of the tube.

INSTRUMENTATION REQUIRED FOR THE MANUFACTURE OF COLOR-TELEVISION KINESCOPES . . . By C. P. SMITH, TUBE DIVISION, Lancaster, Pa. Presented at Instrument Society of America (Central Keystone Section), Elizabethtown, Pa. November 22, 1955. This paper discusses the different types of measurement required for the manufacture of the 21AXP22 color kinescope, the types of measuring instruments used, the units of measurement, and the degree of absolute value required. Consideration is given to measurements required on materials such as phosphors, processes such as aluminizing, and subassemblies such as bulb structures, electron guns, and shadow masks. Electrical tests made on the finished tube are also discussed, including emission tests, focusing and convergence tests, leakage and gas tests, resolution tests, and life tests. Specific types of control measurements such as X-ray diffraction, spectroscopy, and wet and dry chemical analysis are also described.

MICROPHONES FOR HUMAN USE . . . By R. M. CARRELL, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented before the IRE Conference of the Professional Group on Audio held at Dayton, Ohio, December 1, 1955. The factors governing the design of microphones for personal use by artists are different from those which govern the design of a microphone for studio use. In the human use of microphones the interaction of the complex speech spectrum, the sound field around the mouth and body, and the characteristics of the microphone must be taken into account. This calls for specialized instrumentation and techniques which can make measurements using real human voices instead of an artificial voice.

A LIQUID DIELECTRIC VARIABLE CAPACITOR . . . By H. BARRACLOUGH, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in ENGINEERS DIGEST, Nov.-Dec., 1955. The author describes the advantages of constant-capacity, low-dielectric power loss, high-dielectric strength, and long life under vigorous conditions. Capacitors withstand peak r-f voltages of 8500 with plate spacings of less than $\frac{1}{32}$ inch. A size advantage of 4 to 1 is obtained over equivalent air capacitors.

NOMOGRAPHS FOR DETERMINING SIGNIFICANT DIFFERENCES . . . By C. H. LI, TUBE DIVISION, Harrison, N. J. Published in METAL PROGRESS, November, 1955. This paper presents nomographs which make it possible to determine quickly the significance of attributive test results on two samples of equal size. Real differences in test results are easily separated from chance occurrences, thus avoiding the possibility of costly indecision or adoption of false conclusions. When a test has shown qualitatively that one process, product, or material is better than another in a certain respect, the use of the nomographs makes it possible to determine quantitatively how reliable the test results are. With this information, it is possible to make systematic comparisons of the two processes, products, or materials, weighing together such other factors as economic considerations, engineering difficulties, and the like.

CHARACTERISTICS OF THE "PERFECT" LENS AND THE "PERFECT" TELEVISION SYSTEM . . . By O. H. SCHADE, TUBE DIVISION, Harrison, N. J. Published in the JOURNAL OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS, November, 1955. A "perfect" image is defined optically as an image in which the light-intensity distribution is determined by diffraction alone. In this case the finite boundary (lens stop) of a lens acts as a low-pass filter which determines the sine-wave spectrum of the perfect lens. A perfect television system can hence be defined as a system in which the performance is limited only by the electrical cutoff filter of the system and the optical filter requirements imposed by the raster process. It is shown that the performance of a "perfect" television system differs in many ways from that of a perfect lens and photographic system, and that a close approach to its performance is possible with practical systems.

35 MM INTERMITTENT MOTION-PICTURE PROJECTOR FOR COLOR TELEVISION . . . By W. F. FISHER, COMMERCIAL ELECTRONIC PRODUCTS, and W. R. ISOM, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in the October, 1955 BROADCAST NEWS and in the December issue of SMPTE. A 35 mm motion-picture projector for use with the three-vidicon film camera for color television is described. The projector employs a modified Geneva intermittent that permits long application of light and non-locked synchronous operation. The light source is an incandescent lamp. Compensation for variation in film density, without affecting color balance, is provided. The unique accommodation of 24-frames/sec film rate to the 30-frame television system makes the projector adaptable for all storage and semi-storage film pickup systems.

SOME IMPORTANT CHARACTERISTICS OF TANTALUM ELECTROLYTIC CAPACITORS . . . By J. G. DZWONCZYK, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in ENGINEERS DIGEST, Nov.-Dec., 1955. The author describes some of the common applications for tantalum electrolytic capacitors and considerations which should be given attention. Tantalum exhibits extremely stable properties (capacitance and temperature) and is highly resistant to chemical attack.

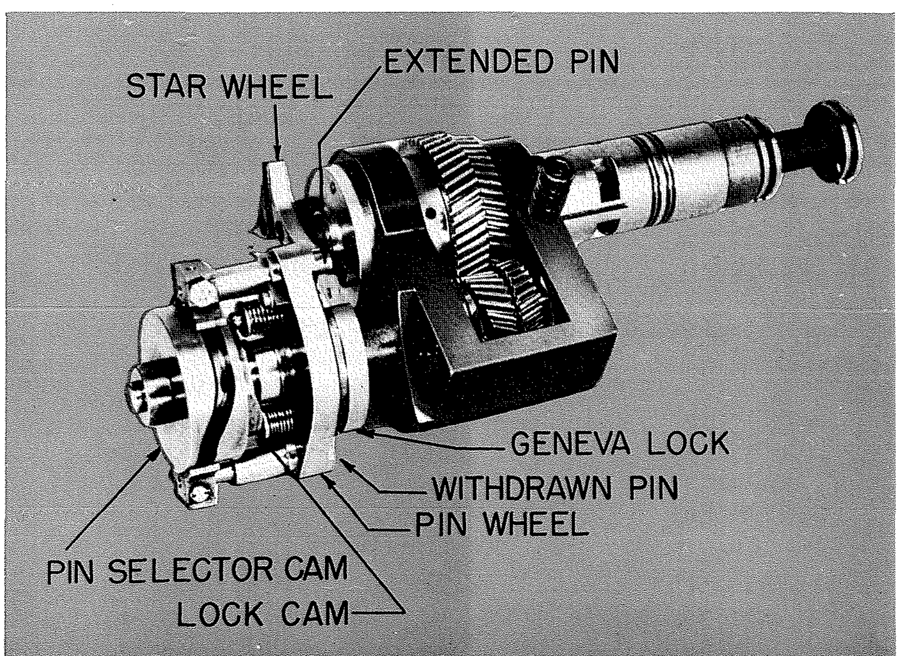
A DIRECT READING ACOUSTICAL IMPEDANCE METER . . . By R. M. CARRELL, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented at the Acoustical Society Meeting held at Brown University, December 16, 1955. A Device for the measurement of acoustical impedance was described which employs a high-impedance source, monitored by a ribbon element acting as an acoustical ammeter. The output of the ribbon acts through an automatic volume control cricuit to maintain constant the volume current injected into the impedance under test. The sound pressure so developed is proportional to the absolute acoustical impedance and is measured by a high-impedance probe microphone. The ribbon element also serves as a phase angle of the unknown impedance. The total acoustical path length from the ribbon to the diaphragm of the probe microphone is kept to an absolute minimum.

RCA SEMICONDUCTOR DIVISION . . . By R. E. HIGGS, SEMICONDUCTOR DIVISION, Harrison, N. J. Presented at Chamber of Commerce, Raritan, N. J., December 6, 1955. This paper discusses the organization of the RCA Semiconductor Division, now located at Harrison, N. J., and the new semiconductor plant being built at Bridgewater Township, N. J. The advantages of semiconductor devices, particularly of transistors, for applications such as hearing aids, radios, computers, and military equipment are evaluated. Avenues of future growth of transistor business are discussed. Details are given of the new semiconductor plant being built in Bridgewater Township, which will be known as the Somerville Plant. Types of jobs which will be filled from the local labor market and special aptitudes required for these jobs are described. Advantages of the new plant location to both RCA and the community are pointed out.

AUDIO-STANDARD GENERATOR . . . By PETER KOUSTAS, TUBE DIVISION, Harrison, N. J. Published in ELECTRONICS, December, 1955. This paper describes an experimental standard-audio-frequency generator suitable for such applications as the calibration of sensitive test equipment. This unit, which is less complex and less expensive than most conventional equipment for such applications, features tuning-fork frequency control, relatively simple circuitry, and reliability, and eliminates the need for adjustments. Although the circuit requires a large number of tubes, seven triode sections are used as cathode-follower output stages, and all frequency multiplication is accomplished by the use of diodes.

INVESTIGATION OF POWER GAIN AND TRANSISTOR PARAMETERS AS FUNCTIONS OF BOTH TEMPERATURE AND FREQUENCY . . . By DR. A. B. GLENN and I. JOFFE, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Prepared by A. B. Glenn and I. Joffe and presented by Mr. Joffe at the Symposium on Aeronautical Communications held at Utica, N. Y., November 22, 1955. In equipments operating under conditions of large changes in ambient temperatures, it is important to know how the performance of such equipment is affected. This is especially true in airborne electronics equipment utilizing transistors since transistors are known to be temperature sensitive. The purpose of this paper is to present the results of an investigation made to determine the effects of both temperature and frequency on the transistor parameters and power gain. These measurements were made on alloy junction germanium transistors over the frequency and temperature ranges of 0.5 to 4.0 megacycles and $-55°$ to $+70°$ respectively. A theoretical discussion of the variation of the hybrid pi equivalent circuit parameters with temperature is presented. An expression for power gain is then developed using these parameters. Experimental results are then shown indicating the validity of the hybrid pi representation not only at room temperature but also at low and high temperatures. Both measured and calculated power gain are shown to decrease with increase in temperature with good correlation indicated. Power gain as a function of frequency is also shown to decrease at the rate of 6 db per octave for the alloy junction germanium transistors. This is in full agreement with previously published theoretical predictions.

TRANSIENT RESPONSE OF DETECTORS IN SYMMETRIC AND ASYMMETRIC SIDEBAND SYSTEMS . . . By T. MURAKAMI and R. W. SONNENFELDT, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. Published in RCA REVIEW, December, 1955. Detector response in symmetric- and asymmetric-sideband systems is analyzed in this paper. It is shown that the limitations of the envelope detector are eliminated when a synchronous detector is used. Unlike the envelope detector, the synchronous detector gives an output linearly related to the original modulation, so long as the transmission system is linear. Curves and equations are given to develop this result in general, and then in particular for the flat, staggered-triple band-pass filter for various modulation levels. The improved transient performance of the synchronous detector is shown, experimentally. A simple form of synchronous detector is analyzed. Detailed conclusions are drawn from the analysis and experimental results.



View of 35 MM projector intermittent mechanism

PEN *and* PODIUM

continued

IMPORTANCE OF PRODUCT DESIGN TO AUTOMATION . . . By H. S. DORDICK, DEFENSE ELECTRONIC PRODUCTS, Camden, N.J. Published in ENGINEERS DIGEST, Nov-Dec, 1955. This article describes how product design is the key to successful production of electronic equipment through Automation. Close coordination is required between the engineers who design the machines, and the engineers who process the operation and materials.

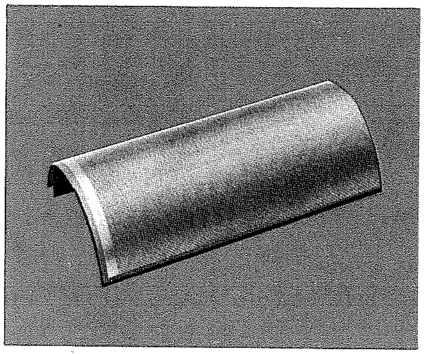
PRINTED DEFLECTION YOKE DESIGN . . . By H. J. BENZULY, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. TELE-TECH, December, 1955. Describing the construction of a deflection yoke for an image-orthicon color TV camera which was built entirely from printed circuits (see illustration at right) and operated in a camera. With the exception of resistance, the parameters of a conventional wire wound yoke have been precisely reproduced.

CONTROL OF LIGHT INTENSITY IN TELEVISION PROJECTORS . . . By K. SADASHIGE and B. F. MELCHIONNI, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Published in October 1955, BROADCAST NEWS. The authors describe the need for maintaining a constant level in television film systems regardless of die variations in film density. Light intensity control methods are described. How the neutral-density filter works, the bridge circuit, solving development problems, eliminating infrared rays, adapting the control to projectors and integrating the control into film systems are other topics covered.

MATHEMATICAL MODELS FOR RELIABILITY DESIGN . . . By S. A. MELTZER, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented at the Symposium on Guided Missile Reliability at Wright-Patterson Air Force Base, Ohio, Nov. 3, 1955. In this paper a mathematical model is presented by which the designer of an electronic equipment can compute its survival probability. Any performance parameter (gain, power output, bandwidth, etc.) can be expressed as a function of the individual components of the circuit. The statistical distribution of the component characteristics (dependent on both operating time and environment) are then used in conjunction with the circuit equations to yield an expression for the circuit survival probability.

WHAT AUTOMATION MEANS TO THE DESIGN ENGINEER . . . By G. H. GOODMAN, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in ENGINEERS DIGEST, Nov-Dec, 1955. This paper deals with the need in automation for the design engineer to assume responsibility for the details of fabrication as well as functional aspects of equipment. Optimum design can be achieved through flexible thinking, which embraces automation standards, modular design, mechanical modules and some philosophy of systems engineering.

IMPROVED TECHNIQUES IN ELECTRON-TUBE TESTING . . . By J. M. LOWERY, TUBE DIVISION, Camden, N. J. Presented at IRE Section Meeting, Cleveland, Ohio, November 10, 1955. This paper describes a new test instrument, the WT-100A MicroMho-Meter, which may be used for the accurate prediction of electron-tube behavior in associated circuitry. In the determination of knee currents and cutoff voltages, this instrument relates the current-passing ability and the plate-current cutoff point in such a manner that the action of the tube under pulse conditions may be approximated. High-current, low-voltage tests reveal the cathode-emission conditions. Advantages of this instrument as compared with methods previously used in tube testing are discussed. Design features of the unit are described, and its versatility is illustrated.



Section of printed electrostatic shield formed for assembly. Material is melamine glass with .0027" copper. Narrow conductors are 15 mils wide, evenly spaced at 60 mils. The common bus is 3/16 inch wide.

DEVELOPMENT OF THE "CANDELABRA" ANTENNA SYSTEM . . . By L. J. WOLF, DEFENSE ELECTRONIC PRODUCTS, Moorestown, N. J. Published in October 1955 BROADCAST NEWS. The author describes the multiple TV Antenna System which enables Stations KLRD-TV and WFAA-TV to broadcast from Superturnstile Antennas on top of a 1438 foot tower. The paper discusses specifications, scale model antennas, future possibilities and application. Also see "The Hill-Tower Antenna System" by R. H. Wright and J. V. Hyde, RCA ENGINEER, Vol. 1, No. 2, August-September.

HOW HOUSEWIVES AND BRIDGE LAMPS INFLUENCED THE EVOLUTION OF PICTURE TUBES . . . By M. B. KNIGHT, TUBE DIVISION, Harrison, N. J. Presented at Kiwanis Club, Montclair, N. J., November 3, 1955. After the manufacturers of a new technical product overcome the basic technical problems and reach the first plateau in reducing costs, the emphasis usually shifts to the development of features which may give one product an "edge" over competitors. It happened to the television picture-tube industry a few years ago. These features may seem to be just "gimmicks" to the general public because they do not play a major role in a person's decision to buy a television set. But the "gimmicks" may be all-important in his choice of brand, and the competitive engineering and production activity is intense in a race for new features. Highlights of the story of television picture-tube developments are the rectangular tube, methods of improving picture contrast, and the reduction of reflections of lamps and windows from the television screen.

CHEMISTRY IN METALLURGY . . . By J. S. MARTIN and P. D. STRUBHAR, TUBE DIVISION, Lancaster, Pa. Presented on Television Program of the American Chemical Society, Southeastern Pennsylvania Section, November 27, 1955 (WGAL-TV, 3 to 3:30 PM). This paper discusses the relationship of metallurgy to chemistry, and defines extractive metallurgy, refining metallurgy, and physical metallurgy, including the imparting of specific properties to metals by variations in processing. Malperformance of a power tube due to presence of lead in oxygen-free, high-conductivity copper is considered as a typical problem. The role of analytical chemistry in identifying and analyzing the impurity is described. The solution of the problem is shown to depend on the source of the impurity occurrence in the copper. The influence of extractive metallurgy upon ore content is discussed, and specification requirements are evaluated. Inspection standards used to maintain required quality are also described.

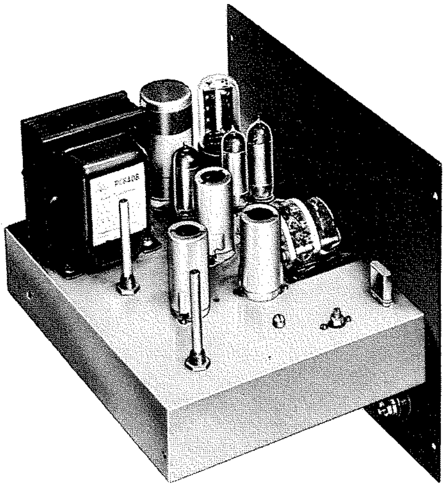
SUSTAINING ENGINEERING . . . By J. F. UNDERWOOD, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in ENGINEERS DIGEST, Nov-Dec, 1955. This article describes the program of Sustaining Engineering in Aviation Electronics Engineering which is a specialized effort to provide adequate engineering support for Airborne Fire Control equipments, during production, installation, and use in the field, to insure an improved and reliable product.

RECENT IMPROVEMENTS IN THE 21AXP22 COLOR KINESCOPE . . . By R. B. JANES, L. B. HEADRICK, and J. EVANS, TUBE DIVISION, Lancaster, Pa. Presented by L. B. Headrick at IRE Section Meeting, Cleveland, Ohio, November 10, 1955. The 21-AXP22 has proven to be a high-quality color kinescope which is readily adaptable to quantity production. As a result of manufacturing experience in the making of thousands of tubes and changes made in the construction and processing, nearly perfect color purity and white uniformity have been achieved. A good deal of the processing improvements are due to changes made in the "lighthouse" on which the phosphor screens are exposed. After a brief review of the principles of the tube and data on its operation, both the tube and lighthouse changes are explained. Equipment used to obtain the data for changes is also described.

EXPECTED LENGTH OF STRINGS AFTER THE FIRST SORTER PASS . . . By F. H. FOWLER, JR., COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented at a Seminar on Applied Mathematics held at Princeton University, November 21, 1955. A sequence of random numbers is divided into maximal increasing subsequences referred to as strings. The even numbered strings are used in their original order to form sequence 0 and the odd number sequences form sequence 1. Some of the strings in original sequence will combine in sequence 0 or 1 to form a single string. The expected total number of strings in both sequences 0 and 1 is approximately

$$0.5\ (9\text{-}3e)$$

times the number of random numbers.



Top view of chassis of the secondary frequency standard. A portion of the chassis deck is cut away to clear switch S1.

A SECONDARY FREQUENCY STANDARD . . . By R. M. Mendelson, Tube Division, Harrison, N. J. Published in HAM TIPS, December, 1955. This paper describes a secondary frequency standard which can be built by the average ham with little difficulty and at low cost. This unit provides accurate and highly stable 10-Kc, 100-Kc, and 1-Mc markers, with the 1-Mc markers readable up to 250 Mc. It is useful not only for marking the ends of amateur bands, but also for receiver calibration, for frequency measurement of received signals, for supplying an accurate, stable signal when "polishing" crystals, and as a signal generator for intermediate-frequency or front-end alignment. Construction details are given for the unit, and adjustment procedures are described.

APPLICATIONS OF TRANSISTORS . . . By K. E. Palm, Defense Electronic Products, Camden, N. J. Presented before the New York Section of A.I.E.E. on December 13, 1955 in New York City. Applications of transistors to military and commercial equipment were discussed. The reduction in size, weight and power consumption were outlined. Attention was given to areas in which transistors provide performance not obtainable with vacuum tubes. The present state of transistor circuit development was examined. Specific transistorized designs were displayed with demonstrations of transistorized equipments in the audio and radio fields given.

EPD PRIMARY FREQUENCY STANDARDS . . . By J. H. Ollis, Defense Electronic Products, Camden, N. J. Published in ENGINEERS DIGEST, Nov-Dec, 1955. This article describes General Radio Type 1100-AP Primary Frequency Standards which employ high-precision piezo-electric oscillators, a 1000 cycle synchronous clock driven by the oscillators, a bank of multivibrators, and a power supply.

THE ROLE OF THE DESIGN ENGINEER IN THE FIELD SUPPORT OF COMPLEX AIRBORNE ELECTRONIC EQUIPMENT . . . By H. W. Brown, Defense Electronics, Camden, N. J. Presented before the Philadelphia Section of the IRE Professional Group on Aeronautical and Navigational Electronics. The success of a complex airborne electronic equipment is highly dependent upon a well planned and timely implemented field support program. The design engineer, however, plays a very fundamental and basic role and the fulfillment of his responsibilities is of major importance. In following good engineering design practice he must consider the requirements imposed by the field. Among these are packaging, the incorporation of self testing circuitry and test points, and accessibility of adjustments and components, all of which contribute to ease of maintenance, thus reducing the turn around time of non-operating equipment. Of equal importance is his analysis of field failure reports, reflecting where necessary any improvements into the design of the equipment.

PRINCIPLES OF COLOR TV FOR THE LAYMAN . . . By D. G. Garvin, Tube Division, Lancaster, Pa. Presented at: Rotary Club, Mount Joy, Pa., November 29, 1955; Rotary Club, Maytown, Pa., December 1, 1955; Rotary Club, Elizabethtown, Pa., December 9, 1955; Lions Club, Mountville, Pa., December 13, 1955. This paper outlines the development of compatible color television by RCA, and compares compatible color with mechanical non-compatible systems of reproduction. A brief description of the operation of color television is given, including the use of the image orthicon in the studio camera and the use of the color kinescope in the receiver in the home. The Lancaster plant where these tubes are manufactured is described, and the major products of the plant are listed. Present development work on color television tubes is mentioned, and broad plans for future work are outlined.

RCA'S PROGRAM FOR COLOR PICTURE TUBES . . . By H. R. Seelen, Tube Division, Lancaster, Pa. Presented to Representatives of Electronic Products Manufacturers at Elmwood Park, Chicago, Illinois, on November 15, 1955. This paper describes the present position of RCA in the field of picture tubes for color-television receivers. The design of the RCA-21AXP22 color kinescope is described, its major dimensions are given, and its operating principles are discussed briefly. Associated components and tubes used in the color-television receiver are also described. The shadow-mask design is shown to be the only practical answer to color-picture reception at the present time. The selection of the 21AXP22 is based upon consideration of mechanical factors, including internal stability, economy, and envelope availability. The use of rectangular tubes for this application is discussed briefly.

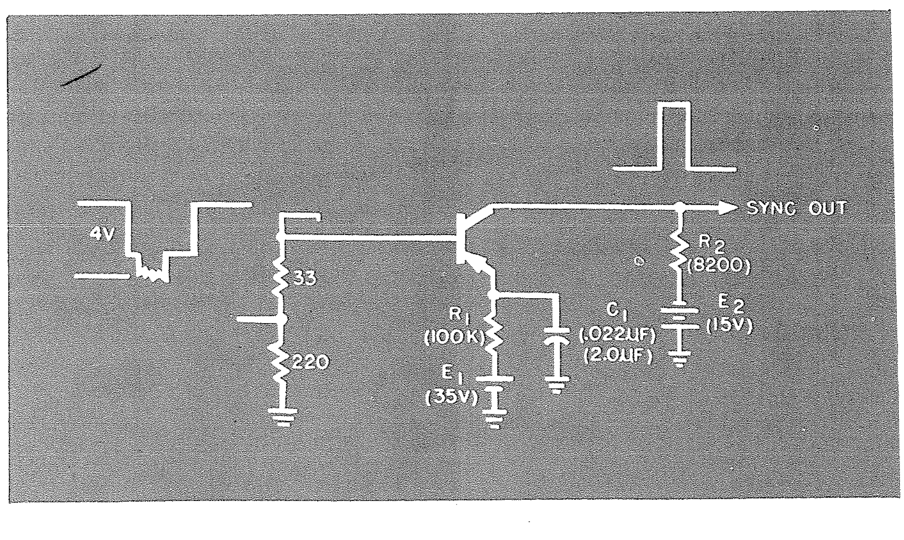
MECHANIZATION AND AUTOMATION FOR PRINTED WIRING PRODUCTION . . . By Lewis Iby, Defense Electronic Products, Camden, New Jersey. Presented at the Winter Conference of Eastern Pennsylvania Council of Industrial Management Clubs at Coatesville, Pennsylvania on December 3, 1955. This paper reviews the progress to date made in areas of printed wiring production. The paper defines the type production system being developed, the necessities of product standardization in order to effect a high degree of mechanization and discusses the degree of mechanization achieved to date.

The importance of a universal system to suit custom electronics quality and quantity factors are discussed and technical problems in areas of material handling and soldering were defined together with proposals for solution of the problems.

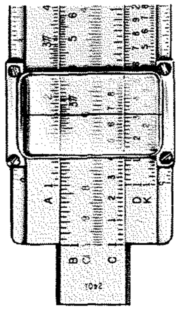
TRANSISTORIZED SYNC SEPARATOR CIRCUITS FOR TELEVISION RECEIVERS . . . By H. C. Goodrich, RCA Victor Television Division, Camden, N. J. Published in RCA REVIEW, December, 1955. This paper presents transistorized sync separator circuits which appear to meet commercial requirements for operation under both good and adverse conditions. Tests on a limited number of transistors indicate good interchangeability and satisfactory performance up to 60°C. The impulse-noise immunity of sync separators is discussed. A method of using diode switching to control the time constant of a single-transistor separator for optimum impulse-noise performance is given.

Transistor collector voltage ratings must be at least equal to the level of sync output voltages required. High-frequency response on the order of that of the experimental SX-160 is needed in the horizontal separator for good sync rise time. Low I_{co} and I_{eo} are desirable, but most of the circuits described will tolerate high-temperature leakages of the order of 50 to 100 microamperes.

Because of the abrupt low-voltage "knee" of the junction transistor, one transistor will produce double-clipped sync. Since this function is usually accomplished with a two-stage vacuum-tube amplifier, the use of a transistor results in increased circuit simplicity.



One stage transistorized sync separator

Engineering  NEWS *and* HIGHLIGHTS

RCA ENGINEERS NAMED TO NEW POSTS IN RECENT ORGANIZATION MOVES

RCA engineers have recently been named to a number of new responsible positions revealed during latest official announcements. These assignments are a continuation of those reported earlier in the Dec.-Jan. issue. All of the new activities have been created as a result of the formation of the new Semiconductor Division and the realignment of EPD into two separate units: Defense Electronic Products and Commercial Electronic Products. See article *"How RCA Organization is Planned to Meet Changing Needs"* in this issue by J. L. Mastran, explaining the philosophy behind recent organizational changes.

DEFENSE ELECTRONIC PRODUCTS (DEP) . . . Reporting to T. A. Smith, Vice President and General Manager, are the following engineers: M. C. Batsel, S. W. Cochran, A. N. Curtiss, C. A. Gunther, and H. R. Wege.

M. C. BATSEL, Chief Technical Administrator, is responsible for coordinating military and industrial engineering relations, will advise and assist the DEP management staff on technical matters, for the development of programs in broad areas—automation, transistors, modular construction and reliability, and will also participate in the work of industry planning committees and programs, and represent RCA with military groups and committees. See *RCA ENGINEER,* Vol. I, No. 1, for Mr. Batsel's biography.

S. W. COCHRAN, Manager, Surface Communications Department, is responsible for Marketing, Engineering and Staff Services, which constitute the Surface Communications Department.

A. N. CURTISS, Manager, West Coast Electronic Products Department, is responsible for Marketing, Engineering, the Los Angeles Manufacturing Plant, and Staff Services, for the West Coast Electronic Products Department.

C. A. GUNTHER, Chief Engineer, Defense Engineering Department, is responsible for Engineering Standards and Services, General Engineering Development, Technical Administration, and Camden Engineering Personnel. He also has functional engineering responsibility for the four operating departments.

H. R. WEGE, Manager, Missile and Surface Radar Operations, is responsible for Marketing, Engineering, the Moorestown Engineering Plant, and Staff Services.

Other Department Managers reporting directly to T. A. Smith are: J. M. Hertzberg, Manager, Airborne Systems Department, and S. N. Lev, Manager, Defense Production Department. In staff positions reporting to Mr. Smith other than Messrs. Batsel and Gunther are: F. H. Engel, Assistant to the Vice President, Washington Office; T. W. Massoth, Manager Operations Control, and Acting Manager, Defense Marketing, and W. L. Richardson, Manager, Defense Planning and Projects Coordination.

COMMERCIAL ELECTRONIC PRODUCTS (CEP) . . . Reporting to A. L. Malcarney, General Manager, are: W. R. Fitzpatrick, Manager, Personnel; J. J. Graham, Controller; J. Hillier, Chief Engineer, Engineering Department (See *Engineering News and Highlights,* Vol. I, No. 4); A. R. Hopkins, Manager, Broadcast and Television Equipment Department; L. R. Jones, Manager, BIZMAC Marketing; C. M. Lewis, Manager, Communications Products Department; J. F. O'Brien, Manager, Theater and Sound Products Department; and H. R. Swartz, Manager, Commercial Production Department.

SEMICONDUCTOR DIVISION . . . Reporting to Dr. A. M. Glover, General Manager, are: F. R. Buchanan, Controller; N. H. Green, Manager, Production Department; T. R. Hays, Manager, Sales Department; Dr. L. Malter, Chief Engineer, Engineering Department; F. F. Neuner, Manager, Marketing Department.

STANLEY W. COCHRAN graduated from the University of Washington in 1927 with the degree B.S. in E.E. He spent three years with General Electric Company at Schenectady. In 1930 he joined RCA, Camden, as a design engineer. In Special Devices Engineering, under his guidance, sound powered telephones, battle announce equipment, and shipboard sound motion picture equipment were developed.

In 1940 Mr. Cochran became a product manager of government sound equipment at the Indianapolis plant. He returned to Camden in 1945 as Manager of Special Devices Engineering. For his services during the war he received the Certificate of Commendation in 1947 from the Secretary of the Navy.

In 1949 Mr. Cochran was appointed Manager of Advanced Development Engineering, specializing in system development work. During 1950, under RCA sponsorship, Mr. Cochran took the Advanced Management Program at Harvard Graduate School of Business Administration. In 1953 he became Manager of Engineering Administration, Standards and Services for the Engineering Products Division, before his appointment in 1955 as Manager, Surface Communications Department, Defense Electronic Products.

ARTHUR N. CURTISS graduated from the University of Pittsburgh in 1927 with a degree of B.S. in E.E. He joined the Westinghouse Electric and Manufacturing Company in 1927, at the same time continuing graduate work at the University of Pittsburgh.

In 1930 he was transferred to RCA in Camden as a design engineer and in 1936 was promoted to engineering supervisor. In 1938 he was transferred to the Indianapolis Plant of RCA as Supervisor of Electrical Design, becoming Head of the Design Section of the Engineering Department in 1943.

In 1945 Mr. Curtiss was transferred back to Camden as Manager of Standards Engineering. In 1950 he was transferred to Los Angeles on a special assignment as Works Manager of the Houston Corporation, which in 1951 was taken over by RCA with Mr. Curtiss as Plant Manager. In December of 1955, this operation became the West Coast Electronic Products Department of RCA, with A. N. Curtiss as Manager.

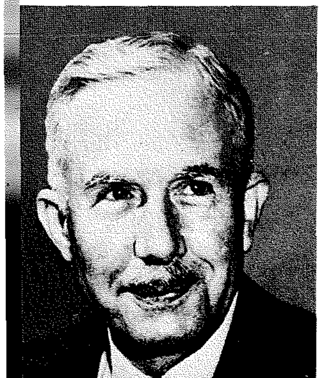
Mr. Curtiss is a senior member and past chairman of the Indianapolis and Philadelphia sections of the IRE. He is also a member of numerous technical and professional societies. He is a registered Professional Engineer in the State of New Jersey.

In January, 1955, Mr. Curtiss was given the RCA Award of Merit.

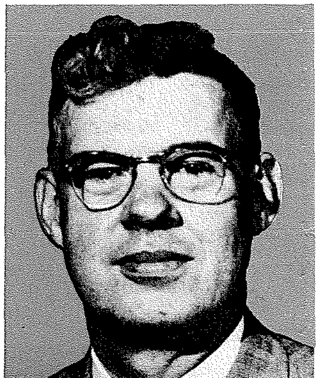
He is the holder of four patents and is the author of a number of articles in the fields of radio, audio and radar.

CLARENCE A. GUNTHER graduated from Princeton University in 1926, with the degree of B.S.E. He entered the employ of the General Electric Company in the Radio Department, and was transferred to RCA at Camden in 1930. He continued to work on

M. C. Batsel

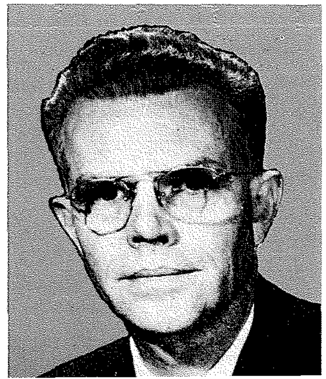


S. W. Cochran

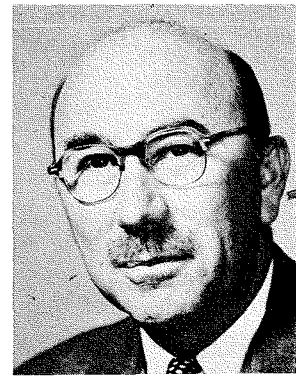


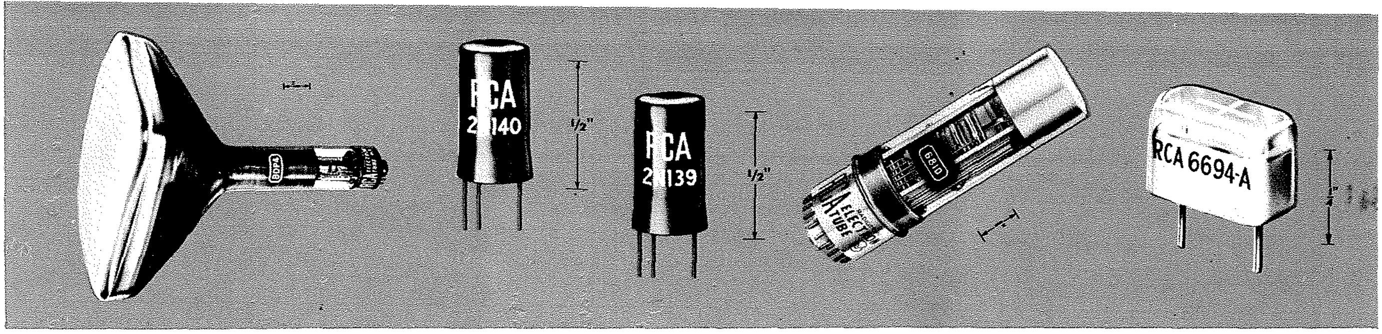
A. N. Curtiss

C. A. Gunther



H. R. Wege





NEW POSTS *(continued)*

special receiver development and soon became section leader of the Special Receiver and Direction Finder Group. In 1945 he was appointed to the position of Assistant Chief Engineer of Engineering Products Division.

In 1955 Mr. Gunther was appointed Chief Government Engineer, responsible for the administration and operation of Government Engineering activities, EPD, and received his present post in late 1955.

Mr. Gunther served as a civilian advisor to the office of the Secretary of War on air warning and bombing during World War II. He is chairman of the Task Group on definitions of RETMA (EA) Reliability. He is a member of the Radio Pioneers Club; the American Society of Naval Engineers, and the Philadelphia section of the Armed Forces Communications Association.

Mr. Gunther received the RCA Award of Merit in 1952; and was awarded a Fellowship in the IRE in 1954.

H. R. WEGE joined the General Electric Company in radio receiver engineering in 1925 after graduating from Kansas State College with the B.S. degree in E.E. He transferred to RCA in 1929 and spent ten years in the engineering of special receivers for commercial and government use.

In 1940 Mr. Wege was appointed supervisor of the Radar Engineering Group, EPD, which was made an Engineering Section in 1950 because of its expansion. The section was moved from Camden to Moorestown Engineering Plant in 1953.

Mr. Wege was Chief Product Engineer for the Missile and Radar Section, EPD, before his appointment as Manager, Missile and Surface Radar Operations, Defense Electronic Products, in late 1955.

Mr. Wege is a member of the American Society of Naval Engineers, the Armed Forces Communication and Electronics Association, Sigma Tau, and a Senior Member of the IRE. He received the RCA Award of Merit in 1954.

L. MALTER obtained a B.S. degree in Physics from C.C.N.Y. in 1926 and a Ph.D. degree from Cornell in 1936. From 1928 to 1930 he was employed at the RCA Technical and Test Department in New York being engaged in research and development in the field of acoustics. From 1933 to 1936 he was employed in the Electronics Research Group at RCA, Camden, working primarily in the fields of secondary emission and electron multipliers. From 1936 to 1941 he worked at RCA, Harrison in the fields of large power tubes, microwave receiving tubes, vacuum pumps and thermionic emission. From 1941 to 1943 he was located at the RCA Research Laboratories in Princeton working on microwave receiving tubes. From 1943 to 1946 he was engaged in Magnetron development at RCA, Lancaster. During 1946-1947 he was in charge of vacuum Tube Research at the Naval Research Laboratories. From 1947 to 1954 he was again located at RCA Research Laboratories at Princeton engaged in research in the fields of Gaseous Electronics. From 1954 to 1955 he was Manager of Engineering for Semiconductor Operations, and he is presently Chief Engineer of the Semiconductor Division of RCA at Harrison, N. J.

NEW RCA SEMICONDUCTOR AND TUBE TYPES

RCA-6694-A is a very small, cadmium-sulfide photoconductive cell of the head-on type. Superseding the previously announced type 6694, the 6694-A features high luminous sensitivity, low dark current, low background noise, and signal output which is approximately proportional to the incident light intensity.

The 6694-A is especially useful in those light applications where a single photosensitive device is desired, in light-controlled relay applications, and in light meters for measuring the brightness of small luminous spots.

RCA-6810 is a head-on type of multiplier phototube intended for use in scintillation counters and in other applications involving low-level light sources. Featuring fast response, high current gain, relative freedom from after-pulses, and a small spread in electron-transit time, the 6810 is particularly useful for fast coincidence scintillation counting. Because the 6810 is capable of delivering pulse currents having magnitudes up to 0.5 ampere without appreciable deviation from linearity, the need for an associated wide-band amplifier is eliminated in many applications.

RCA-8DP4 is a small, compact, directly viewed, rectangular, glass picture tube of the low-voltage electrostatic-focus and magnetic-deflection type. Intended primarily for low-cost, light-weight, compact applications the 8DP4 has a spherical Filterglass faceplate, a screen 7-3/16" x 5⅝" with slightly curved sides and rounded corners and a minimum projected screen area of 35.5 square inches.

Employing wide-angle (90°) deflection, the 8DP4 has a maximum overall length of 10¾".

RCA-2N139 and **RCA-2N140** are two new transistors intended for intermediate-frequency amplifier and converter service in transistorized portable and automobile radio receivers. Both transistors are of the hermetically sealed, germanium-alloy, p-n-p junction type and have excellent stability.

RCA-2N139 is designed especially for 455-Kc i-f amplifier applications. It is capable of providing a power gain of 30 db at 455 Kc in suitable common-emitter circuits of quantity-produced receivers.

RCA-2N140 is mechanically like the 2N-139, but has characteristics which are controlled especially to meet the requirements of converter and mixer-oscillator applications in the Standard AM Broadcast band.

As a result of the controlled characteristics of the 2N139 and 2N140, these types may be interchanged in their respective circuits of suitable design without circuit adjustments.

NEW PRODUCT INSTALLATIONS

SECOND RCA 'RECTANGULAR SLOT' ANTENNA TO BE INSTALLED AT VHF STATION WHTN-TV . . . A 240-foot version of RCA's newly developed "rectangular slot" VHF television transmitting antenna was recently installed at station WHTN-TV, Huntington, West Virginia. The channel-13 antenna is believed to be the largest ever built.

The RCA "rectangular slot" antenna is designed for operation on high-band VHF channels and employs a separate visual section over the aural section. Both are fed by individual transmission lines.

CINEMIRACLE CORP. TO USE SEVEN-TRACK STEREOPHONIC SOUND RECORDING SYSTEM . . . RCA stereophonic film-recording equipment—including the film industry's first transistorized seven-track mixer amplifier—has been leased by Cinemiracle Corporation, Los Angeles, for use with its new wide-screen motion picture process. RCA seven-track playback equipment, and equipment to transfer sound recordings to tape for editing will be installed in a truck, since filming plans emphasize outdoor scenes.

MOBILE COLOR 'STUDIO' FOR LEASE ANNOUNCED . . . A new "studio-on-wheels" service for originating colorcasts of local events will be available to TV stations within a 150-mile radius of Philadelphia. Additional units will be added to extend the mobile service to other major TV centers. The service permits TV stations modified for color to lease a unit completely equipped with video and audio facilities and two "live" studio cameras.

RCA SERVICE CO. TO MAINTAIN EQUIPMENT AT 280 NAVAL AND MARINE CORPS THEATRES . . . The award of a contract to service equipment at 280 theatres on U.S. Naval and Marine Corps shore establishments throughout the country was announced by RCA Service Company, Inc.

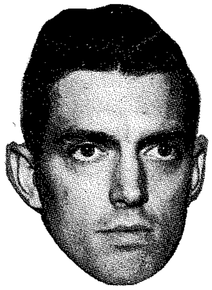
The contract includes the supplying of all parts, tubes and materials for the equipment, in addition to scheduled maintenance calls.

VHF COLOR TELEVISION STATION IS FIRST TO BUY COMPLETE RCA 100-KW INSTALLATION . . . Purchase of a complete RCA 100-kilowatt VHF television installation by a new color TV station in Portland, Oregon, was anounced as the first installation of its kind in the country.

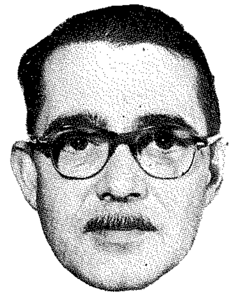
The station will utilize a new RCA 100-kw transmitter and a unique RCA-developed 100-kw superturnstile antenna to achieve 316,000 watts ERP—the maximum established for high-band VHF television stations by the FCC.

RADIO STATION WINS, NEW YORK, TO INSTALL FIRST RCA 50-KW 'AMPLIPHASE' TRANSMITTER . . . Purchase by Station WINS, New York City, of the first production model of an RCA-developed 50-kw AM radio transmitter was announced by Broadcast and TV Equipment Department, CEP. The RCA "Ampliphase" equipment uses two phase-modulated amplifiers to produce a combined power equal to the output of conventional 50-kw AM transmitters.

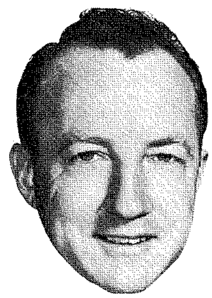
Engineering
NEWS *and* **HIGHLIGHTS**
continued



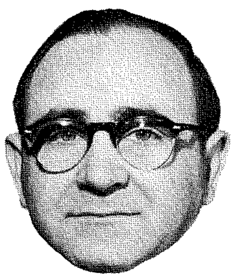
R. C. Beaumariage



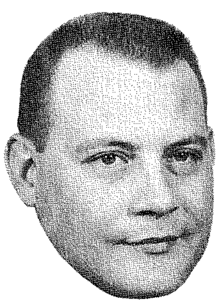
P. J. Herbst



C. E. Hittle



H. Polish



C. C. Simeral

NEW EDITORIAL REPRESENTATIVES APPOINTED

P. J. HERBST APPOINTED EDITORIAL BOARD CHAIRMAN . . . P. J. Herbst has been appointed Chairman, Editorial Board, Defense and Commercial Electronic Products. Mr. Herbst replaces E. D. Blodgett, who is moving into the Marketing activity at the Moorestown Engineering Plant.

Other changes on the "DEP-CEP" Editorial Board are as follows: Dr. D. C. Beaumariage, Airborne Systems, Moorestown Engineering Plant, replaces J. Biewener of that activity.

H. Polish, Manager, Camden Engineering Personnel, replaces H. Krieger, Jr. Mr. Krieger has assumed the post of Administrator, Engineering Personnel Relations, Defense Electronic Products.

C. E. Hittle, Hollywood Engineering, CEP, replaces J. L. Pettus of the Hollywood activity. Mr. Hittle was appointed as a result of an annual rotation policy of editorial duties at Hollywood.

EDITORIAL BOARD CHANGE AT LANCASTER . . . C. C. Simeral, Manager, Engineering Administration, Power Tube Engineering, Tube Division, has replaced E. D. Fleckenstein as Editorial Representative for the Power Tube Engineering function at the Lancaster Plant. Mr. Fleckenstein has transferred to new duties at Lancaster which necessitated relinquishing his editorial duties with the RCA ENGINEER.

The Editors of the RCA ENGINEER wish to thank Messrs. Blodgett, Fleckenstein, Krieger, Pettus, and Biewener for their contributions in the past, and feel assured that they may be counted on for guidance and contributions in future issues of the RCA ENGINEER.

DONALD C. BEAUMARIAGE received a B.E.E. degree in 1946 from Cornell University, an M.S. degree in 1948 and a Doctor of Science degree in Electrical Engineering in 1950 from the Carnegie Institute of Technology. Dr. Beaumariage had been a research assistant and instructor in the electrical engineering department at this institute. Since joining RCA early in 1954, he has held a key position in the development of a secret weapon system. Dr. Beaumariage is a member of Eta Kappa Nu, Pi Mu Epsilon, Sigma XI and Tau Beta Pi.

PHILIP J. HERBST received his B.S. degree in Physics-Mathematics from St. Thomas College, later the University of Scranton, and his M.S. degree from LaSalle College.

In 1927 Mr. Herbst joined the Research Department of the Victor Talking Machine Company. In 1929 he joined the General Electric Company in research in recording sound-on-film for motion pictures. Later the same year, he was transferred to the RCA at Camden, where he carried on development work in the broadcast transmitting field. From 1948 to 1951 he was engaged in analytical review of commercial television as technical advisor on all Broadcast equipment.

In 1950 Mr. Herbst was designated to coordinate the overall RCA effort to improving the quality of video recordings. In 1951 he was appointed Technical Administrator for Standard Products, EPD.

In 1953 Mr. Herbst was made manager of Communications, which include Micro-wave and Mobile Communications. He has 23 patents to his credit, and is a member of the IRE.

CARL E. HITTLE, Film Recording Engineering, Hollywood, graduated from Purdue University in 1933 with the degree of B.S. in M.E. He joined RCA at Indianapolis in 1942, in the Mechanical Design Section, working primarily on film recording apparatus. In 1946 he transferred to Camden, and a year later to Hollywood.

Mr. Hittle is a member of the SMPTE and a registered Mechanical Engineer in the State of California. He has been granted two U.S. patents.

HARRY POLISH is a graduate of Temple University Evening School, Philadelphia, in Accounting. From graduation in 1941 until 1945 he was with the United States Government as an Accountant. Mr. Polish joined RCA in 1945 as an Industrial Engineer, and for the past ten years has progressed in Personnel in Camden and New York. Mr. Polish's present position is Manager, Camden Engineering Personnel.

C. C. SIMERAL graduated in 1943 from Franklin and Marshall College with a B.S. in Physics. From 1943 to early 1946, he was assigned to the Naval Research Laboratory as a Naval officer doing development engineering and analysis work in anti-aircraft fire control radar and computer systems. From 1946 to 1955 he worked in engineering naval and airborne fire control systems at M.I.T., American Machine and Foundry and Melpar, Inc. After a short venture as General Manager of a submersible pump company, Mr. Simeral joined the Tube Division in Lancaster in November 1955. His present position is that of Manager, Engineering Administration, Power Tube Engineering.

COMMITTEE APPOINTMENTS

MAX C. BATSEL, Chief Technical Administrator, Defense Electronic Products, has been appointed Chairman of a new *Ad Hoc* Committee of the Advisory Group on Reliability of Electronic Equipment, Office of the Assistant Secretary of Defense—Applications Engineering. He has also recently become a member of the national Professional Group Committee of the Institute of Radio Engineers, and a member of the Electronics Committee of the American Ordnance Association.

H. KREIGER, JR., Manager, DEP Engineering Personnel Relations, has been appointed a member of the Engineers Joint Council, Committee on Employment Conditions. The Engineers Joint Council is a national organization, composed of representatives from technical societies and industries.

C. M. RYERSON, Standards Engineer, W. Kauffman, EP Administration Quality Control, and R. M. Jacobs, Computer Engineering, have been appointed to the RETMA Quality Acceptance Committee. R. M. Jacobs is Secretary of the QA-1 Laboratory Committee.

G. H. BECKHARDT, General Engineering Development, has been elected Secretary, and R. M. Jacobs, Computer Engineering, has been elected Editor of the Philadelphia section of the American Society for Quality Control.

J. WESLEY LEAS, Chief Product Engineer, Bizmac Engineering, has been named Chairman of the Program Committee for the Joint Computer Conference to be held in New York in December, 1956. The theme of the conference will be "New Developments in Computing Systems and Components."

TWO RADIO & "VICTROLA" DIVISION DRAFTSMEN TRANSFERRED TO ENGINEERING . . . C. H. Emmons and W. C. Roberts, RCA Victor Radio & "Victrola" Division, Cherry Hill, have been transferred to Engineering after receiving their BSME degrees from Drexel Institute of Technology Evening School (Philadelphia) in June, 1955.

Mr. Emmons joined RCA in 1946 as a design draftsman senior and was promoted to drafting checker senior in 1951. Culminating his evening engineering courses last spring, he was transferred to Radio Engineering in late fall.

Mr. Roberts joined RCA in 1950 as a drafting detailer. He was transferred to Bloomington with a government project in 1951 and returned to radio drafting in 1952. Mr. Roberts was promoted through the grades of drafting to the position of checker at the time of transfer as an engineer in late fall, 1955.

MEETINGS, COURSES AND SEMINARS

TRAINING PROGRAM ON FIRE CONTROL PRESENTED . . . Started in the late fall of last year and continuing through the middle of March 1956, a training program describing the MG-10 Fire Control System is being presented in Building 5-2 by the Airborne Fire Control Engineering section of Defense Electronic Products in the Camden, New Jersey plant.

Intended to familiarize about 100 production testing and supervisory personnel with the MG-10 system and begun at the request of Production Engineering, the program purports to give a feeling for the complexity of the MG-10 system. Plant test personnel will thereby attach greater significance to the huge task of testing numerous units and sub-systems which form a factory approved completed system. The course covers 22 topics into which details of the complex system were subdivided to enable an orderly manner of presentation. Three classes (31 one-hour lectures each) with time schedules staggered by approximately two weeks and held at different hours during the week are now in progress. Purpose and Brief System Description, Physical Principles of Basic Radar, Radar Antenna, Radar Search Loop, and Computer Function are topics included among those presented.

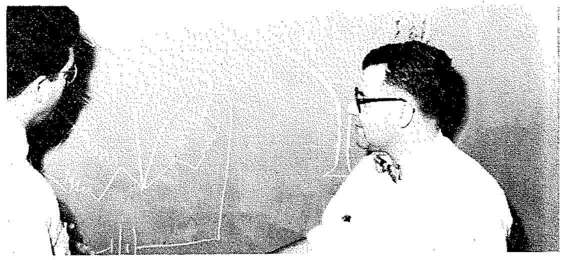
Organized by E. J. D'Amato of Engineering, E. I. Marks and L. P. Comerford of Production Engineering, the major teaching load has been accepted by E. W. Smith. Mr. Smith, F. Pfifferling, R. Perry, R. Magyarics, T. R. Varson, J. S. Williams, C. Cottone and E. R. Campbell, Jr. are combining their efforts to provide a total of over 90 lectures.

H. W. BROWN PRESENTS PAPERS . . . At a meeting of the IRE Professional Group on Aeronautical and Navigational Electronics at RCA on November 29, H. Walcott Brown, Leader of the Field Support group in Airborne Fire Control Engineering, DEP, presented a paper on "The Role of the Engineer in the Field Support of Complex Electronic Equipment." (See *Pen and Podium* in this issue.)

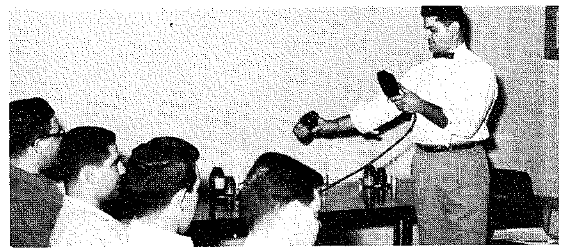
On July 6 and again on November 16, at the request of General Van Deusen, Mr. Brown presented a talk on the "Opportunities in Industry for Electronic Technicians" to the graduating classes at RCA Institutes. The talks have been very well-received and are felt to be valuable in career guidance at the Institute. Talks will be repeated for future classes.

S. D. RANSBURG of Indianapolis Record Engineering, attended the 12th Annual Technical Conference of the Society of Plastics Engineers held in Cleveland, Ohio, on January 17 to 20 inclusive.

SEMINAR ON VACUUM TUBE TECHNIQUES CONDUCTED AT MARION . . . Based on the favorable results of the Seminar on Vacuum Techniques spontaneously initiated and independently conducted by RCA Engineers at Marion in 1954-55, it was decided then to resume the seminar in the fall, covering other fields of interest such as glass, electronics, etc. The new series of seminars is now well underway under the expanded title of "Seminar on Vacuum Tube Techniques and Related Subjects." Occasional sessions have been included on subjects of interest to engineers, though not directly related to their work, e.g., accounting procedures, personnel policies, etc.



W. J. Hart, Marion, lecturing on Glass II, Strain Measurements and Future Development.



R. A. Bergman, Marion, lecturing on Phosphor Manufacture.

Sessions already completed include:

	Date	*Speaker*	*Subject*
1.	Oct. 17, 1955	A. M. Trax	Glass I. Composition and Properties
2.	Oct. 24, 1955	W. J. Hart	Glass II. Strain Measurements and Future Development
3.	Oct 31, 1955	R. A. Bergman	Phosphor Manufacture
4.	Nov. 7, 1955	A. C. Porath	Screen Application
5.	Nov. 14, 1955	J. A. Collins	Work Simplification
6.	Nov. 21, 1955	J. F. Stewart	Purpose and Operation of Equipment Development
7.	Dec. 5, 1955	B. H. McCracken	Accounting Procedures
8.	Dec. 19, 1955	F. M. Polestra	Luminescence

Future Sessions already scheduled include:

W. G. Hartzell	Testing and Interpretation of Associated Data
C. W. Breunig, H. R. Deal, R. C. Horn, J. Keefe, W. Parry, G. Rhetts	Personnel Policies
W. H. Parry	Operations Research
D. C. Ballard	Electron Gun Design
R. A. Bergman	I. C. I. Diagram
R. A. Bergman	Practical Quality Control

Other sessions tentatively planned include talks on Filming and Aluminizing, Purchasing, Parts Manufacturing, and work of other RCA Divisions.

REGISTERED PROFESSIONAL ENGINEERS

In response to the invitation to publicize RCA Registered Professional Engineers as indicated in the last issue of the RCA ENGINEER, the editors are pleased to record the following:

West Coast Electronic Products Department, (DEP)

Name	*Section*	*State*	*Licensed As*	*License No.*
A. C. Blaney	582	Calif.	Elec. Eng.	1987
O. B. Gunby	582	Calif.	Elec. Eng.	3417

Commercial Electronic Products, Hollywood Engineering

Name	*Section*	*State*	*Licensed As*	*License No.*
C. E. Hittle	597	Calif.	Mech. Eng.	10001
J. L. Pettus	597	Calif.	Mech. Eng.	4252
K. Singer	597	Calif.	Mech. Eng.	1973

Corporate Standardizing

Name	*Section*	*State*	*Licensed As*	*License No.*
G. B. Cranston	171	Penna.	Mech. Eng.	11919

RUTGERS COURSE OFFERED FOR REGISTERED PROFESSIONAL ENGINEERING EXAM . . . The University Extension Division of Rutgers University in cooperation with the New Jersey Society of Professional Engineers is offering two refresher courses designed to prepare engineers for the examinations of the New Jersey State Board of Professional Engineers and Land Surveyors. (See *The Registered Professional Engineer*, by J. C. Walter, Vol. 1, No. 4.) The course is offered at the Camden, New Brunswick, Newark and Trenton locations of Rutgers during 1955-56. The complete course consists of 21 sessions, meeting one night a week.

Mr. J. Dudley Hill, Registrar at the Rutgers location at Camden, said that this course is typical of those currently being conducted under joint sponsorship of State Boards of Professional Engineers and local Universities. Where not available, Universities are willing to cooperate in organizing such courses upon solicitation by a group of interested engineers, Mr. Hill said.

Engineering
NEWS *and* HIGHLIGHTS
continued

ENGINEERING DATA AND CATALOGUES

"Interchangeability Directory of Industrial-Type Electron Tubes" (Form 1D-1020A) lists 2000 tube designations presented in a form that should be of maximum assistance to distributors, dealers, servicemen, broadcast stations, and individual tube users in selecting the proper RCA tube type as a replacement. Included in the listings are vacuum power tubes, vacuum and gas rectifiers, thyratrons, ignitrons, magnetrons, cold-cathode (glow-discharge) tubes, phototubes, oscillograph tubes, camera tubes and receiving type tubes for industry and communications. Tubes of 26 manufacturers are indexed in the Interchangeability Directory.

Picture Tube Replacement Directory (Form KB106) is divided into two parts. The first section lists the ratings and characteristics of 60 existing picture-tube types, including the 15GP4 and 21AXP22 color tubes, and 13 discontinued RCA types. The second section lists recommended RCA replacements for more than 150 industry types.

"RCA Photosensitive Devices and Cathode-Ray Tubes" (Form CRPD-105) contains technical data on 45 types of phototubes, 6 types of TV camera tubes, and 56 types of cathode-ray tubes. Each tube type is covered by a text description, tabular data, and a socket-connection diagram. Representative tube types are illustrated throughout the catalog.

Included under phototubes are single-unit types, twin-unit types, and multiplier types as well as their spectral-response characteristic curves and detailed dimensional outlines.

The camera-tube section contains data and spectral response curves for iconoscopes, image orthicons, and vicicons.

SCIENTISTS VISIT MISSILE TEST PROJECT . . . Dr. Otto Schade, Sr., RCA Laboratories, Advanced Development Program, Harrison, N. J., and Messrs. R. O. Drew and D. J. Parker of General Engineering Development, Camden, N. J., recently participated in a series of planning discussions with RCA Service Company's Missile Test Project engineers at Patrick AFB, Florida.

Their visit was a part of an RCA program which would provide assistance to MTP on specialized problems in the optics, electro-optics and photographic fields.

ENGINEERING ASSISTANCE BUILDS GOOD WILL FOR RCA . . . When KMTV, Omaha, Nebraska, ran into difficulty on the eve of their highly publicized inaugural color TV program, a hasty appeal to RCA sent Bill Derenbecker, of Television Engineering, on a fast plane flight to Omaha. Bill arrived at midnight, spent the rest of the night checking out the color camera installation, and during the following day, held a color clinic to indoctrinate station personnel in the operation of the equipment. The owners and staff were high in their praises of the expert service rendered them and expressed their appreciation two weeks later with an order for another color camera.

LUMINESCENT MATERIALS MANUFACTURING STARTED AT MARION . . . Parts Manufacturing Production Engineering now has the responsibility of luminescent materials manufacture. Facilities were recently completed and production started under the direction of B. F. Miller, Manager, Production Engineering.

Mr. Miller came to RCA at Marion in 1951 as a Manufacturing Engineer in Parts Manufacturing. In 1954 he was appointed to his present position.

Engineers who will have the specific responsibility of luminescent materials will be Mr. William Neale and Mr. Daniel Smith. Mr. Neale and Mr. Smith joined RCA in August, 1953.

ENGINEERING MEETINGS AND CONVENTIONS

February-April, 1956

FEBRUARY 15-17
Conference on High-Speed Computers
Louisiana State Univ.
Baton Rouge, La.

FEBRUARY 16-17
IRE, AIEE, Univ. of Pa.
Conference on Transistor Circuits
University of Pennsylvania
Phila., Pa.

FEBRUARY 22-25
RETMA's 1956 Industrial
Relations Round Table
Gen. Oglethorpe Hotel
Savannah, Ga.

FEBRUARY 24-25
Ninth Annual Meeting
Western Radio and Television
Conference
San Francisco, Calif.

FEBRUARY 26-29
American Institute of Chemical
Engineers
Statler Hotel, Los Angeles, Calif.

FEBRUARY 27-29
Second Annual Electronic
Conference & Exhibit, AMA
Hotel Commodore, New York, N. Y.

FEBRUARY 27-MARCH 2
National Meeting of the ASTM
Committee Week at the Hotel Statler
Buffalo, New York

FEBRUARY 28-29
Scintillation Counter Symposium
IRE, AIEE
Shoreham Hotel, Washington, D. C.

MARCH 6-7
Conference on Radio Interference
Reduction
Armour Research Foundation
Chicago, Ill.

MARCH 8-9
Fourteenth Annual
SPI Canadian Conference
Sheraton-Brock Hotel
Niagara Falls, Ontario, Canada

MARCH 12-16
Corrosion Show, held in conjunction
with the Twelfth Annual Conference
of the NACE
Hotel Statler, New York, N. Y.

AIEE Fifth Annual Spring Conf.
Cleveland, Ohio

MARCH 18-21
American Society of Mechanical
Engineers
Spring Meeting
Multnomah Hotel, Portland, Oregon

MARCH 19-22
IRE National Convention and
Radio Engineering Show
Waldorf-Astoria and
Kingsbridge Armory
New York, N. Y.

MARCH 27-APRIL 2
13th Annual Pacific Coast
Section Conference
The Society of the Plastics
Industry, Inc.
St. Francis Hotel
San Francisco, Calif.

APRIL 5-6
Special Technical Conference on
Magnetic Amplifiers
co-sponsored by:
AIEE, IRE, and ISA
Hotel Syracuse, Syracuse, N. Y.

APRIL 10-12
Twelfth Annual Meeting and
1956 Metal Powder Show of the MPA
Hotel Cleveland, Cleveland, Ohio

APRIL 10-11
Symposium for Management on
Applications of Analog Computers
University of Kansas City
Kansas City, Missouri

APRIL 11-12
IRE 7th Region Technical Conf.
Salt Lake City, Utah

APRIL 13-14
Tenth Annual Spring
Television Conference
sponsored by Cincinati Sec., IRE
1349 E. McMillan St.
Cincinnati, Ohio

APRIL 15-19
34th Annual Convention of NARTB
Conrad Hilton Hotel
Chicago, Ill.

APRIL 17-19
Fourth National Conference on
Electromagnetic Relays
Oklahoma Inst. of Tech.
Stillwater, Okla.