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.

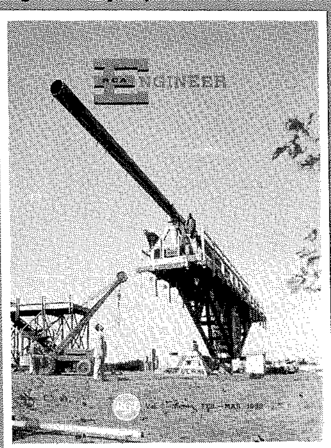
To serve as a medium of interchange of technical information between various engineering groups at RCA.

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

This issue, our cover features the Gibbsboro (N. J.) Broadcast Antenna Test Site. The 15-ton turntable is supporting an Ultragain TV transmitting antenna scheduled for station WTPA, Channel 27, Harrisburg, Pa. Preparing for vertical pattern measurements are (atop turntable, from left) Guido Bastianelli and Edward Lingard. In the foreground is engineer Vincent J. Carita, with Charles Van Dyke and Charles Smith (in crane) looking on. Measurements are taken in small building in the background. (See article this issue by H. E. Gihring.)

KEEPING IN TOUCH WITH YOUR PROFESSION

Our most important asset is KNOWLEDGE. Those of us who are now practicing in industry have found that, no matter how large our background of formal training and practical knowledge, we must continually search out more facts. With limited time to spend in study, we are forced to be selective in our reading. Condensed articles—good ones—are always welcome, particularly those in our personal and our company's field.

The *RCA Engineer* has fulfilled a most important need in my own experience of many years with RCA. Recently I returned to Camden after a number of years with the RCA Laboratories at Princeton. While at Princeton, I was kept informed of many projects in the corporation and the names and photographs of the engineers involved. This was valuable to me at that time and continues to be now as a member of IEP.

This issue contains a typically excellent group of articles including a number which originated in IEP. These describe specific projects for which a single division is responsible but which, in most instances, have a real relationship to other divisions. The strength of RCA is more than the mere summation of its parts. Our success in combining personal and departmental assets in working in a common field may provide the major difference between our competitors and ourselves. The value of combined effort in a single field is obvious in such examples as television, multiple use of a single channel of product distribution, use of the same artists in TV, radio and recording, and technical effort in subjects having several applications. In the latter group may be included electronic data handling, wave propagation and antennas, video circuits, acoustics, magnetic recording, and microwave techniques. Articles describing what other departments are doing and who is doing it are helpful by providing a knowledge of "areas of activities" in addition to the specific information in the text.

In spite of the apparently highly specialized nature of engineering today, there are real advantages to be gained from a knowledge of activities in related fields. The *RCA Engineer* continues to provide a most valuable medium for the communication of technical information and I heartily recommend the reading of every article.

George H Brown

George H. Brown
Chief Engineer
Industrial Electronic Products
Radio Corporation of America

CONTENTS

VOL. 3, NO. 4 • FEB.-MAR., 1958

RCA ENGINEER

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

AWARDS FOR ENGINEERS

by **C. O. CAULTON, Mgr.**

New Product Development
Industrial Electronic Products
Camden, N. J.

C. O. CAULTON, Manager of New Products Administration within the IEP Engineering Department, received his B.S. degree in Physics and Mathematics from Juniata College in 1929.

He joined RCA that year as a development and design engineer in the loudspeaker and acoustical laboratories. In 1939, he became sales engineer in charge of the Private Label Home Instrument Department. During the war he handled sales contacts for the research and development work performed by RCA in all its locations.

In 1946, he was appointed Commercial Product Development Manager for Home Instruments, and in 1950 became Staff Assistant, coordinating color television and mobilization activities for Home Instruments.

In 1951, Mr. Caulton joined Corporate Staff Product Planning, first as Mobilization Coordinator, and later as Facilities Administrator of Planning.

In 1954, Mr. Caulton was appointed Manager, Commercial Electronics Coordination. He was responsible for analyzing and planning commercial product lines.

EACH YEAR MANY AWARDS are available to those in the various professions of engineering and science. Offered by technical societies and corporations, these awards are created not only as an incentive to encourage contributions to science, but are also provided as a means to recognize meritorious contributions to the art.

Electronics, along with its allied professions, has grown into many complex and highly specialized fields to the point where there is a profusion of awards offered to the engineer. Confusion sometimes occurs in identifying these many honors, and this article is an attempt to list those offered by the major technical societies, and from within RCA.

HOW NOMINATIONS ARE MADE

A question in many engineers' minds is how nominations are made for these awards. This depends on many factors.

Some awards are made for the excellence of technical publications, which are usually judged by a committee appointed by the awarding society. Some are conferred in recognition of many years of prominence in a particular field. These, too, are usually awarded from within the society.

On the other hand, many awards are given by a selection from nominees solicited from industry. In these cases the engineer must depend on his associates and his supervisor for the nomination. In the latter instance, the decision of the board of judges rests in most cases on the written records submitted. Final designation of the winner is ordinarily made on a very impersonal basis, depending primarily upon the material submitted by the engineer's supervisor. It is most important, therefore, that nominations and supporting material are prepared in a most persuasive manner.

In rare instances an award is a "natural" as a result of one of those sparks of genius that immediately establishes an individual as a major contributor in his field. Genius, however, is not an everyday occurrence, and most awards are made on a somewhat lower order of achievement. Younger engineers are honored to inspire and encourage them and their peers to make even greater contributions to their profession. Older and more experienced engineers are awarded in recognition of their permanent and essential contributions to the well-being of mankind.

Some awards require a membership in the organization offering the award, whereas others are not restricted in this manner.

Some organizations permit their award committees to grant an honor other than the one for which an individual is nominated. Some awards can be made to teams of engineers, while others are limited to an individual. In the latter case, it becomes necessary to select that one individual who either had the basic idea or made the major contribution. In some societies, nominees are held over for one or more years and are automatically reconsidered by the awards committee.

The tabulation accompanying this article has been prepared to show RCA engineers and managers some of the awards available from a group of the major technical societies as well as from RCA. It is hoped that the list will assist RCA managers in nominations for these awards. As it will be seen from an examination of the tables, the qualification requirements differ, and the dates for submission of nominations vary. In some instances, a man's work might qualify him to be nominated for any one of several awards.

RCA RECOGNIZES AWARDS

RCA has recognized the value of awards, particularly in technical fields—as evidenced by the number of honors offered by RCA in the accompanying list. The Company encourages its engineers to compete for technical honors. Supervisors are also encouraged to sponsor nominees for the various awards. The author hopes that the material presented here will provide a systematic basis for obtaining proper recognition for the engineer's achievements.

LIST OF AVAILABLE AWARDS FOR RCA ENGINEERS

Award	*Submission Date*	*Award Date*	*Type of Award*	*Eligibility Requirements*
ACOUSTICAL SOCIETY OF AMERICA (ASA)				
Biennial Award For Noteworthy Contributions to Acoustics		About Sept. 1	$100	To a young member of the Society (under 35) active in the Society and contributed to the advancement of acoustics.
The Gold Medal of the Society		Odd numbered years	Gold Medal & Certificate	Awarded to an individual making outstanding contributions to acoustics.
Wallace C. Sabine Medal (Newly established award)		Fall of 1957 Awarded every 2 yrs.	Medal and Certificate	Awarded to an individual who has made outstanding contributions to the science of architectural acoustics.
AMERICAN INSTITUTE ELECTRICAL ENGINEERS (AIEE)				
Edison Medal	By May 1	January	Gold Medal	Awarded for meritorious achievement in the electrical sciences, electrical engineering or electrical arts.
Lamme Gold Medal	Dec. 1	Mid-year	Gold Medal	Awarded to a member who has shown meritorious achievement in the development of electrical apparatus or machinery.
John Fritz Medal	At AIEE by May 1	November	Medal	For notable scientific or industrial achievements. Administered by United Engineering Trustees representing four National Engineering Societies, AIME, AIEE, ASME and ASCE.
Washington Award Joint Award of AIEE with ASCE, AIME and ASME	At AIEE by May 1	November	Bronze Plaque	To an engineer whose work has been noteworthy for merit in promoting the public good.
Alfred Nobel Prize Joint Award of AIEE with ASCE, AIME and ASME	Published Paper	January	Approximately $350 and Certificate	A member under 31 years of age of one of the four National Societies in Civil, Mining, Mechanical and Electrical Engineering or the Western Society of Engineers for a paper of merit accepted by a Society for publication. Award yr. from June 1 to May 30.
AMERICAN SOCIETY MECHANICAL ENGINEERS (ASME)				
Honorary Member	Announced 30 Days in Advance	November	Engraved Parchment Certificate	Awarded annually to not more than 5 for "Distinctive Accomplishment in Engineering or Science or Industry or Research or Public Service and those allied pursuits beneficial to the engineering profession." Highest Award of Society.
ASME Medal	"	November	Gold Medal & Engrossed Certificate	Awarded for distinguished service in Engineering and Science. Second Highest Honor.
Holley Medal	Prior to March 1	November	Gold Medal & Engrossed Certificate	"Awarded annually if warranted for a unique act of genius of an engineering nature."
Junior Award	Prior to March 1	November	Engrossed Certificate and $50.00	For the best paper published during the year by a junior member of the Society under 30.
Melville Prize Medal	Prior to March 1	November	Gold Medal & Engrossed Certificate	"Best original paper on a mechanical engineering subject presented for publication and discussion—limited to an ASME member, single authorship only and for a current paper."
Pi Tau Sigma Gold Medal	Prior to March 1	November	Gold Medal and travel expenses	"For outstanding achievement in mechanical engineering within ten years after graduation—under 35 years of age."
Richards Memorial Award	Prior to March 1	November	Certificate, $250 and travel expenses	"For outstanding achievement within 20 to 25 years after graduation—candidate under 45."
ETA KAPPA NU				
The Outstanding Young Electrical Engineer for ——(Year)	May 15 of Each Year (Engineering Manager should submit to Coordinator at least 2 weeks earlier)	Late in Year	Honorary	Not older than 35 and a Graduate EE not more than ten years previously.
FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA				
Franklin Medal	*	*	Gold Medal	Awarded to workers in physical science or technology whose efforts have most advanced the knowledge of physical science or its applications.
Elliott Cresson Medal	*	*	Gold Medal	For discovery or original research adding to the sum of human knowledge irrespective of commercial value.
Howard N. Potts Medal	*	*	Gold Medal	For distinguished work in science or the arts; important development of previous basic discoveries, inventions or products.
John Price Wetherill Medal	*	*	Silver Medal	For discovery or invention in the physical sciences or for new and important combinations of principles or methods already known.
Edward Longstreth Medal	*	*	Silver Medal	For inventions of high order and for meritorious improvement and development in mechanical processes.
Louis Edward Levy Medal	*	*	Gold Medal	Awarded for paper of special merit published in the Journal of the Franklin Institute; preference given to researchers in a subject of fundamental importance.
Stuart Ballantine Medal	*	*	Gold Medal	Awarded for outstanding achievement in the fields of communication and reconnaissance employing electro-magnetic radiation.

LIST OF AVAILABLE AWARDS FOR RCA ENGINEERS—*(Continued)*

Award	*Submission Date*	*Award Date*	*Type of Award*	*Eligibility Requirements*
FRANKLIN INSTITUTE OF THE STATE OF PENNSYLVANIA (continued)				
Boyden Premium	*	*	Premium	Awarded once every five years for notable experimental determination of the speed, in free space, of radiation in any region of the spectrum.
Certificate of Merit	*	*	Certificate	Awarded to persons judged worthy thereof for meritorious inventions, discoveries or improvements in physical processes or devices.
* Selection made by Institute acting through its Committee on Science and the Arts.				
INSTITUTE OF RADIO ENGINEERS (I.R.E.)				
Medal of Honor	RCA Eng. Mgrs. Submit about Feb. 28 Due Section Mar. 31 IRE Headquarters Apr. 30	Annual Banquet March	Bronze Medal	Advancement of the art through theoretical analysis, research, invention, education, development, or other equivalent activities.
Morris Liebmann Memorial Prize Award	RCA Eng. Mgrs. Submit about Feb. 28 Due Section Mar. 31 IRE Headquarters Apr. 30	Annual Banquet March	Certificate and $1,000 Check	IRE member (in the opinion of the Board of Directors) who has made the most important contribution to the radio art during the 3 years preceding the adjudication year.
Vladimir K. Zworykin TV Prize Award	"	"	Citation and $500 Check	Annually for 20 years (1952-1971) at the discretion of the Board of Directors. IRE member who has made the most important technical contribution to TV during the preceding three years.
Fellow Grade	"	"	Citation	Unusual professional distinction and conferred by invitation of the Board of Directors. Member of IRE.
W.R.G. Baker Award	RCA Eng. Mgrs. Submit about June 30 Due Section July 31 IRE Headquarters Aug. 31	"	Income from 100 Shares of G.E. Stock	Member or non-member of IRE—author(s) of best paper in IRE Professional Group TRANSACTIONS during period July1-June 30.
Browder J. Thompson Memorial Prize Award	"	"	$100	Paper published in period July 1 to June 30 in the technical publications of IRE by author(s) under 30 years of age which constitutes the best combination of technical contribution to the field and presentation of the subject.
Scott Helt Memorial Award (Newly Established Award)	July 1 to June 30	Fall 1958 at Symposium of the IRE PGBTS	Suitable Award not to exceed the sum of $250.	Annual award to a Member of IRE for the best paper published in the IRE Professional Group TRANSACTIONS on "Broadcast Transmission Systems" during period July 1-June 30.
Founders Award	Not a routine award. Given only when an outstanding name of unquestioned merit presents itself.	Annual Banquet March	Bronze Medal	Established by Board of Directors. "For outstanding contributions to the Radio Engineering profession through wise and courageous leadership in the planning and administration of Technical developments which have greatly increased the Impact of Electronics on the public welfare."
SOCIETY MOTION PICTURE & TELEVISION ENGINEERS (SMPTE)				
Journal Award	**	Fall Convention	Journal Award Certificate	Outstanding technical paper published in the SMPTE Journal.
Progress Medal Award	**	Oct. thru January	Medal	Significant advances in development of Motion Picture Technology.
Samuel L. Warner Memorial Award	**	Fall Convention	Gold Medal	Most beneficial invention to SMPTE—Not necessarily a member of SMPTE.
David Sarnoff Gold Medal Award	**	Fall Convention	Gold Medal	New completed technical contributions to the art of television.
Herbert T. Kalmus Award	**	Fall Convention	Gold Medal	Current important technical contributions in the Color Motion Picture Industry.
Honorary Membership by Election	**	—	—	Substantial basic contributions to the Motion Picture and/or TV Industries.
Fellow Award	***	—	—	Active member of SMPTE—not less than 30 years of age. Outstanding engineer or executive of the Motion Picture and/or TV Industries who has made substantial contributions to the work of the SMPTE.

** Award Committee of five or six members appointed by SMPTE President. Committee report presented to Board of Governors at July meeting. RCA nominations should be submitted prior to June 1st.

*** Committee similar to above but consisting of approximately 32 members representing national officers and local sections.

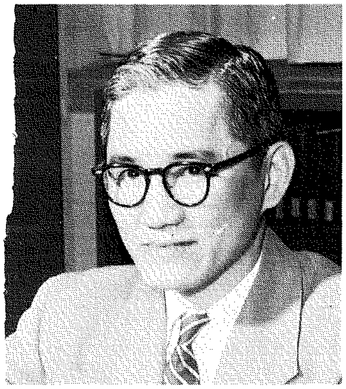
RADIO CORPORATION OF AMERICA

A number of awards and fellowships are available through routine channels which are administered by appropriate departments and individuals and who advise Engineering Managers through proper means. Some of these awards are quite flexible in handling insofar as appointments and dates are concerned. Therefore, the following should be considered only as a guide.

Award	*Submission Date*	*Award Date*	*Type of Award*	*Eligibility Requirements*
The David Sarnoff Outstanding Achievement Award in Engineering	Nominations by the Chief Engineers of the RCA Divisions to Selection Committee by Nov. 15, 1957	To Be Announced	Gold Medal and Citation Certificate	Annual award to the outstanding engineer in the RCA Product and Services Divisions in recognition of an exceptional contribution, through technical accomplishments, which has resulted in marked improvements in products and services of RCA. All engineers up to group leaders are eligible.

TWO RCA ENGINEERS ELECTED IRE FELLOWS

Early in 1958 The Institute of Radio Engineers announced the election of two RCA engineers to the Fellow Grade. Conferred annually by the Board of Directors, the grade of Fellow is one of distinction, and appointment is made on the basis of eminence and distinguished service.



WEN YUAN PAN "For advancement of radio broadcast and television receiver design."

Dr. Pan received the E.E. Degree in 1939 and Ph.D. in 1940 from Stanford University. He was a research associate at the Radio Research Lab. at Harvard U. during the last war. Since 1945, he has been with the RCA Victor Television Division. He is now Group Manager of R-F Circuits Development.

Dr. Pan served as an advisor to the China Defense Supplies in 1941, the International Civil Aviation Conference in 1944, and the Committee of the United Nations Telecommunications in 1946. He is an honorary member of the Veteran Wireless Operators' Association, a member of Sigma Xi, A.O.E., A.A.A.S.

Dr. Pan holds more than twenty patents in Electronics.

ROLF W. PETER "For his contributions to the reduction of fluctuation noise in traveling-wave tubes."

Dr. Peter received the M.S. degree in Electrical Engineering in 1944, and the Ph.D. degree in Radio Engineering in 1948 from the Swiss Federal Institute of Technology in Zurich, Switzerland. From 1946 to 1948 he was Assistant Professor of Radio Engineering at the Swiss Federal Institute of Technology. In 1948 he joined the RCA Laboratories in Princeton, N. J. where he has been engaged in research on traveling-wave tube amplifiers.

In January, 1957, he was made Director of the Physical and Chemical Research Laboratory at RCA Laboratories. Dr. Peter is a Member of Sigma Xi.

Award	*Submission Date*	*Award Date*	*Type of Award*	*Eligibility Requirements*
RADIO CORPORATION OF AMERICA (Continued)				
The David Sarnoff Outstanding Achievement Award in Science	Nominations of the Research Directors to Selection Committee by Nov. 15, 1957	To Be Announced	Gold Medal and Citation Certificate	Annual award to the engineer who during the preceding year has accomplished what is deemed to be the outstanding research achievement in the field of interest of RCA. All members of the research staff of RCA Laboratories will be eligible.
General Management Resident Courses	School Deadline*	Session	Value Varies between $750 and $3500	Selected by Management from employees who have demonstrated management potential. Selection coordinated by Management Development.
* Local Report Due on all Schools by January 15.				
A. M. A.	Varies	4 weeks	"	" "
Columbia	4/1 4/1	6/16-7/27 8/11-9/21	"	" "
Harvard	5/15 12/1	9/12-12/2 2/20-5/17	"	" "
Indiana	4/1	6/10-6/28 (3 wks. for 2 yrs.)	"	" "
M. I. T.	2/1	3/5-5/11	"	" "
Northwestern	3/21 3/21	6/23-7/19 7/21-8/16 8/18-9/13	"	

Non-Resident General Management Courses—These courses are similar to the above and vary from thirty hours to two years and may be at such locations as New York University and The University of Chicago.

Specialized Courses—These may be resident, part time, correspondence or "in plant." A large range of courses are included from meetings of a few days, such as the A.M.A. orientation and workshop seminars, through engineering course of very specialized or broad coverage.

Award	*Submission Date*	*Award Date*	*Type of Award*	*Eligibility Requirements*
Graduate Business Administration Program at Harvard	Oct. 1st	January to August	7½ Months Residence Certificate Award	Individuals already experienced in industry but selected by their Supervisors and processed through the Manager of Management Development to receive additional training. Candidates average 6 yrs. of experience and are usually in the 28 to 35 age group.
Sloan Fellowship for Executive Development —M. I. T.	Jan. 1st	12 Months June to June		Graduate level course provides a degree of MS in Industrial Administration. Selected individuals average 30 to 35 years of age, have had good grades in undergraduate work, at least 5 years business experience and have demonstrated managerial responsibilities. Selection by recommendation of supervisors.
David Sarnoff Fellowships	Jan. 1st	Feb. 15	Tuition, Living Expenses, plus Gift to School	Young employee having academic aptitude, promise of professional achievement and of high character. Award covers one year—recipient eligible for reappointment.

BROADCAST ENGINEERING

By **V. E. TROUANT, Chief Engineer**
Broadcast and TV Equipment Engineering
Telecommunications Division, IEP
Camden, N. J.

Editor's Note: Over the years RCA has gained an enviable reputation as leader in the Broadcast and Television field. An engineering philosophy of designing and producing the finest equipment at a competitive price . . . a consistent policy of teamwork and understanding between engineering, the customer, and marketing groups . . . and an intense pride for product . . . all combine to make this outstanding record possible. We believe the reader, just as we did, will capture this same feeling as he peruses the articles written by our Broadcast Engineers.

Broadcast and Television Equipment Engineering as we know it today developed, not from inner strength or compulsion, but rather from the surging demands of an industry supplying a public service of unquestioned value in our modern civilization. The growth of broadcasting could no more have been stopped than the rising of the sun, once the public began to benefit from this improved medium for disseminating knowledge and entertainment.

CHALLENGE OF KEEPING UP-TO-DATE

The business of broadcasting, first sound then vision, was one of the earliest and most important phases in the development of the vast, complex field of Electronics. The training of engineers has rapidly expanded in this field to keep pace with technical developments. The tremendous growth in the volume of technical knowledge and literature places a growing challenge on both new and experienced engineers to acquire the knowledge demanded in their respective fields. However, the basic function of the engineer is still the same—to harness the forces of nature through understanding and effective application of fundamental physical laws. The very existence of such a vast amount of technical knowledge places emphasis on the need for better academic training so that an engineer can absorb specific knowledge more readily.

IMPROVING PRODUCTS

The expansion of Electronics into so many fields has had a strong influence on the nature of products. A significant effect of this complex society of products is the need for minimizing interference. This has been especially true since the growth of military electronics and the mushrooming of both civil and military aeronautics. In addition to meeting this problem of "community living," broadcast equipment must be highly reliable to satisfy requirements for uninterrupted public service. As a result, such equipment is subjected to stringent tests for spurious emissions and for reliable performance over wide ranges of temperature, humidity and altitude.

TEAMWORK WITH OTHER GROUPS

Engineering has had able assistance from manufacturing and marketing activities. It is well known today that success in a technical product business comes from integrating abilities of different departments, and from a mutual understanding of objectives.

A still further facet of the engineer's responsibility is an intimate knowledge of the customer's point of view and problems. Many of these problems are in training people in the use of equipment. Engineers must employ the art of "human engineering," *designing equipment that is easy to use!* Extending this concept to the ultimate leads to the "Systems Concept" where engineering starts with a basic objective and follows with a concrete plan for —not just a single equipment package—but a complete equipment system, having many integrated units.

Because of the specialized nature of the market, Broadcast and Television Equipment Engineering has enjoyed an unusually close relationship with customers, as well as with Marketing and Manufacturing. This relationship has resulted in a product line, notable for acceptance and reliability.

DIVERSIFIED PRODUCT ENGINEERING

Broadcast Engineering today includes development and design of Broadcast Transmitters, Antennas, and related equipment such as high-power communication transmitters and international short-wave broadcast transmitters. Forms of transmission include TV, AM, FM, UHF, VHF, Scatter and Single Sideband. Frequencies range from audio to 1000 megacycles and power levels stretch from milliwatts in crystal oscillators to hundreds of kilowatts in TV transmitters. Super-power military and commercial equipments reach and exceed one megawatt. RCA Antenna designs, such as the New York Empire State Building's top installation that accommodates several TV stations on one mast, are equally outstanding. TV and radio studios across the country are equipped with RCA microphones, amplifiers, control consoles, and magnetic tape recorders.

For television studios, engineers develop cameras, projectors and important auxiliary equipment such as film multiplexing equipment, monitors and recording equipment. Color Television requires greater precision in design and imaginative new test equipment.

FUTURE

The next twenty-five years are more interesting to contemplate than the past twenty-five years. Certainly transistors will be well established. The myth of a saturation in engineering is no more true now than at any time in the past. Simplified, yet reliable operation are continuing goals which will require increasing ingenuity on the part of present and future engineers.

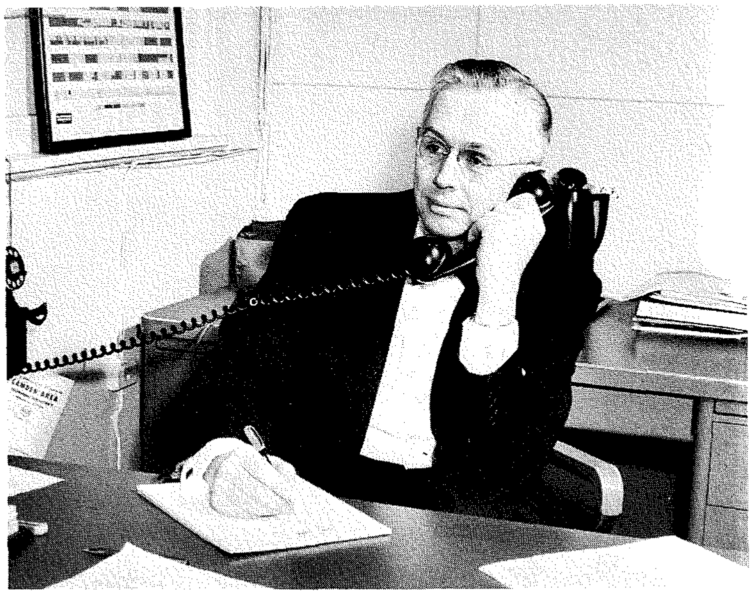
V. ELMER TROUANT, Chief Product Engineer for Broadcast and Television Equipment Engineering, received his BSEE from the University of Maine in 1921. With Westinghouse Electric he specialized in automotive ignition systems and later transferred to radio transmitter engineering. Coming to RCA in 1933, Mr. Trouant designed one of the early 50-kilowatt broadcast transmitters. He continued as a supervising engineer until his 1945 appointment as Manager of the Communication and Radio Frequency Section. In 1951, he was appointed Chief Design Engineer for Standard Products.

Typical of RCA developments under Mr. Trouant's guidance are high-power transmitters with high-level modulation, air-cooling, and grounded grid amplifiers. He has also directed the design of a complete line of broadcast transmitters for AM, FM and television—plus apparatus and test equipment for color television broadcasting.

Mr. Trouant is a member of AIEE, SMPTE, and is a Senior Member of IRE.

JOHN E. YOUNG was graduated from Drexel Institute in 1928 with the degree of B.S. in E.E. Upon graduation, he joined General Electric Co. in their training course for radio engineers. He was assigned to the development of what was then described as the first super-power broadcast transmitter, rated at what now seems to be a modest 50 kw. These transmitters were manufactured in 1929 and 1930. Mr. Young spent these two years installing several 50-kw broadcast stations in U. S. and Mexico. Mr. Young was transferred to RCA Victor Co. at Camden in 1932 and participated in design of the first transmitter project undertaken by this Company, a 500 watt Navy transmitter. Since then, he has been concerned mainly with the design of broadcast transmitters and antennas, successively as a Design Engineer, Group Manager, and now as Manager of Broadcast Transmitter Engineering.

Mr. Young is a Senior Member of IRE, having served on Committees for Transmitters and Modulation. He has also served on a number of committees and panels of the Electronic Industries Association, and is presently Chairman of the Panel on AM and FM Broadcast Transmitters. He is also currently active on the Transmitter Panel of TASO.



25 YEARS OF TRANSMITTER ENGINEERING

By **J. E. YOUNG, Mgr.**
Broadcast Transmitter Engineering
Telecommunication Division, IEP
Camden, N. J.

RCA's ACTIVE PARTICIPATION in Broadcast transmitter design and construction began almost simultaneously in two fields—design and manufacture of a 500-watt transmitter for the Navy, and design of a 250-watt and 1-kw broadcast transmitter. This work started in 1933 when RCA began to engineer its own broadcasting equipment in competition with other manufacturers supplying transmitters to the Armed Services. This issue of the RCA ENGINEER appropriately marks the twenty-fifth anniversary of RCA's transmitter engineering and manufacturing.

EARLY LACK OF STANDARDS

Early transmitter designs were turned out in a very different atmosphere from that existing today in RCA's numerous engineering sections. The most striking difference perhaps (were we suddenly transported back to that early environment) would be the complete absence of Standards of any kind. This extended to manufacturing as well, so that a large part of the design engineer's time was spent in discussion of very fundamental manufacturing matters, and in making a choice of components on which his information was meager.

RELIABILITY AND STYLING VITAL FACTORS

Despite these provocative and interesting problems, and perhaps because of them, a philosophy of design began to emerge which is still a guide today. Reliability and operating convenience were stressed, with simplicity and ease of installation only slightly less important. Attractive, distinctive appearance was considered so necessary that a well-known industrial designer was consulted on cabinet styling, and his recommendations were closely followed. This unusual attention to the Broadcasters' needs gained a high degree of acceptance for RCA's equipment—an acceptance still enjoyed today.

HIGH-LEVEL MODULATION

The first 250-watt broadcast transmitter designed and built by RCA was designated the Type 250D. It used the high-level system of modulation in which conversion of audio to radio-frequency energy takes place in the output stage of the transmitter, and the modulator stage is operated Class B. This circuitry had many advantages over the low-level method of modulation most frequently used up to that time, and *indeed this basic circuitry*

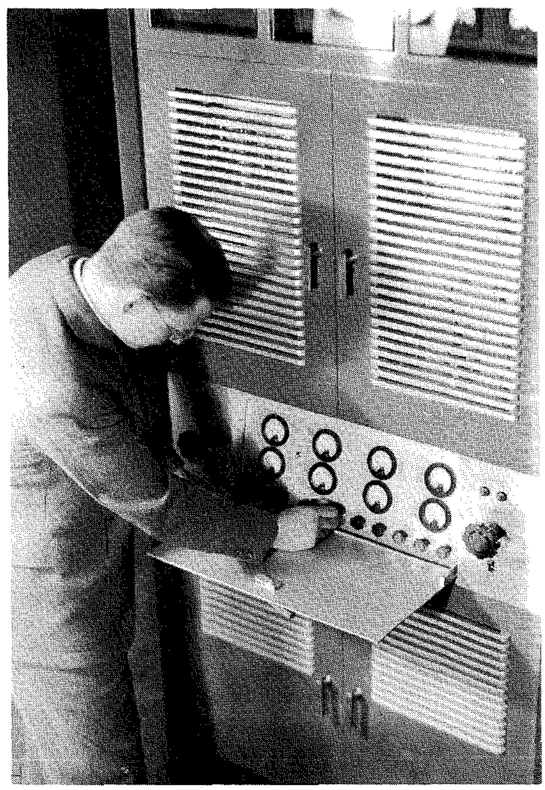


Fig. 1—C. M. Lewis (then RCA Engineer and now Manager, Marketing Plans, Telecommunications Division, IEP) shown at the controls of the first "250 Watter" designed and built by RCA in 1935. This also served as a driver for 1-kw transmitter.

is still used in RCA's standard band transmitters up to 10-kw output power. The coupling between the modulator and final r-f amplifier in such transmitters is provided by an iron core transformer. At power levels above 10 kw, this transformer becomes difficult to engineer and expensive. This did not prevent the construction of much higher-power transmitters, however, and a number of 50-kw broadcast transmitters are now in operation using this principle. Several 500-kw high-level transmitters have also been built by RCA, and at least one of these performed a vital service during World War II.

"AMPLIPHASE" MODULATION

Engineers have continually searched for other modulation methods which would retain the advantage of high efficiency without the cost and complexity of the Class B modulator coupling transformer. In one such system the r-f output load is divided between two tubes so that the share of the load, and the magnitude of the plate impedance of each tube shifts as a function of the modulating signal. This system has the disadvantage of circuit complexity and high inherent distortion. In another, the outputs of two chains of Class C amplifiers are connected together and the phase of the exciting signal of the two chains is differentially varied by the modulating signal. The phase of the two outputs varies from full opposition to full reinforcement, as a function of the modulating signal, producing an r-f signal which is amplitude modulated in exact conformance with the applied signal. This method of modulation, first used by Chierex, has been greatly refined by RCA engineers and used for our newest 50-kw standard band transmitter.* This system, named "Ampliphase" eliminates all dependence on high-power, audio-frequency iron core transformers, and opens the way to very-high-power amplitude modulated transmitters with much simplified circuitry.

FM, UHF AND COLOR TV

FM broadcasting, for which transmitters were designed just before, and just after World War II imposed new requirements on transmitters with respect to modulation methods and operating frequencies, and these requirements were extended and broadened by the advent of monochrome television, and later, color television. To meet these new demands, new tubes and circuits were developed and in more than one case old circuitry was brought out, dusted off, revised, and used again. Transmission bandwidths were widened to accommodate the television signal and r-f carrier frequencies were pushed up into the VHF and then the UHF range as a larger and larger part of the spectrum was required for broadcast transmission.

GREATER ECONOMY ATTAINED

In parallel with the extension of frequency, power, and type of transmission there was also a continuing improvement in the transmitting equipment. In the face of rising costs of material and labor, transmitter costs were held steady, and in many cases reduced; performance, reliability, and operating convenience were improved. These gains were due to a number of factors. The engineers and manufacturing people acquired experience and knowledge; basic techniques, such as the use of feedback were invented and applied to transmitters; and radical improvements were made in materials and components. Each of these things affected cost, size, and performance of transmitters. World tensions and conflict, and electronics' important part in this situation greatly accelerated all these developments.

CONSTANT PROGRESS

This steady progress has caused each newly designed transmitter to be soon improved upon, and then obsoleted by other newer designs. Although there are a number of standard band broad-

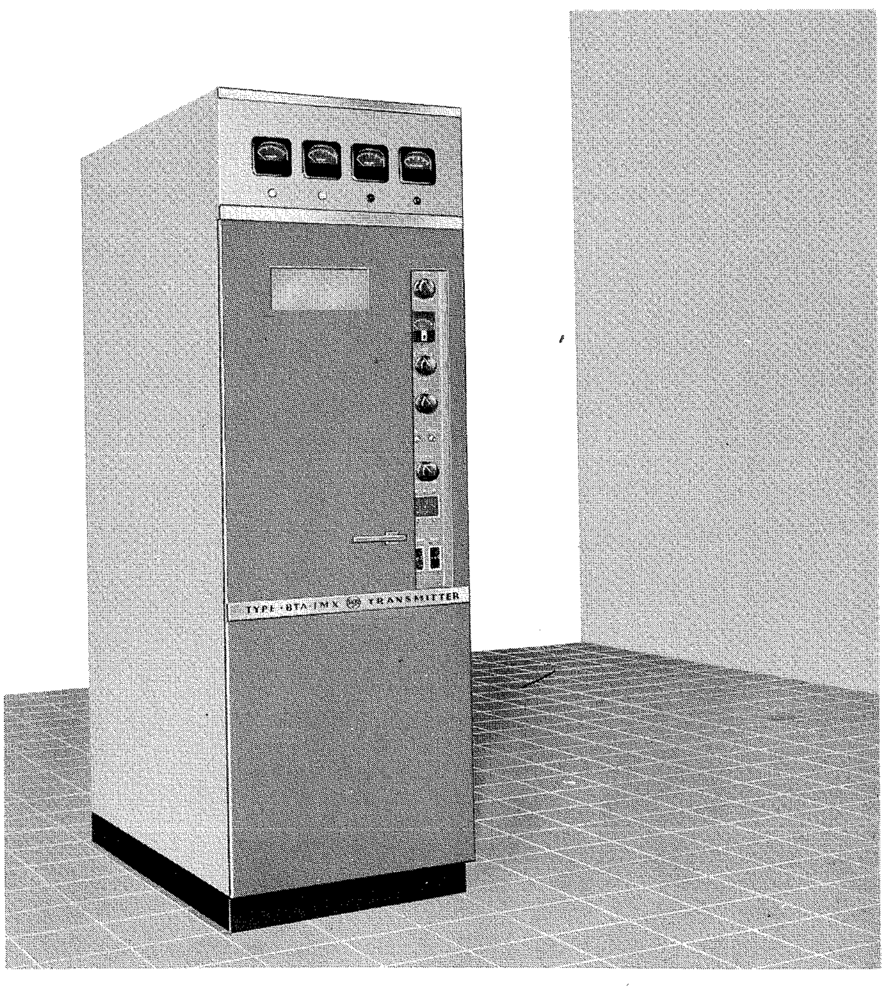
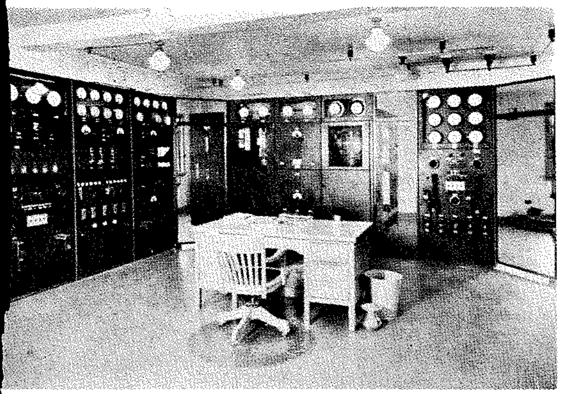
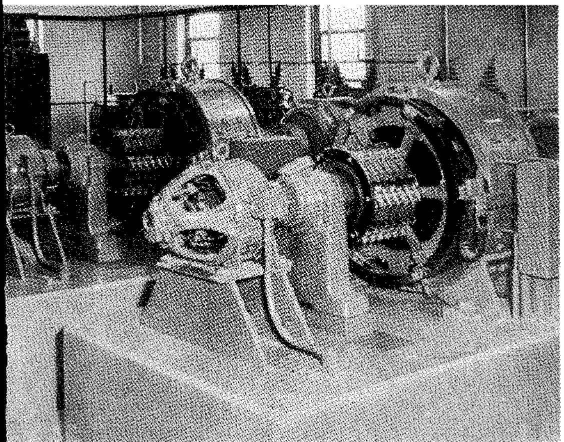


Fig. 2—A recent 1-kw AM Transmitter designed for maximum economy and compactness.

* See article this issue by C. J. Starner, "Recent High-Power Transmitter Design."

Fig. 3—The type 50-B transmitter of thirty years ago was sturdily built and devoid of styling. It required two floors because of its bulk and the heavy power apparatus required.





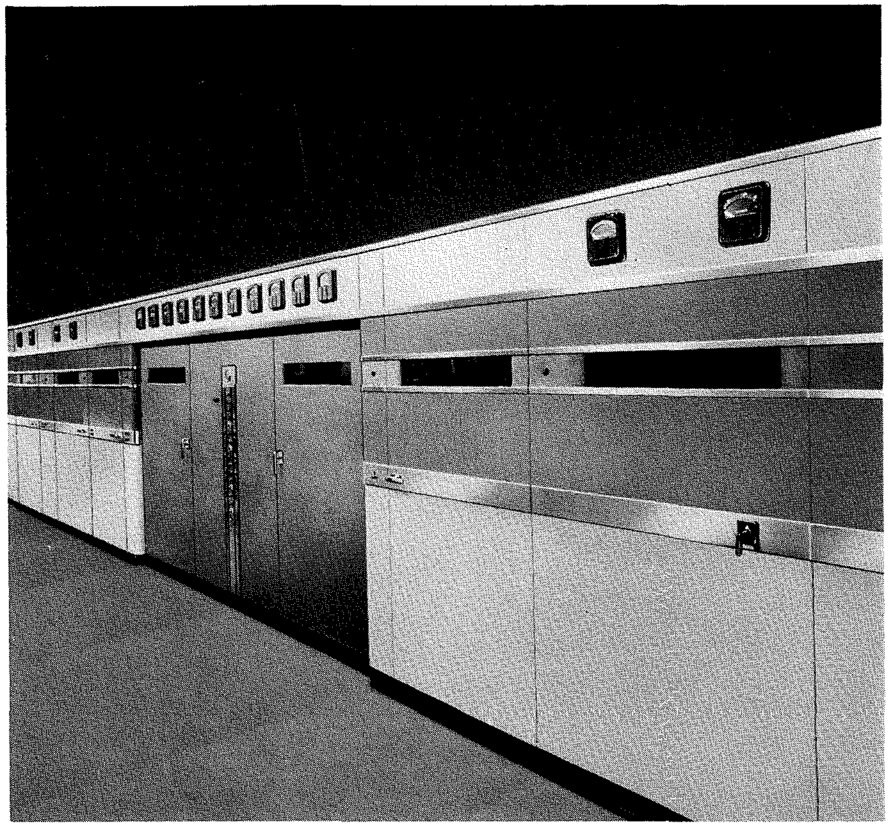


Fig. 4—Recent 50-kilowatt designs are styled to provide a unified, streamlined appearance. Compactness results in economical, one-floor installations.

cast transmitters still giving service 15 to 20 years after first installation, the life of most designs as a salable item is not much more than 3 years. For instance, RCA's 250-watt standard band transmitter has been brought out in new model form some eight times. Not all of these models contained radical changes, yet each was a sufficient improvement to justify the expense of the redesign. This continual search for improvement, for new techniques, new features, partly under the spur of competition, but partly from an innate urge to build better is typical of our engineering creed.

Illustrative of the external changes and simplifications which have been made are the accompanying illustrations. Fig. 1 shows the RCA Type 1D transmitter, the first 1-kw design made by RCA. Fig. 2 shows the BTA-IM, a recent design for this power level. In the same way, Fig. 3 shows the Type 50B transmitter and Fig. 4 shows a model which is entirely self-contained, except the plate transformers and distribution switches.

The Type 50B transmitter illustrates the lack of interest in styling typical for this class of equipment thirty years ago. As broadcasting gained importance, the broadcast plants became places of public interest, and RCA took the lead in styling transmitters to fit into the broadcaster's showplaces. Fig. 4 shows the Type BTA-50F, 50-kw transmitter which illustrates this trend. Later, the transmitter plant became less accessible to the public, transmitters began to be remotely controlled, and although good, clean styling is still important, such lavish attention to appearance is no longer needed. This trend is shown in Fig. 1 of the article by C. J. Starner.

At each stage in design progress, it appears that the ultimate has been achieved; in fact, more than one good engineer shifted his interest from broadcasting to other fields in the late 1930's because no further improvements could be imagined. This feeling is partly attributable to the fact that each of the broadcast media—standard band AM, FM, and television—is a system with parameters of power, transmission form, bandwidth, and frequency, closely circumscribed by federal regulation and millions of existing receivers. Any change must be compatible with these limitations. Fortunately, progress has continued as new materials, new components and new techniques have steadily appeared, and as long as ingenuity, vision, and competition exist we can be confident that change and improvement will continue.

ANTENNAS FOR TV AND RADIO BROADCASTING

by **H. E. GIHRING**
TV Broadcast Antenna Engineering
Industrial Electronic Products
Camden, N. J.

In the center of any metropolis or on its outskirts you will see red lights blinking in the night sky indicating the presence of a tower or other tall structure. Under a great number of these blinking lights you will find RCA broadcast antennas. Since 1946 RCA has sold hundreds of TV transmitting antennas, representing a major portion of the market.

The responsibility for designing these antennas and maintaining RCA's position in a highly competitive market through a quality product rests with a group of twenty-five engineers —known as the Broadcast Antenna Group.

TELEVISION ANTENNAS

Some of the earliest television broadcast antennas were designed for the Empire State Television Installation where broadcasts were started as early as 1931. The first antennas were simply vertical dipoles, one for visual and one for aural transmission. As the television art progressed, design concepts have steadily changed.

Gain

Early antennas had power gains (referred to a dipole) from three to six. It soon became apparent that increasing gain was an economical method of achieving a higher value of effective radiated power which, when properly directed, increased coverage. Cost analyses have indicated that effective radiated power achieved in the antenna is more economical than increasing the transmitter power, as long as antenna length does not exceed 175 to 200 feet and provided the required value of field strength is maintained over the service area.

Vertical Patterns

The vertical pattern of a broadcast antenna determines the field strength that will exist in various parts of the service area, since it is a plot of the relative field strength at each vertical angle. Fig. 1 is a vertical pattern of an antenna aperture of 38 wavelengths having uniform current distribution and all radiating sources in phase. The lower scale indicates that zero nulls would punctuate the service area at frequent intervals for the first seven miles for the conditions given. This type of coverage is practically unusable because of the low field strength areas. These areas under certain conditions are filled in by energy scattered from reflecting points in high intensity areas which result in multiple images.

With antennas having gains of 6 or less, the null areas are usually close enough to the transmitter location so that they are not detrimental. For greater gains they are often detrimental depending upon the distribution of population and the height of the antenna above terrain. Hence, definite measures for achieving a more uniform field strength must be used. These will be discussed under specific types below.

Horizontal Pattern

For television broadcasting the great majority of antennas have a pattern that is designed to be omnidirectional, although most types depart from a true circle because of radiator configuration. A specification of ± 3 db or better is generally accepted as omnidirectional.

Usually there is little advantage in the use of a directional antenna since the maximum effective radiated power specified by the FCC cannot be exceeded.

Some stations have used directional antennas when a great natural height such as a mountain was located on one side of the service area. In another case, a directional antenna was used to avoid a multiple image caused by a higher mountain in back of the transmitter location.

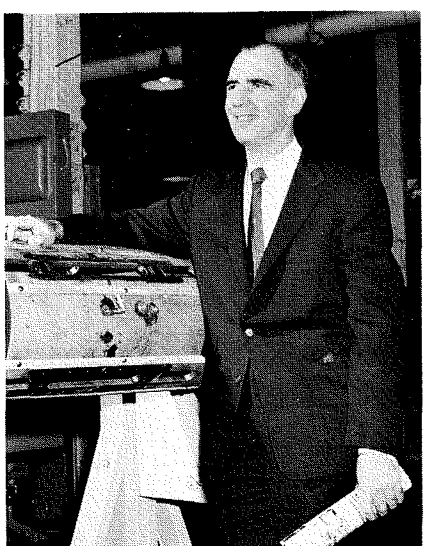
Windload

The supporting tower cost is a large item in the initial expense of a station. Its cost is related to the overturn moment of the antenna. Hence, this overturn moment is an important consideration in antenna designs.[1] As a result, the trend in RCA's newer designs is toward slotted cylinders having a low wind load and high reliability, and which are also economical to manufacture.

De-Icing

Since ice may affect the electrical performance of the antenna adversely, electrical heaters are used to de-ice the antenna. Strip heaters applied near the slots or in the radiating ele-

H. E. GIHRING received his degree of B.S. in E.E. from Washington University in 1926. From 1926 to 1928, he served as Electrical Assistant in the Signal Corps. In 1929, he joined the Technical and Test Dept. of RCA. In 1930, he was transferred to Camden in the newly formed Broadcast Transmitter Section, and from 1930 to 1935 he was assigned to propagation and antenna work. In 1936, he was transferred to New York for a year to work on the Empire State television transmitter installation, and from 1937 to 1940 he was engaged in television transmitter development. In 1940, he was assigned to the supervision of the Television Transmitter Group which expanded into Radar activities until 1944. From 1944 to the present time, he has been engaged in television transmitter and antenna work in a supervisory capacity and is presently the manager of the Broadcast Antenna Group. Mr. H. E. Gihring is a senior member of the IRE.



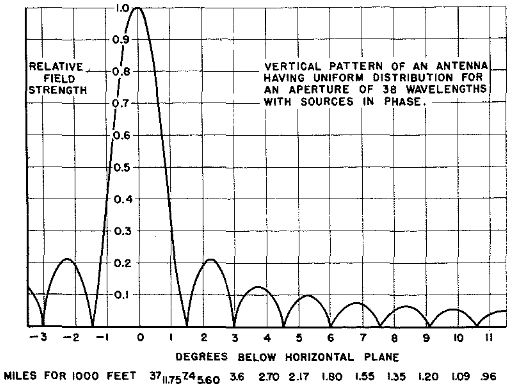


Fig. 1—Vertical pattern for an antenna having uniform distribution and sources in phase for an aperture of 38 wavelengths.

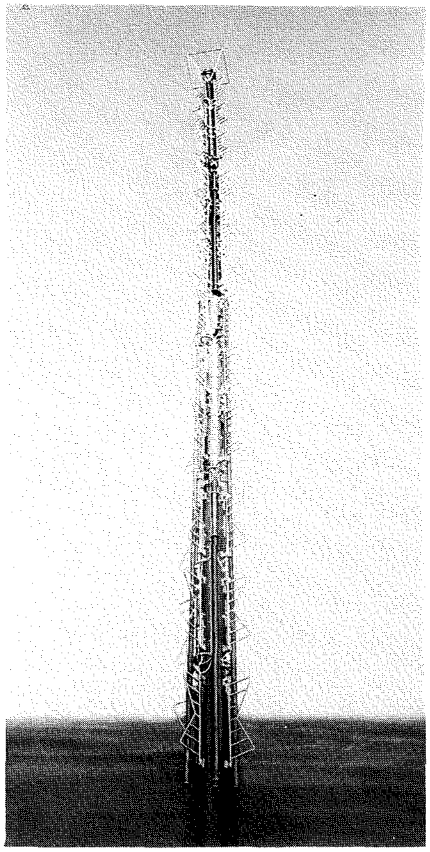
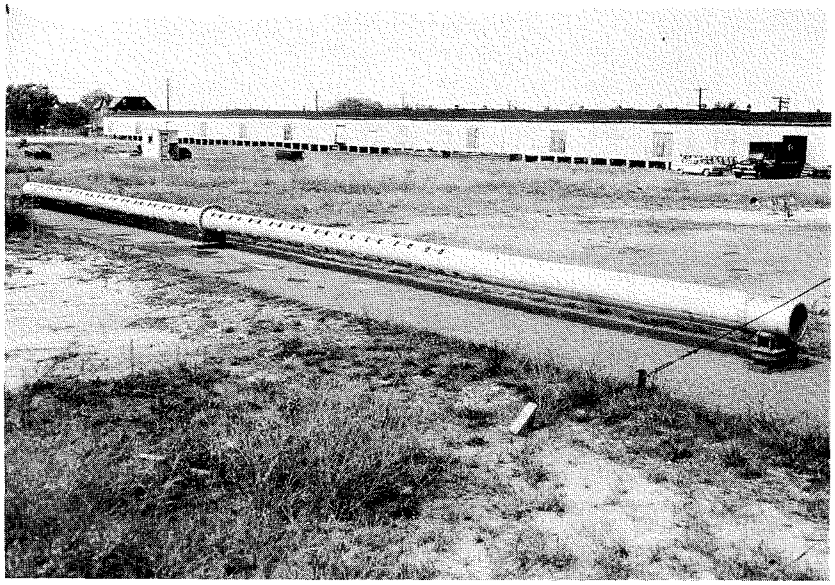


Fig. 2—TF-12BH Superturnstile Antenna.

Fig. 3—The lower portion of "Traveling Wave Antenna" designed for a gain of 15 at channel 8.



ments have been found to be most effective.

THE SUPERTURNSTILE ANTENNA

This antenna was developed by RCA in 1945 and has been the standard of the industry for television broadcasting. At the time of the television "freeze" which terminated in 1952, the line of Superturnstile antennas was completely redesigned[2] to handle the higher power permitted by the FCC and also to provide gains up to 12 for all VHF channels. Performance characteristics and production methods were also improved so that a high quality product could be built in quantity at a low cost. RCA has supplied over 300 of these antennas to date, most of them in the United States. Fig. 2 is a photograph of a 12BH antenna which has a gain of about 12 and consists of 48 radiating elements. Antennas with gains from 1 to 18 have been supplied. By the use of a current-sheet radiator, a bandwidth of 30% has been achieved. Two of those sheets are used in intersecting planes at right angles to each other so that there is negligible mutual coupling. This provides two independent antenna systems which are quadrature fed, thus producing a circular pattern.[3,4] The quadrature feed permits the simultaneous transmission of aural and visual signals from one antenna by means of a bridge network.[3,11]

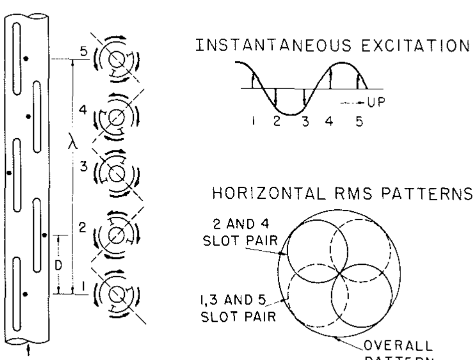


Fig. 4—Excitation and Horizontal Pattern Formation of the Traveling Wave Antenna.

The "filling-in" of nulls in the vertical pattern has been accomplished by various methods. In the channel 7-13 twelve-section antenna (TF 12AH) it has been done by dividing the power between the upper and lower six sections in a ratio of 70:30. The TF 12BH antenna[5] provides 200 mv/m with 316 kw ERP from a 1000 foot tower from 20° below horizontal to the point where attenuation in the main beam brings it below this value. This high uniform field over the service area is achieved by varying the phase of the radiating elements in the antenna.

The Superturnstile antenna has also been used in many other custom applications for withstanding higher windloads, stacking several antennas for multi-channel operation, and placing several antennas on a platform on the top of the tower in a "candelabra" arrangement.[6,7]

THE SUPER GAIN ANTENNA

This antenna[8] utilizes the same general principles as the Superturnstile antenna. The radiating elements, however, are specially designed dipoles mounted in front of a screen approximately one half wavelength wide. The four screens are mounted on the four faces of a tower. The fact that the tower has a cross section one half wavelength square makes it suitable for multiple stacking arrangements. An outstanding example is the Empire State Bldg. installation for five stations in New York City.[9]

TRAVELING WAVE ANTENNA[10]

In July, 1952, specifications were written for an ideal television broadcast antenna. In 1953, advanced development work started on a contract to Ohio State University where Wayne Masters, formerly with RCA, started development work on the antenna. He evolved the basic idea of the Traveling Wave antenna. In November 1957, after considerable development work at RCA, both theoretical and experimental, the first antenna was shipped to KGHL in Montana. Fig. 3 is a photograph of this antenna. The Traveling Wave antenna is mechanically quite simple, consisting of a slotted pipe with a single center conductor. It has the advantages of inherently low VSWR, a null-free pattern, and low wind load.

The antenna is fed through a broadband input to the single central conductor. A single transmission line connects this input to the station equipment. A filterplexer[11] is used to combine the visual and aural signals.

The general method of operation is shown in Fig. 4. Slots are disposed as shown in intersecting planes at right angles to each other and are fed with probes from the central conductor so that the currents on the pipe produce a pattern similar to the dotted dipole. The currents from the adjacent slot produce a similar pattern in the orthogonal plane. Since "D" is a quarter wavelength, the vectors will add in quadrature so as to produce a substantially circular pattern as shown in the sketch.

Up to this point, the theory is similar to that of the Superturnstile antenna. There are differences, however, in the method of feed and in broadbanding. Each of the probes is set at the same depth so that the energy radiated along the pole produces a tapered distribution. This results in a vertical pattern which does not have the lobes and nulls characterizing an aperture with uniform distribution, but has the vertical pattern shown in Fig. 7. The figure shows depression angle below the horizontal vs. relative radiated voltage. Since depression angle can be converted to miles for a given height, the distance in miles is shown on the curve for a 1000 foot elevation. The curve of depression angle vs. relative field needed to produce 100 mv/m and 200 mv/m under most favorable conditions is also shown. It can be seen that the antenna which has a gain of 18 provides an almost ideal coverage for the service area. If a lower gain antenna is used, the value of field strength produced is even higher. Hence, even though the antenna has a power gain of 18, a substantially null-free pattern can be produced with high uniform field strength.

UHF ANTENNAS

Since high power gains can be achieved in UHF antennas with relatively small antenna aperture, gain values started in the vicinity of 20. To obtain a suitable vertical pattern, nulls were filled in by a combination of unequal power distribution and electrical beam tilt. These antennas consisted of slotted cylinders in which each slot is fed by a coupling loop.[12] Over 100 of these antennas were built and sold by RCA.

The effective radiated power of UHF stations at this time ranged from 15 to 200 kilowatts, whereas a maximum of one megawatt was permitted. A study was made to determine the most economical means of achieving a megawatt and it was found that a 25 kw transmitter with an antenna gain of 50 would provide excellent coverage at the desired power. The first installation was made at WBRE in Wilkes-Barre, Pa.[13] which went on the air December 31, 1954. Since that time additional installations have been made. Fig. 6 shows one of these antennas being assembled at Gibbsboro.

The first reaction of almost everyone to a gain of 50 is that the beam is so sharp that the signal will overshoot the service area. However, if full advantage is taken of the latest techniques in pattern shaping, the coverage obtained is superior to that of lower gain antennas in which this is not done. A tapered distribution of radiated power, high in the center and lower at the ends of the antenna, is used to obtain a null-free pattern. Furthermore, in order to reduce the unused radiation above the horizon an asymmetrical phase distribution is used. A typical calculated pattern with a measured pattern superimposed is shown in Fig. 5. It can be seen that good correlation is obtained. A high uniform field strength can be achieved by this method out to the point where attenuation in the main beam brings it below this value.

Since each antenna is custom built, almost any reasonable pattern requirement can be offered. This is done by a special method in which the pattern requirement is converted into the amplitude and phase requirement for each radiator.

TESTING PATTERNS OF VHF AND UHF ANTENNAS

As can be seen from the above the pattern produced by the antenna is very important to good coverage. In order to obtain assurance that antennas are performing in accordance with calculations, RCA has built an antenna pattern test site near Gibbsboro, New Jersey.[14]

Gain and the vertical pattern is determined by measuring the power flow through a sphere.[15] The problem in this type of measurement is in overcoming various errors due to reflections from objects, ground reflections, etc. Before the site was chosen tests were made to determine its suitability.[13] After this three turntables were constructed to handle antennas up to 15 tons, 3 tons, and 1 ton respectively. The first one was located on the south-

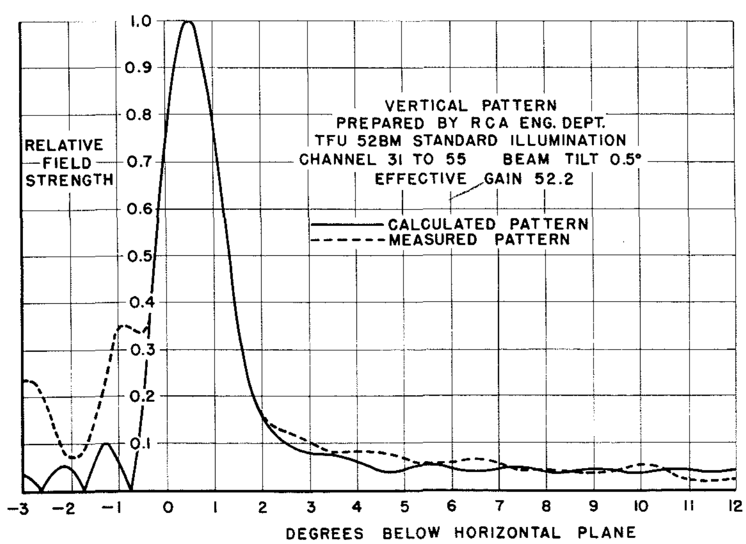


Fig. 5— Calculated and measured pattern of the TFU 52BL antenna.

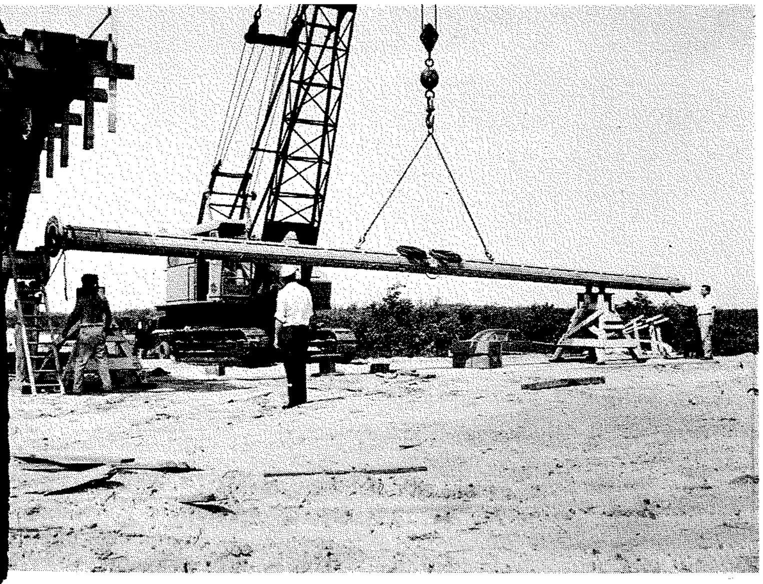


Fig. 6—Two halves of one of the high gain antennas being assembled.

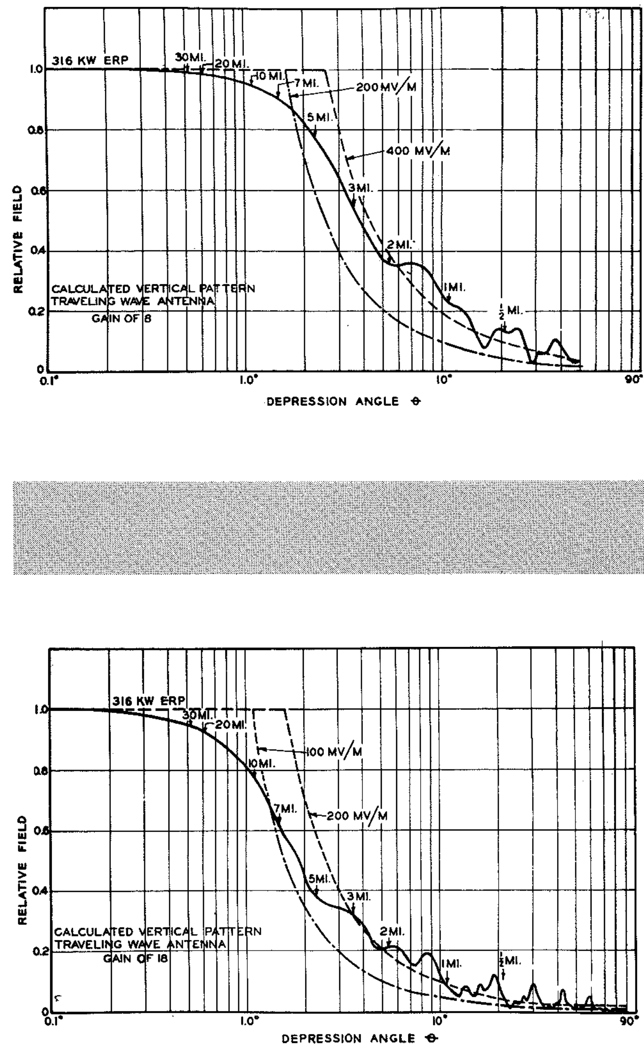


Fig. 7—Vertical patterns of the Traveling Wave Antenna for a gain of 18 and a gain of 8.

Fig. 8—View of the Gibbsboro Test Site. The 15 ton turntable is in the background.

ernmost hill (Fig. 8) and the other two on the northernmost hill 800 feet removed. The cover photograph is a close-up view of the 15-ton turntable which will take antennas up to 130 feet long. A crane for handling the antennas (Fig. 6) is kept on the site at all times. The antennas are rotated at speeds up to one RPM by a thyratron-controlled d-c motor and gear reduction drive. Signals at required frequencies are transmitted from an 80-foot tower at Union Mills, 2.4 miles away. Fig. 9 is a photograph of this tower on which various transmitting dishes and corner reflectors are located for both VHF and UHF. The shack below contains oscillators which can be turned on and off and varied in frequency by remote control from the turntable location. The antenna under test is used as a receiving antenna so that it and the pattern recorder are at one location.

Fig. 10 shows the recording equipment in which the chart is selsyn-driven to produce a continuous recording. All three of the turntables are similarly equipped.

In the valley between the two hills, is a building used as headquarters for the operation. Most of the assembly and impedance work is done in this area. The building also contains a small machine shop and office.

These facilities have been invaluable for development work on antennas and also for testing production antennas.

FM ANTENNAS

Initially the Turnstile antenna was used for FM broadcasting.[16]

In 1944 and 1945 development work on a cylindrical slot antenna named the "Pylon Antenna" was completed.[17] The antenna was 20 inches in diameter and utilized a single row of slots, each about 1.3 wavelength long, fed at the center. The ratio of diameter to wavelength was low enough so that the horizontal pattern was substantially omnidirectional. The antenna is described in the literature.[18] It was built for different gains from 1.5 to

12. Over 300 antennas of this type were sold.

With the advent of television, many broadcasters desired to use their television antennas to transmit FM signals. This was accomplished for channels 4, 5, and 6 by the use of a Triplexer[19] which permitted simultaneous transmission.

STANDARD BROADCASTING ANTENNAS

Up to about 1930 most broadcasters used "T" antennas suspended from two towers. After this, tower antennas began to be used in which the tower itself, insulated from the ground, became the radiator. Various tower shapes were used including tapered towers and also towers resting on a single insulator with the widest cross section at the center. Some work on models of towers[20] in 1935 demonstrated the desirability of using towers of uniform cross section, since current distribution vitally affected the performance of these radiators.[21]

The ground system used at that time consisted of relatively few radials less than one quarter wave in length. Dr. G. H. Brown made some studies which were borne out in practice, showing that efficiency could be markedly increased by the use of larger ground system consisting of at least 120 radials one half wave in length.[22,23]

Shortly after this time, broadcasters resorted more and more to the use of directional antennas, not only to obtain improved coverage over the service area but also to prevent interference to other stations using the channel. By "protecting" the other stations, more stations were able to use the same frequencies. The groundwork for the design of directional antennas was laid by Dr. G. H. Brown in articles which became the handbook of the industry on this subject.[24,25]

CONCLUSION

The trend in TV antennas is to higher gain, largely because of economics, and because vertical patterns can now be obtained which will provide a substantially uniform high field strength over the service area. On some antennas the distribution of field strength can be varied to suit specific requirements.

The trend in RCA antennas has been to slotted cylinders both for VHF and for UHF, since they offer a minimum of wind load with a simplified rugged structure.

As an aid in development and to determine conformance to specifications on certain antennas, a pattern testing site utilizing three turntables was constructed at Gibbsboro, N. J. Development of new types of antennas to enhance both reliability and performance is continuing.

REFERENCES

1. "Wind Velocity and its Effect on Transmitting Antennas and Towers," D. W. Balmer, *Broadcast News*, Vol. 82.
2. "New 50 KW VHF Superturnstiles," H. H. Westcott, *Broadcast News*, May-June 1953.
3. "The Turnstile Antenna," G. H. Brown, *Electronics*, April 1936; *Broadcast News*, December 1936.
4. "The Superturnstile Antenna," *Broadcast News*, R. W. Masters, January 1946.
5. "The New 12BH High Gain Antenna," Irl T. Newton, Jr. and H. H. Westcott, *Broadcast News*, March-April 1954.
6. "Predicting Performance of Candelabra Antenna by Mathematical Analysis," Matti Siukola, *Broadcast News*, October 1957.
7. "The Hill-Tower Antenna System," R. H. Wright and J. V. Hyde, *RCA Engineer*, August-September, 1955.
8. "High Gain and Directional Antennas for Television Broadcasting," L. J. Wolf, *Broadcast News*, Vol. 58.
9. "Multiple Television and Frequency Modulation Transmitting Antenna Installation on the Empire State Building," J. B. Dearing, H. E. Gihring, R. F. Guy, *Proc. IRE*, March 1953.
10 "Traveling Wave Antenna," Matti Siukola, *Broadcast News*, Vol. 94, April 1957.
11. "Diplexers and the VHF Filterplexer," I. E. Goldstein and H. E. King, *Broadcast News*, September-October 1952.
12. "A New UHF Television Antenna—TFU24-B," O. O. Fiet, *Broadcast News* March-April, 1952.
13. "The Ultra-Gain High Power UHF Antenna," E. H. Shively, *RCA Engineer*, June-July 1955.
14. "Gibbsboro Test Site for Ultra-Gain UHF Antennas," *Broadcast News*, February 1955—Page 10.
15. "Pattern Measurements of RCA UHF TV Antennas," E. H. Shively and L. D. Wetzel, *Broadcast News*, February 1955.
16. "A Pretuned Turnstile Antenna," G. H. Brown and J. Epstein, *Electronics*, June 1945.
17. Patent #2,513,007, Inventor W. Darling.
18. "Measured Characteristics of the Pylon Antenna," O. O. Fiet, *Broadcast News*, December 1947.
19. "Triplex Antenna for Television and FM," by L. J. Wolf, *Electronics*, Vol. 20—Page 88, July 1947.
20. "General Considerations of Tower Antennas for Broadcast Use," by G. H. Brown and H. E. Gihring, *Proc. IRE*, April 1935.
21. "A Critical Study of the Characteristic of Broadcast Antennas as Affected by Antenna Current Distribution," G. H. Brown, *Proc. IRE*, January 1936.
22. "The Phase and Magnitude of Earth Currents near Radio Transmitting Antennas," G. H. Brown, *Proc. IRE*, February 1935.
23. "Ground Systems as a Factor in Antenna Efficiency," G. H. Brown, J. Epstein and R. F. Lewis, *Proc. IRE*, June 1937.
24. "Directional Antennas," G. H. Brown, *Proc. IRE*, January 1937.
25. "Adjusting Unequal Tower Broadcast Arrays," G. H. Brown and J. M. Baldwin, *Electronics*, December 1943.

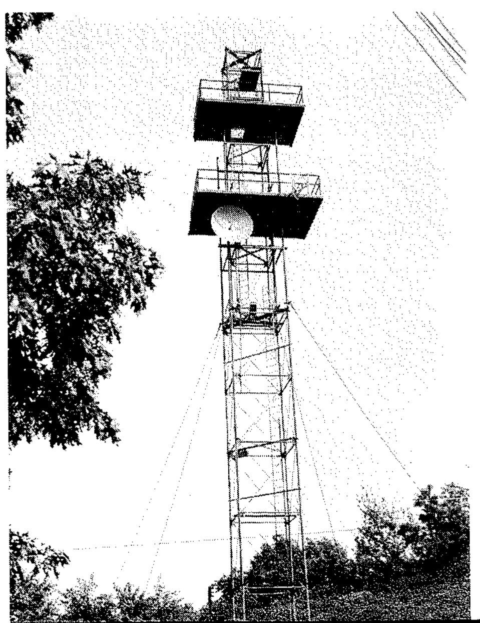


Fig. 9—Transmitting tower located 2.4 miles from the turntables at the Gibbsboro test site.

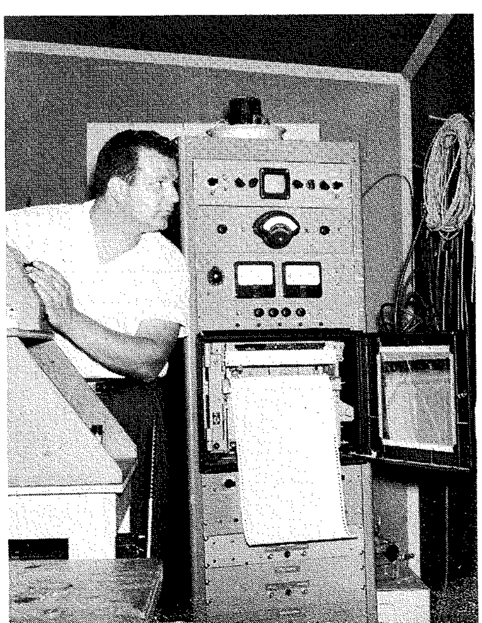


Fig. 10—Patterns taken on the antennas are continuously recorded as shown. The speed and rotation of the turntable is controlled from this point.

CURRENT HIGH-POWER AM TRANSMITTER DESIGN

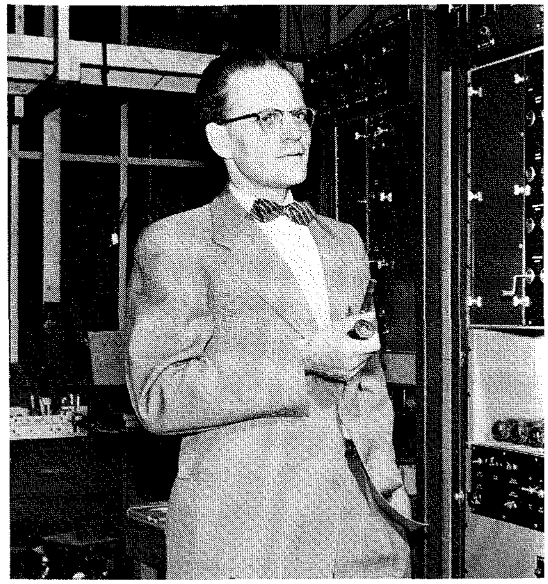
By **CHARLES J. STARNER**
Broadcast Transmitter Engineering
Industrial Electronic Products
Camden, N. J.

OUR CURRENT high-power AM transmitters have been designed after giving careful consideration to many factors. Rising building costs indicated the desirability of a small package as does the existence of a sizable replacement market. The imminent likelihood of remote operation, now a reality, indicated need for simplicity and reliability. The industry competitive situation emphasized the need for an economical first cost as well as low-cost operation. Additionally, there was every indication of a future sizable market for equipment at power levels as high as 750 KW.

CHARLES J. STARNER received the BS EE degree from Gettysburg College in 1930, and for one year did graduate work at Stanford University. He joined RCA in 1931 as a Technical Representative. In 1934 he joined the Ker-o-kil Manufacturing Company (Industrial Oil Burners) as Chief Engineer.

In 1940 Mr. Starner rejoined RCA as a design engineer in Broadcast Transmitters. He is currently Leader of High-Power Broadcast Transmitter Engineering.

He is a Member of IRE, and has 6 U. S. Patents.



A comparative analysis of the various methods of modulation indicated that the Ampliphase system would meet every requirement imposed by the factors outlined above, and most importantly, would carry on the high standards of performance expected of an RCA transmitter.

The BTH-250A (250-KW transmitter) is an outstanding example of the advantages gained by the Ampliphase design. An extension of the existing 50-KW transmitter, it was designed and manufactured in a quantity of one at a cost substantially lower than that possible with other systems of modulation (see Fig. 1).

AMPLIPHASE MODULATION THEORY

As the name implies, amplitude modulation is effected by first differentially phase modulating two identical r-f amplifier chains and combining their outputs through suitable networks into a resultant amplitude modulated signal. Fig. 2 is a vectorial representation of the process wherein the phase modulated outputs of the two separate amplifier chains combine to produce the wholly amplitude modulated signal.

On the vectorial presentation, OB, OB_1, and OB_2 represent the current from Channel B. The angular positions represent the relative phase difference between the two channels, with OB and OC being the carrier position, OB_1 and OC_1 the trough of modulation and OB_2 and OC_2 the peak of modulation.

The addition of these currents in the common load resistance R will result in a current represented by OA. It can readily be seen that changing the relative positions of vectors OB and OC will result in a change in amplitude of vector OA. If the positions of OB and OC are differentially and equally changed, there will be a change in amplitude of OA but no change in the position of OA. Thus, the combined output represented by vector OA will have amplitude modulation only and no phase modulation.

If Channels A and B were in phase, each would see a load resistance of 2R. Conversely, if they were out of phase by 180°, each would see a load resistance of zero. It can be shown that over a range between these two points each would see a load impedance following a cosine squared function of one-half the phase angle between them. This load impedance Z is

$$Z_1 = 2R \cos^2 \frac{\theta}{2} \pm J2R \sin \theta.$$

If we cancel the reactive component $\pm J2R \sin \theta$, as is done in practice, by off-setting the plate tuning of each output stage by an equal and opposite amount, then

$$R_1 = 2R \cos^2 \frac{\theta}{2}$$

where R_1 = load resistance seen by each tube. Now, if we choose θ as 135° for the carrier condition, then R will increase to four times its carrier value when θ is reduced to 90° and to zero when θ is increased to 180°. Inspection of a cosine squared function over this angular range will show that the variation is quite linear with respect to angular change. If a constant current is available from each channel, then the power in R will also vary linearly from zero to a value four times that obtained at the 135° phase difference point (carrier level).

To obtain this constant current, a 90° network is used as the plate tank circuit for each channel output tube, as shown in Fig. 3. Three requisites are fulfilled. First, the load resistance is inverted and transformed to a value suitable to the output tube. Second, constant current is assured if constant voltage is maintained at the input or tube end of the network. Third, a suitable tank circuit is available for correct class C operation of the output tubes.

From the above, it is evident that

the output tubes will see widely varying impedance during the modulation cycle. If a reasonably constant r-f plate voltage is to be maintained over the modulation cycle (to maintain constant current into the varying common load and constant efficiency), the grid drive must vary synchronously, but inversely, with the load impedance variation. This is accomplished by grid-modulating the driving tubes with the audio signal phased so that the drive voltage is raised at the peak of modulation and lowered at the trough.

PHASE MODULATORS

The phase excursion required for complete modulation is approximately ± 25 degrees on each channel. It is relatively difficult to obtain this amount of linear phase modulation from a simple, easily adjustable single modulator. Accordingly, three phase modulators are operated in cascade to provide the necessary ± 25 degree of phase modulation. Cascading is accomplished by arranging the modulated r-f amplifiers in series and applying the modulating signal in parallel to the variable resistance modulator tubes.

The basic modulator amplifier consists of pentode tube driving a tank circuit so constituted and adjusted that it presents a constant impedance to the driving tubes regardless of its phase angle. It can be shown by Equation (1)

$$|Z| = \left[\frac{(X_L^2)\ (R_1^2 + X_C^2)}{R_1^2 + (X_L - X_C)^2}\right]^{1/2} \qquad (1)$$

that if the circuit, Fig. 4, is adjusted so that $2X_C = X_L$, the impedance $|Z|$ will be constant and equal to X_L regardless of the value of R. If, then, R is caused to vary, only a change in phase will result in accordance with Equation (2) giving amplitude free phase modulation.

$$\theta = \tan^{-1} \frac{2R_1^2 - \frac{L}{C}}{2X_L R_1} \qquad (2)$$

If the variable resistance is replaced by a triode vacuum tube (Fig. 4-a), with proper circuitry, R will vary with audio signal on its grid in accordance with Equation (3) and the phase modulated output of the modulated amplifier will be linear and free of distortion.

$$R_1 = \frac{1}{\frac{1}{R_k} + \frac{1}{R_p} + \frac{1}{G_m}} \qquad (3)$$

THE BTH-250A TRANSMITTER

Modulator

Fig. 5 shows the basic circuitry of the BTH-250A transmitter. R-F is generated by a crystal-controlled oscillator operating at carrier frequency. This r-f is separated into two channels differing in phase by 180°. Each channel is then passed through two adjustable phase shifters which reduce this phase difference to approximately 135°. These phase shifters set the carrier power level and are the means used to provide variable power output to compensate for changes in line voltage or output impedance variations.

From here each channel passes through three cascaded phase modulators, each contributing approximately ± 7.5° of phase modulation, resulting in a total phase excursion of ± 22.5°, corresponding to 100% amplitude modulation.

Drive Regulator Unit

This unit supplies the necessary drive voltage variation to match current demands on the output tubes. Circuitwise, it consists of two low-level audio stages driving a cathode follower stage, which modulates both 4X5000 driver tubes simultaneously.

Exciter

Functionally the exciter consists of a first r-f class C amplifier and the 4X5000 grid-modulated driver stage. Conventional single-ended circuitry is employed in both stages, with inductive coupling to the output grids. A nominal amount of r-f fixed loading at the output grids provides a reasonably constant load for the 4X5000 over the modulation cycle. All adjustments for both stages are

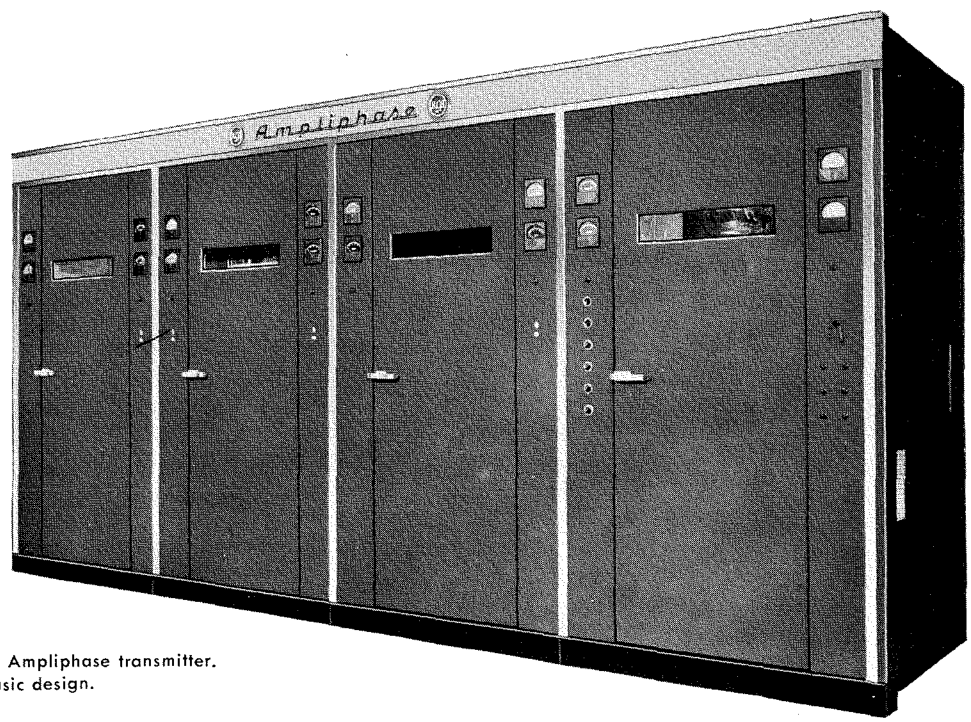


Fig. 1—Front view of the BTA-50G, 50-KW Ampliphase transmitter. The 250-KW unit is an extension of this basic design.

conventional, i.e., maximum grid current indication of the following stage.

Output Stages

The output stage for each channel is a conventional grounded-cathode class C amplifier using a single 6949 shielded-grid triode. Water-cooled throughout, the 6949 is capable of producing a peak power (100% modulation) of 500 KW, with a power gain of approximately 100 in this service. Its unique shielded grid construction allows grounded cathode power gain with grounded grid stability. No neutralization is needed for stability at these frequencies. However, broad band transformer neutralization is applied to prevent detrimental incidental phase modulation from the finite (15.5 $\mu\mu$fd) grid to plate internal capacity. A conventional 90° pi network forms the plate tank circuit.

Harmonic Filter

The impedance of the combined output of the two output stages is approximately 20 ohms, while the nominal transmitter output is 70 ohms. A low-pass filter transforms the common point impedance of 20 ohms to the transmitter output of 70 ohms, and provides added attenuation for the higher order r-f harmonics which exist in the common point output.

Power Supplies

Low-power and auxiliary power supplies are conventional. The main power supply departs from conventional practice in that a unitized combination of transformer and rectifying tube is employed.

Two identical rectifier units are used in parallel. Each consists of 6 type 857B mercury vapor tubes in a 3-phase, full-wave circuit. The tubes are mounted on the main high-voltage transformer case, with their individual filament transformers mounted in the main transformer tank and insulated by the same insulating oil as the main high voltage windings.

Each rectifier unit has a continuous duty rating of 16.5 amperes at 18,000 volts or a combined rating of 33 amperes. In the event of the operational loss of one rectifier unit, program operation at 75% of full power is possible with one rectifier.

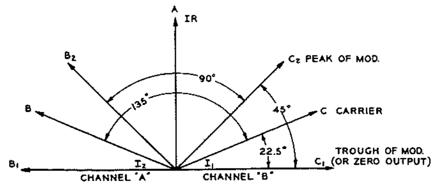


Fig. 2—Vector Diagram, output circuit

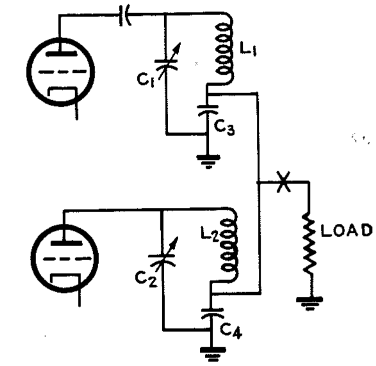


Fig. 3—Schematic diagram, output tank circuits

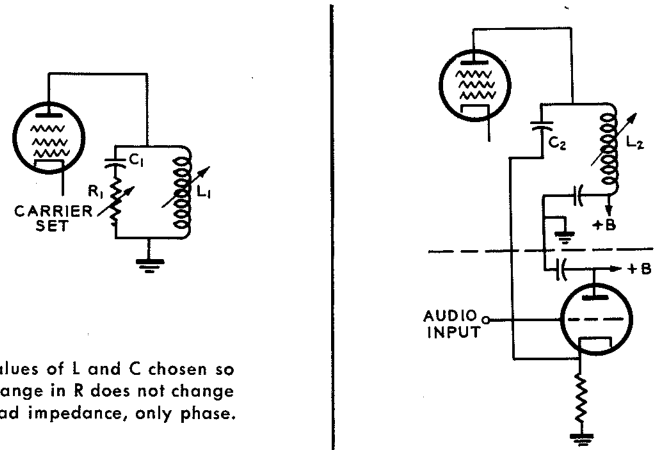


Fig. 4 and 4A—Simplified schematic modulator circuit

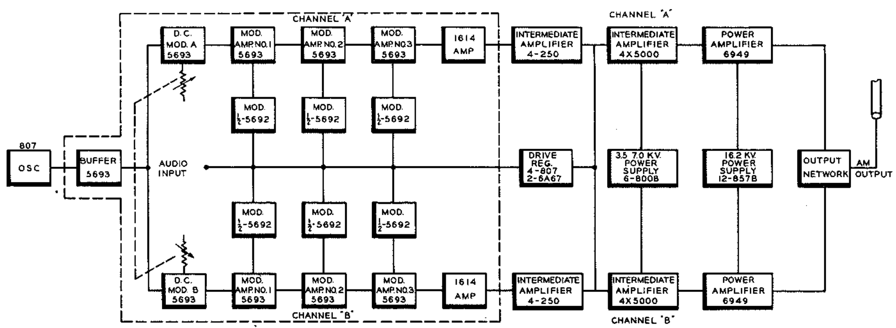


Fig. 5—Functional (Block) Diagram of the Ampliphase transmitter

6949 Tube Protection

In the event of a momentary fault in the 6949 such as a "gas ping" the short-time current available from the combined rectifiers would be in the order of 600 amperes. Additionally the filter capacitors could be expected to discharge through the 6949 tube elements. These currents would be highly destructive to the tube unless protective measures were taken.

In the event of any abnormal rise in current through the 6949 tubes, an electronic short circuit is instantaneously applied across the power source (including filter capacitors) ahead of the 6949 to divert the fault current from the tube elements. This electronic short or "crow-bar" consists of a 5630 type Ignitron placed across the power supply, in a "hold-off" condition and arranged to be fired by any rise in the cathode current of either or both 6949 tubes. By the use of low-inductance cathode elements and hydrogen thyratron firing tubes, protection capable of intercepting and interrupting an extremely steep wave front of current is assured. The entire cycle from start of rise of fault current to complete diversion of fault current can be as low as 10 microseconds.

Fig. 1—Kelvin Keech performing before a pair of Western Electric carbon-button microphones. Because of unpredictable "packing," these microphones were used in pairs to improve reliability. (Early 1920's).

FROM SCANNING DISKS TO VIDEO TAPE— THE BROADCAST STUDIO STORY

By

JOHN H. ROE, Mgr.
TV Camera Engineering
Broadcast Studio Engineering
Industrial Electronic Products
Camden, N. J.

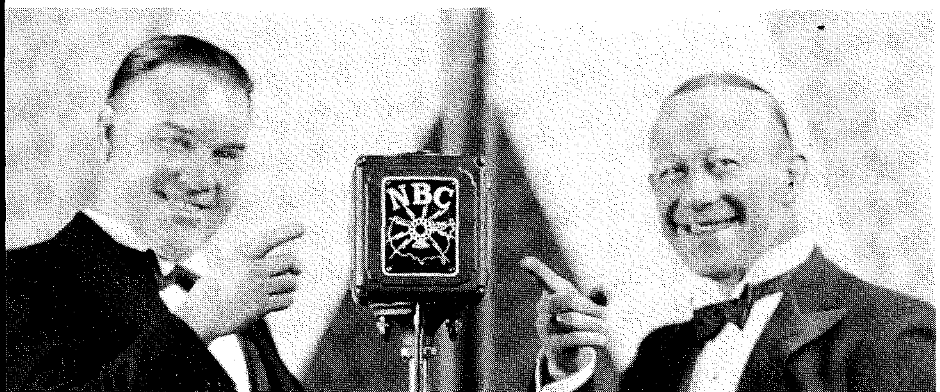


Fig. 2—"The Interwoven Pair" (Jones and Hare) with an RCA condenser microphone. Preamplifiers, built into the housing, were required because of high characteristic impedance. (Late 1920's and early 1930's).

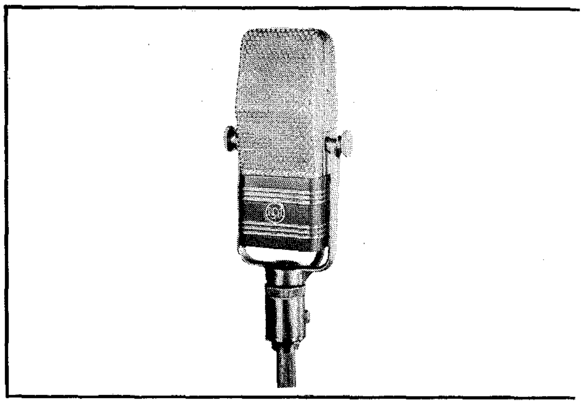


Fig. 3—The RCA Type 44-BX ribbon microphone. Still a favorite in many stations, this microphone first appeared in 1934.

THOUGH TELEVISION may have stolen first place in the limelight among the media of home entertainment, any reminiscing must properly begin with the birth of sound broadcasting. Perhaps the first chapter belongs even more justly to the earlier era of the invention of the phonograph (and almost simultaneously of the telephone) in which are to be found the first significantly fruitful efforts of man to devise transducers for the conversion of sound. However, about 1920 the inception of radio broadcasting inspired much more rapid development of sound transducers and all the related system components.

In the next several years, the Western Electric Company, with its background of telephone experience, developed the carbon-button microphones and d-c operated amplifiers which found their way into the AM stations that sprang up in large numbers. In this same period, the newly formed Radio Corporation of America was expanding into the broadcasting field with emphasis about equally divided between transmitters and studio equipment. Principal contributions of RCA to progress in the art were improved microphones (Fig. 2 and 3) and a line of a-c operated amplifiers which almost completely replaced the earlier cumbersome and less reliable types. Expansion to include all the necessary items for sound broadcasting such as loud-speakers (Fig. 4), turntables, and control consoles followed in rapid sequence.

The influence of television on audio equipment began to be felt in the late 1930's. Since that time, requirements for compactness and for very complex staging have set the objectives in the design of both components and systems. The new BK-6B dynamic microphone (Fig. 5) is typical of the trend toward small concealable devices. Today the audio line is pioneering the use of printed wiring and transistors in the broadcast equipment field with even further advancements in the economy of space and power.

TELEVISION

The Camden Plant of RCA, which to most people has always been the home of Broadcast Television Engineering, was acquired by RCA in 1929. Prior to this time, engineers under the direction of E. F. W. Alexanderson were actively exploring the possibilities of scanning disks and photocells as visual-electrical transducers. An early type of flying-spot scanner, employing a scanning disk in the light path of a high-intensity arc lamp, is shown in Fig. 6 together with a cluster of large photo-cells which picked up the reflected light from a performer standing front of them. An experimental receiver for the system is shown in Fig. 7. These seem rather crude by our present-day standards, but such were the beginnings of the television art which has become so firmly established as part of our lives today.*

* It is well-known that the conception of the scanning disk belongs to Paul Nipkow in about 1880, but practical utilization of the idea was not possible until the vacumm tube made amplification of weak electrical signals a reality.

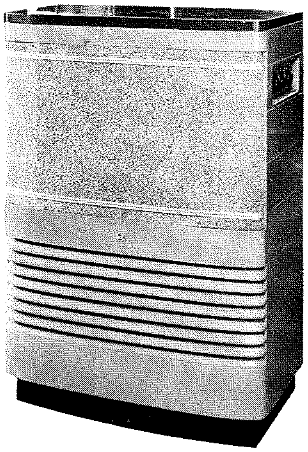


Fig. 4—The RCA Type LC-1A duo-cone, wide-range loud-speaker, found in many broadcast stations.

Fig. 5—The new RCA Type BK-6B miniature dynamic microphone now widely accepted in TV stations.

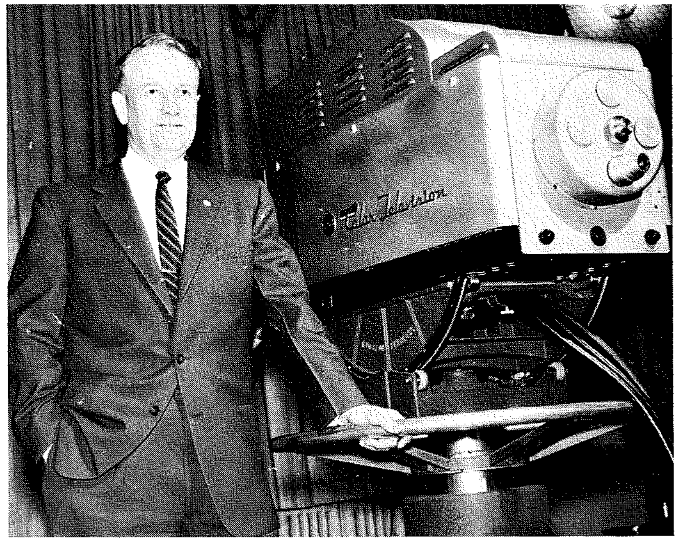
Among the television engineers who staffed the RCA Camden plant in 1929 was Dr. Vladimir K. Zworykin, who had conceived the idea of the iconoscope, an electronic device for converting lights and shadows in an optical image into an electrical signal. About this same time, electronic reconversion of the signal into visual information was first accomplished by the use of a cathode ray tube called a kinescope. These two basic devices were the key to the successful development of commercial all-electronic television, and it was around them that the plans for more rapid engineering development were built.

ALL ELECTRONIC TV UNDER WAY

Elimination of the mechanical scanning process immediately opened the door to a more realistic approach to televising fast motion and fine detail. Scanning standards were quickly raised to 120 and 240 lines. Then the concept of interlacing to conserve bandwidth and to reduce flicker brought further increases to 343, 441, and finally (through the excellent coordination and effort of the National Television System Gommittee in 1940-41) to our present 525 line system.

Development work on a complex television system required intensive effort in many aspects of fundamental sciences and electronics. By 1935, the television effort had evolved into three distinct groups, one working on pickup tubes and kinescopes, one on studio equipment and transmitters, and the third on receivers.

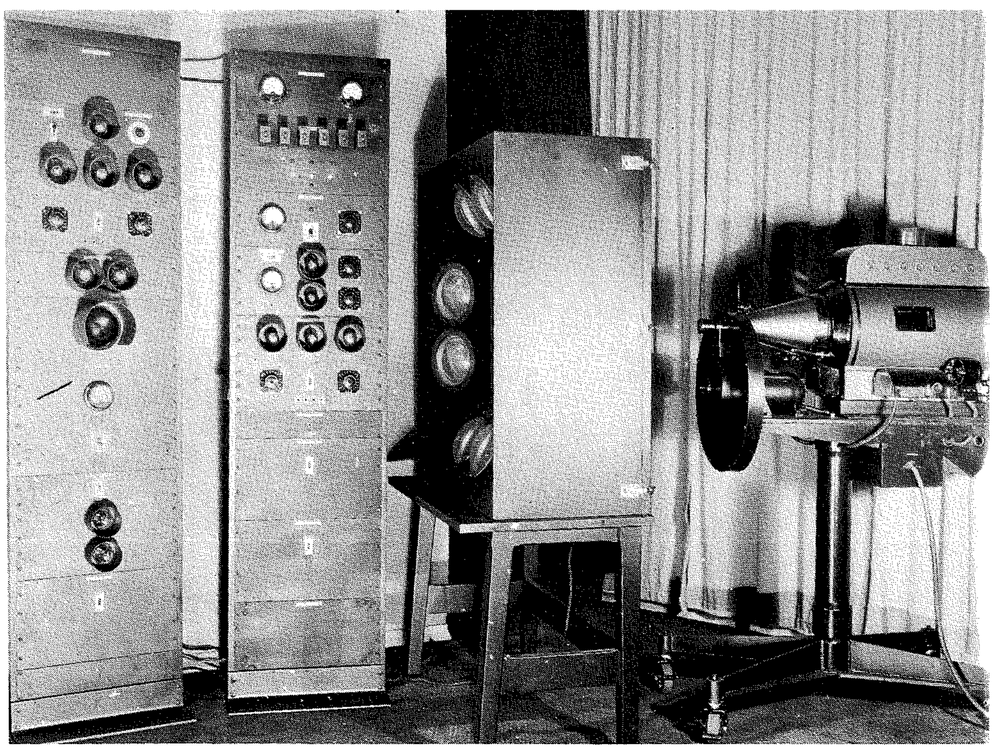
It was soon realized that successful development could not be carried on entirely within the walls of the laboratory. Just prior to 1930, experimental



JOHN H. ROE received his BS in EE in 1930 and his MS in EE in 1932 from University of Minnesota. He did research work at the University until 1933. He then joined RCA as a Tester for returned photophone equipment and became a Student Engineer in 1935. From 1936 to 1947 he worked on TV studio equipment and in January of 1947 became Unit Supervisor in the TV Terminal Engineering. In July 1948 he was made Supervisor of Camera Engineering in the TV Terminal Section. He has held his present position, Manager, TV Camera Engineering, since 1952. In this capacity he is responsible for development and design engineering on all types of TV cameras for broadcast stations, microwave equipment for TV program relaying, and kinescope recording.

Mr. Roe is a Senior Member of IRE, Member of SMPTE, Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

Fig. 6—Early 48-Line Flying Spot Scanner for Studio Pickup. The scanning disk is within the circular housing on the front of the high-intensity arc lamp, while the box-like structure holds a group of large photocells for sensing reflected light from a performer standing in front of it.



TV broadcasting was undertaken in New York City by the Technical and Test Laboratory of RCA, and was continued for several years. The culmination of a series of field tests came in 1936 with the major installation of full-scale live-pickup (Fig. 10) and film studios to be operated by NBC in Radio City, and of a high-power transmitter in the Empire State Building. Iconoscope cameras were used for both film and live studio functions with 343 lines, but within about a year after installation they were converted to work at 441 lines. Field-test receivers made for this project contained 33 tubes including a 9 inch kinescope.

The success of the 1936 field test aroused interest in other places and brought the first paying customers to our doors. In 1937, a system duplicating NBC's in magnitude, was made for Russia. In 1938, the Columbia Broadcasting System purchased a similar installation for studios in the Grand Central Terminal in New York.

Fundamental research in pickup tubes led to the next significant advance. The type 1840 orthicon, employing the principle of low-velocity scanning, in contrast to the high velocity scanning in the iconoscope, provided an escape from one of the most troublesome characteristics of the iconoscope, namely dark-spot signal and the requirement for shading correction, and at the same time

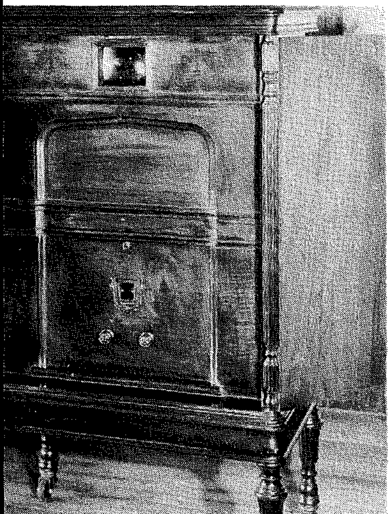


Fig. 7—48-Line Receiver of the type used with the scanner shown in Fig. 6. The picture was about 3" square.

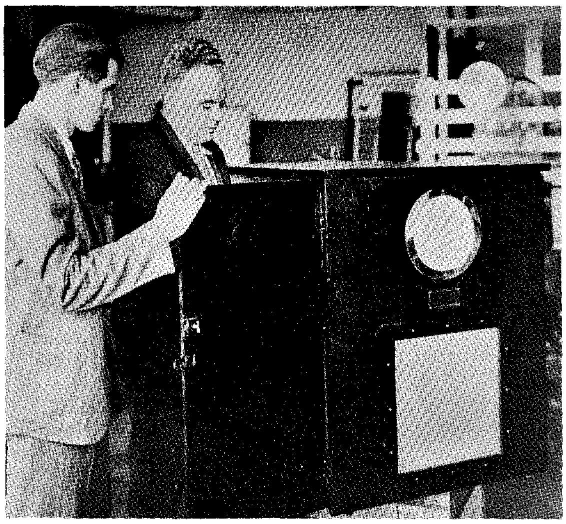


Fig. 8—48-Line projection receiver giving a picture 18" square, with R. D. Kell (left) and M. A. Trainer.

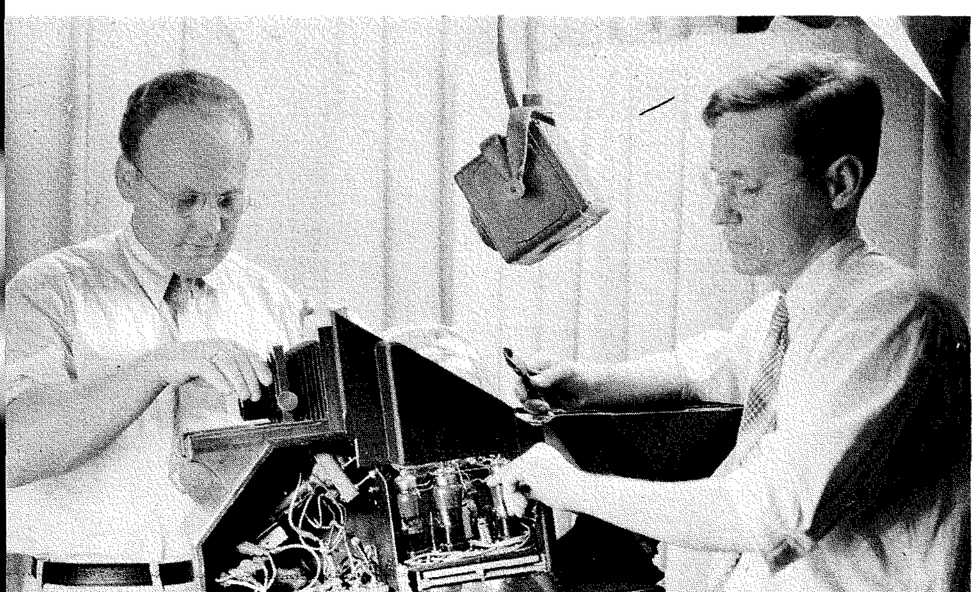


Fig. 9—Experimental iconoscope camera (Note also the condenser microphone) with M. A. Trainer (left) and A. V. Bedford. The iconoscope shown was of an early spherical type.

Fig. 10—NBC's Studio 3H with iconoscope cameras. This was the first full-scale live pickup studio built by RCA for the 1936 field test.

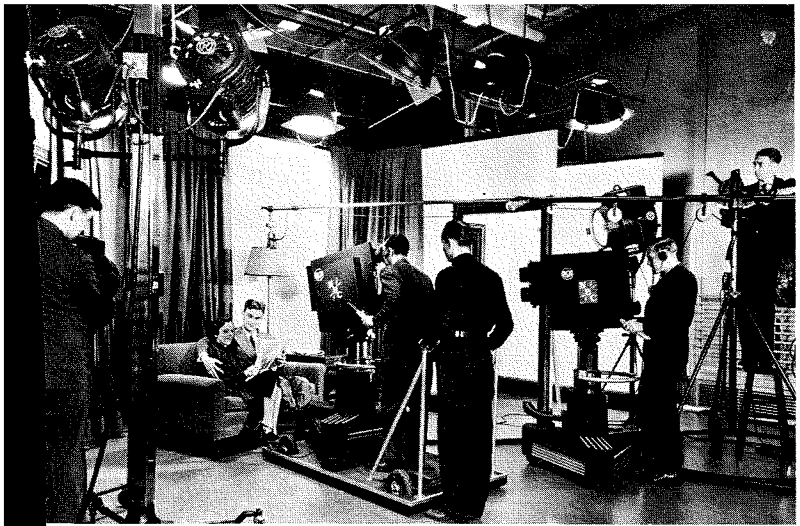
brought a substantial increase in sensitivity. Cameras employing the orthicon (Fig. 11) were built in small numbers for NBC, CBS, and Don Lee Television. These appeared about 1940-41 along with the production of about 4000 improved receivers (TRK-12), with 12-inch kinescopes, for an expansion of the New York field test into commercial service.

WAR AIDS IN TV DEVELOPMENT

Inability of the orthicon to cope with large ranges of light dampened enthusiasm for it. Furthermore World War II stopped all expansion of a commercial broadcasting service. Existing iconoscope and orthicon cameras continued in limited use for training in civilian defense, but the limited number of receivers made such efforts rather ineffective. During the war period from 1942-45, all work was channeled into the development of military television largely intended for applications in airborne reconnaissance and missile guidance. One of the typical equipments for such purposes is shown in Fig. 12.

The most significant development of the war effort on television was the rapid perfection of the image orthicon pickup tube with its astounding increase in sensitivity and ability to handle enormous ranges of light intensity. RCA's extended experience in applying this tube to military uses (several hundred Block III cameras using this tube were made) was of great value in the post-war effort which began to gather momentum in late 1944 toward the development of a full commercial product line.

This work was concentrated first on developing portable field equipment around the image orthicon, and improved film equipment around the iconocsope. Microwave equipment, used for the first time for TV program relaying, and studio image orthicon cameras were quickly added. By 1947 deliveries were being made at an increasing rate to the rapidly growing list of TV broadcast stations. The year 1948 was expected to be a boom year until the "freeze" on further station construction was imposed by the FCC because of the allocation prob-



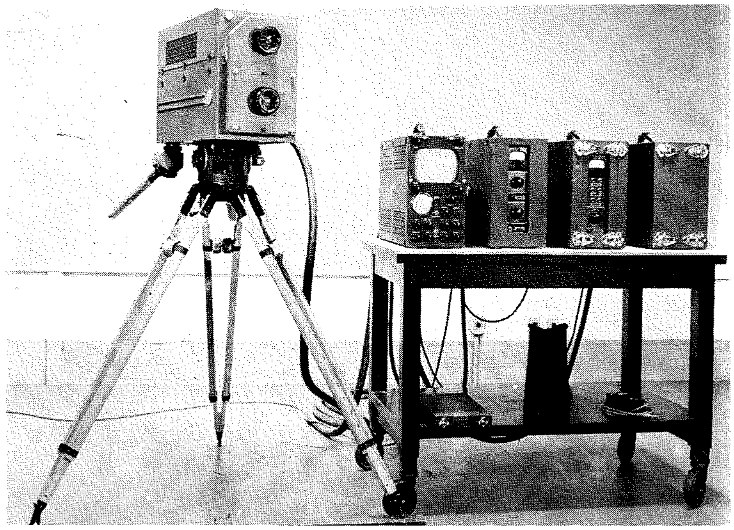


Fig. 11—Early portable field equipment employing the type 1840 orthicon in the camera.

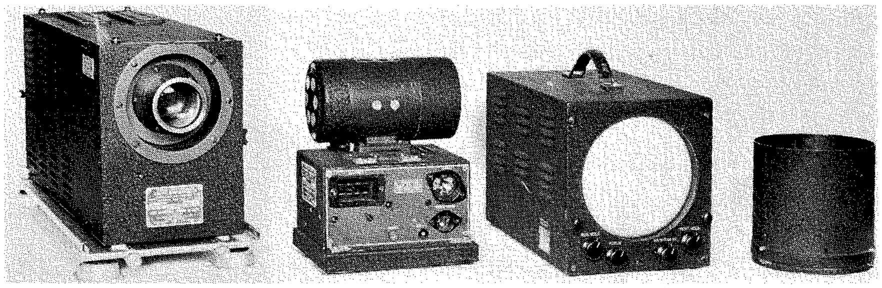


Fig. 12—Block I Airborne Television System (World War II Period). The camera (left) contains a small iconoscope in the front, and includes a 10 watt, 100 mc transmitter in the rear. Dynamotor power supply and monitor for ground setup are shown.

lem. However, 109 stations had been authorized up to that time, and nearly all were in operation. Although the "freeze" lasted for more than three years, and incidentally overlapped the opening of the struggle over color standards, the existing stations provided service in most of the large cities and crystallized beyond doubt the acceptance of television in the daily living of the nation. Lifting of the "freeze" in 1952 opened the real boom in station construction which reached a peak in 1954.

THE ULTIMATE IN TV: COLOR

The color hearings before the FCC in 1950 made it abundantly clear that color would be an engrossing subject in the engineering world from that time on. The field sequential system first demonstrated by Dr. Peter Goldmark about 1940 had undergone no basic change at the time it was again proposed in 1949, but by that time it was clear that color standards should be compatible with those in the existing well-established black-and-white industry, and the need for developing something other than the field-sequential system became imperative. The story of the development of our present compatible system is too long and too well-known to include here, but its effect on the organization and work of Broadcast Studio Engineering was little short of an upheaval. The rapid increase in personnel with the need for training everyone in a new field increased an already heavy burden.

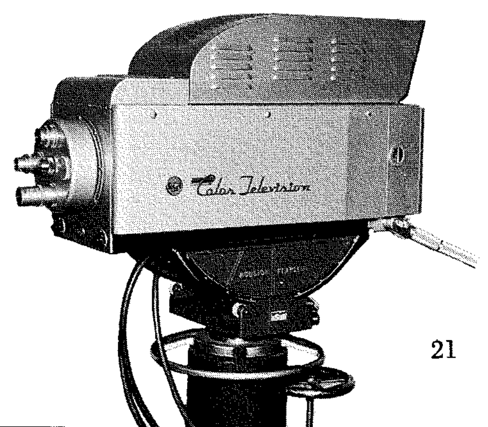
New products of a far more complex form began to take shape. First were the three-image-orthicon live camera (Fig. 13) and a flying spot scanner for color slides. Effective solution of the color film pickup problem lagged behind the other areas. Realization of the potential of the vidicon as a film pickup device led the way finally to the use of three-vidicon cameras which could be used with intermittent projectors modified only slightly for the color application. The more precise system requirements to handle color signals dictated replacement designs for almost every important item in the product line. This process is not yet complete, for each improvement seems to emphasize the need for like improvements in still more remote corners of the system. Recent development of a precise and stable color monitor is an excellent example of advances which are coming from the concentrated effort for mastery of the color system.

The recent break-through in the field of video tape recording, described in another article in this issue, appears to be well on the way toward solving the greatest remaining problem in color, that of recording programs for delayed broadcasting.

Much credit is due to the technical management which has permitted RCA to play the major role in the romantic and fabulous development of our electronic television system, but perhaps it is even more important to recognize that the growth of television as a profitable business to RCA, and of the television industry as a potent factor in our national economy, is a tribute to the vision and courage of those in RCA who were willing to risk the investment of many millions of dollars over a period of almost twenty years before the appearance of significant returns.

It is hoped that the reader will understand the author's predicament in desiring to mention the names of all those who have contributed to the developments described herein, but in not having space for more than the few which are included.

Fig. 13—Type TK-41 color studio camera using three image orthicons.



ENGINEERING COLOR VIDEO TAPE RECORDING

A. H. LIND, Mgr.,
Audio and Mechanical Devices Engineering
Broadcast Studio Engineering
Industrial Electronic Products
Camden, New Jersey

THE BASIC POTENTIALITIES of magnetic tape as a storage medium for television signals have been appreciated for some time. The need for a practical system of video tape recording has had increasing emphasis with the advent of color TV in order to permit storage of programs to accommodate the time difference between East and West Coast regions. Kinescope recording on film has solved this problem in black and white TV for many years. However, a similar approach for color by recording directly on color film stock has been hampered by both the cost and processing. The capability of magnetic tape for immediate playback without intermediate processing, and the ability of the system to record tonal (gray scale) gradations accurately are such outstanding advantages as to justify concentrated effort to solve the problems.

DEVELOPMENT OF QUADRUPLEX SYSTEM

During a period of several years of research several methods of recording wideband electrical signals on magnetic tape were explored. Following a review of these approaches to color TV recording for broadcast purposes a product development program that has led to the Quadruplex system was initiated.

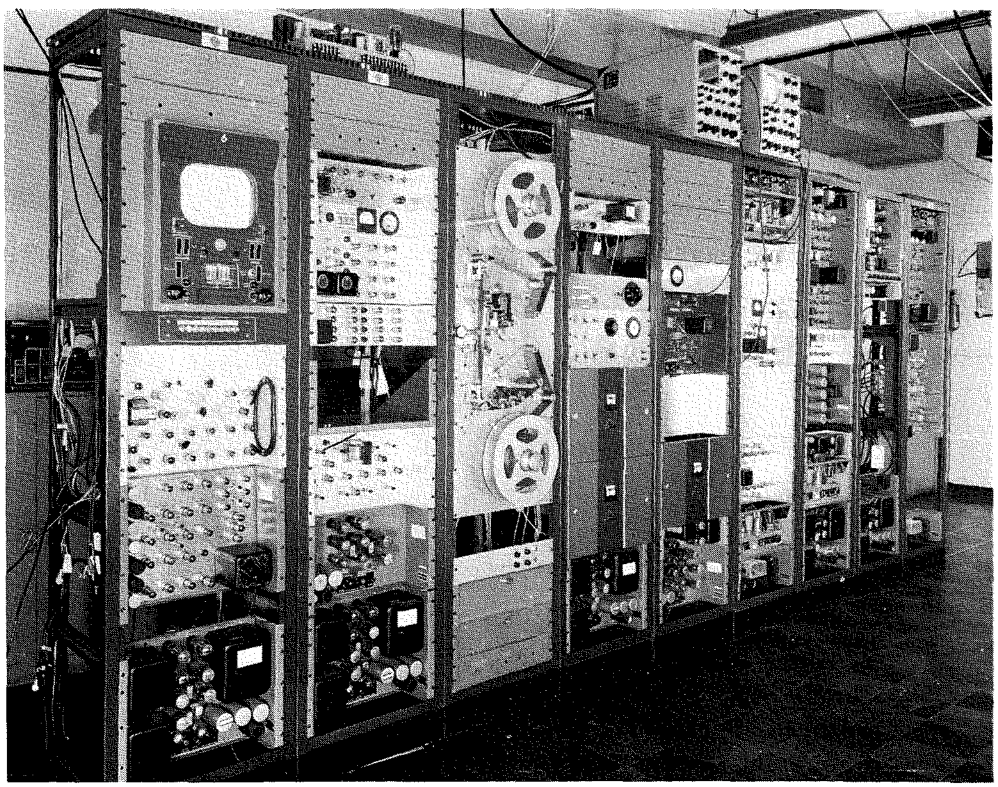
The objective of the project was to develop a professional color TV tape recorder/reproducer. It must record and reproduce color TV signals with essentially no deterioration of the picture quality. It must be capable of recording continuously for a minimum of one hour. It must use magnetic tape efficiently in a form that is convenient for handling and shipping. The operating costs for the tape recording system must be competitive with existing film recording costs.

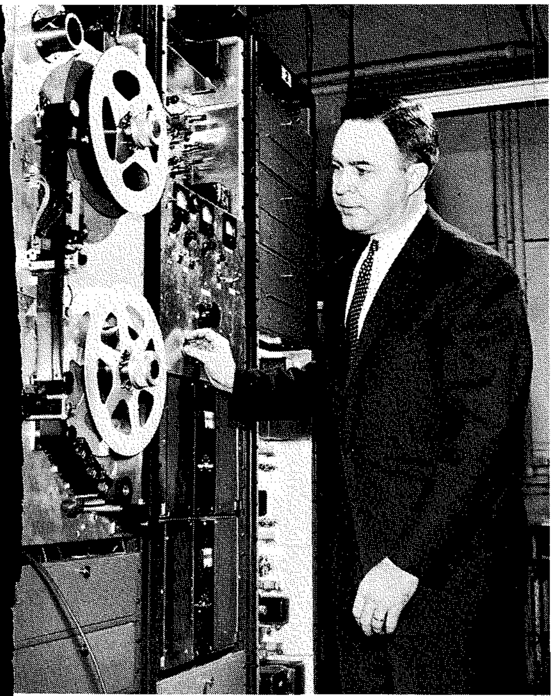
Among the numerous basic problems encountered were the following:

Recording time

Since the theoretical maximum of information that can be recorded per unit area of magnetic tape is relatively independent of the manner in which the recording is done, the area required per unit of time

Fig. 1—The RCA Color Video Tape Recorder/Reproducer, which is capable of immediate playback of color TV shows with no intermediate processing.





A. H. LIND received a B.S. in E.E. degree in 1946 and an M.S. in E.E. in 1949 both from the University of Wisconsin. He joined the Broadcast Studio Engineering staff of the Radio Corporation of America in 1946. Except for the academic year 1948-1949 which he spent at the University of Wisconsin on an RCA Fellowship, he has worked in the field of studio television and audio equipment. He is now manager of Audio and Mechanical Devices Engineering, which is a part of the RCA Broadcast Studio Engineering Section.

Mr. Lind is a member of Eta Kappa Nu, Tau Beta Pi, IRE and SMPTE.

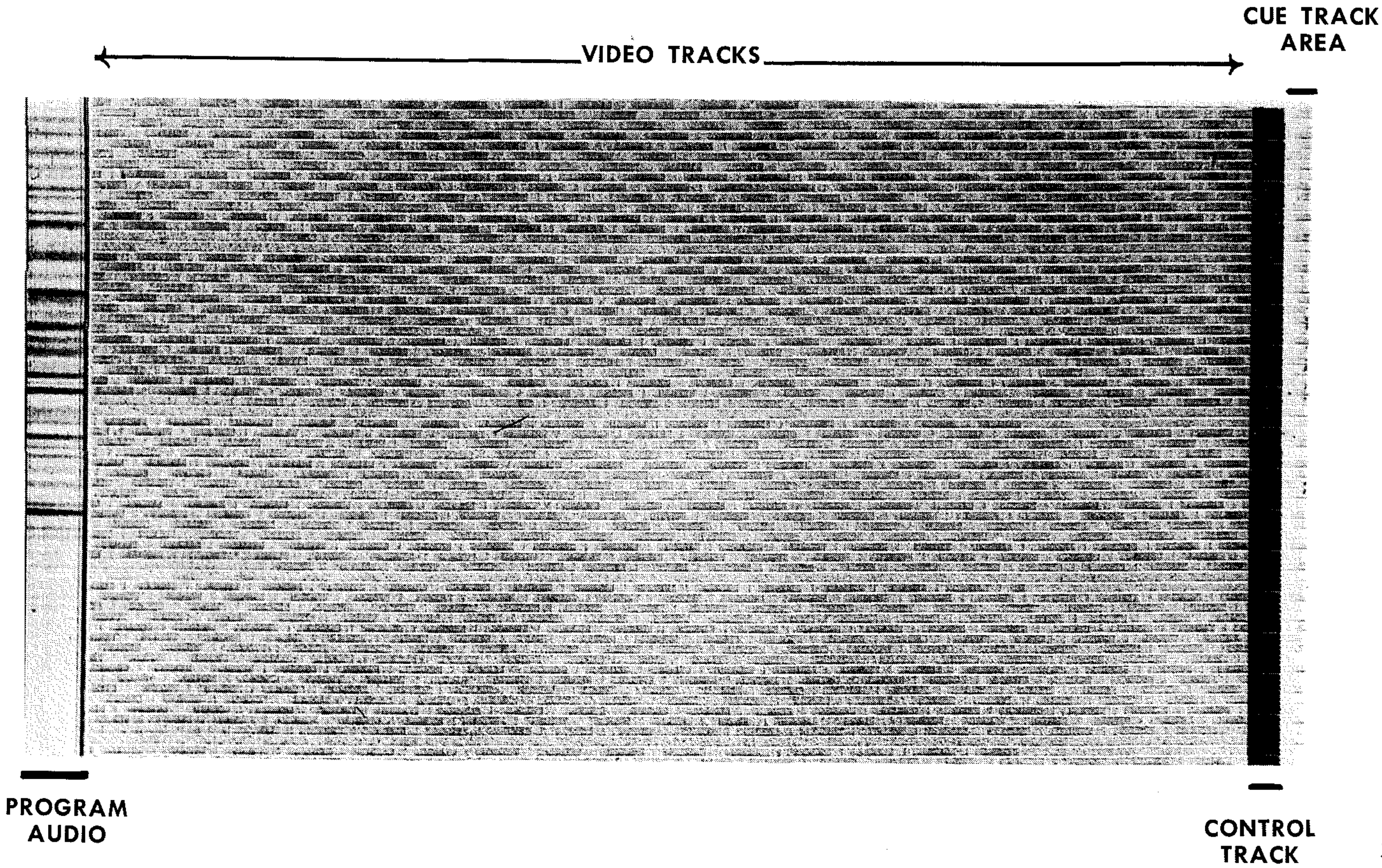
for a given input signal will be relatively constant. Thus in the problem of maximum continuous recording period, the tape form factor enters directly.

Several methods of recording had been investigated. In general, high-frequency recording requires high head-to-tape speeds. A single channel longitudinal recorded track requires very fast linear tape speed but a narrow tape will suffice. One general approach investigated achieved reduced linear tape speed by dividing the incoming signal into several sets of narrower band signals that could be reassembled to duplicate the input, and recording these sets on separate tape tracks. The multiple tracks increased the tape width and permitted slower linear tape speed. However, as the number of tape tracks increased, the electronic complexity of the system also increased very rapidly. A second approach exploits the sufficiency of a narrow recorded track and achieves efficient usage of tape area by orienting the recorded track transversely on the tape. A series of closely spaced transverse tracks can result in two-thirds or more of the total tape area being magnetized, with the recording still being reproduced coherently.

Signal Timing Stability

The reproduced TV signal must have sufficient time stability to permit satisfactory operation of the home television receiver. The goal is a reproduced signal which is not detectably different from the input signal. This requires precise control of the relative motion of the magnetic tape and recording heads which makes essential the use of servo-mechanisms with very tight control. Special signal processing may be required to nullify minute residual timing errors, in the case of a color signal, where an error of one part in 16,000 during a TV line may result in an observable hue shift.

Fig. 2—A section of recorded video tape. The pattern is made visible by an iron particle technique.



Signal Transfer Linearity

As in the case for photographic film, magnetic tape is non-linear in its transfer characteristic. When recording audio signals on tape it is common practice to use an a-c biasing technique which effectively linearizes the transfer characteristic. The a-c biasing signal employed is five or more times the highest audio frequency recorded. This approach is hardly possible when the highest video signal to be recorded is about 5.0 megacycles. However, a high degree of linearity must be achieved to avoid a "recorded" appearance to the reproduced signal and to avoid chrominance distortions when producing a color signal. By frequency modulating the signal recorded on the tape, a linear transfer characteristic for the system is possible.

Wideband Signal Spectrum

A color TV signal frequency spectrum ranges from 60 to approximately 4 x 10^6 cycles per second. Both ends of this frequency band contain appreciable energy, the low end because of the scanning frequencies and the high end because of the color subcarrier and chrominance information. This frequency spectrum occupies approximately 16 octaves. Equalization over a frequency band of 9 octaves on magnetic tape is the present practical limit. Therefore, a frequency modulation system has been adopted to translate the spectrum up to a point where it occupies less than three octaves.

Magnetic Tape Stretch and Shrinkage

The magnetic tape base is an elastic material. It is subject to stretch or shrinkage as a result of tension changes, temperature, humidity and aging effects. In the case of transverse track recording, pole tip wear in the magnetic heads can introduce a very appreciable effect, which must be compensated. For proper playback, means must be provided to scan the tape at the same rate per time increment of signal, as was done when the recording was made. Also, output signal must be continuous.

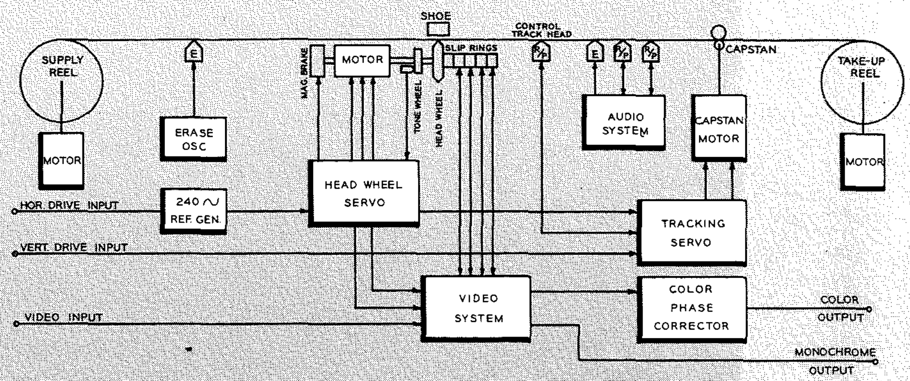


Fig. 3—Simplified block diagram of the video recording system.

Magnetic Recording Heads

Not only must the high frequency recording heads be small in size with extremely small gaps, but they must have a high self-resonant frequency. The high resonant frequency dictates a low inductance which limits sensitivity. Magnetic cores with low losses in the megacycle range are essential.

THE PLAN IN ENGINEERING

The project was organized to take advantage of the best available talent and experience in each of the problem areas. Teams of engineers in five different RCA engineering and research organizations were set up to carry on the development work.

In several instances more than one program was initiated to solve problems in areas of great technical uncertainty. Magnetic recording heads, color processing techniques, and frequency modulation are areas where multiple but parallel development tasks were carried on. As the development work progressed, the tasks of secondary importance became apparent and were dropped. During the early phases, the work was carried on largely in the laboratories of the several engineering sections. As rapidly as the various parts of the machine were completed they were moved to the Broadcast Studio Engineering Laboratory where the complete engineering model of the Quadruplex system was assembled. Continued refinement of circuits, mechanisms and operating techniques resulted in recorded pictures of excellent quality. During the months of August, September, October, and November a number of highly successful demonstrations, first private and then public, were presented. Press demonstrations were followed by customer demonstrations and the announcement in November offering the color video tape recorder/reproducer for sale.

BASIC PRINCIPLES IN THE EQUIPMENT

The Quadruplex system utilizes a single recorded channel for picture information. It is recorded on a two-inch wide tape as a series of closely spaced narrow tracks which are transverse to the direction of tape travel. For the reason of convenient geometry, successive tracks are recorded by one of four recording heads that are caused to scan the tape sequentially. The heads are mounted with equal angular spacing on the periphery of a small wheel which rotates about an axis parallel to the length of the tape. The magnetic heads are thus time-shared in usage. In addition to the

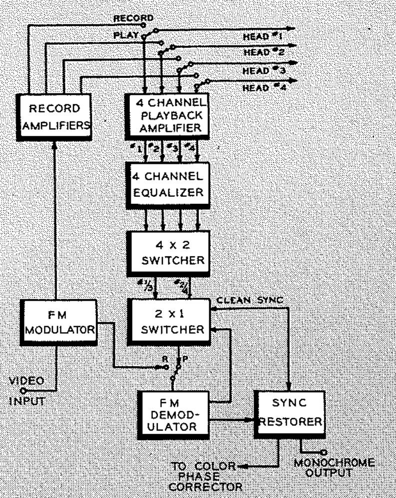


Fig. 4—Detail of the Video System block in Fig. 3. Video is converted to r-f for application to recording heads.

transverse video tracks, two longitudinally recorded tracks are provided with space allowed for the addition of a third track at some future date. The two presently used tracks are recorded along the two edges of the tape. One track carries the program sound in a manner very similar to conventional audio tape recorders. The second track carries control signals which are used as a reference in playback to establish and maintain accurate tracking of the magnetic heads on the transverse video tracks. The third track is a narrow track adjacent to the control track which is available for cuing and special machine control signals. The magnetic pattern on a section of recorded tape, which has been made visible by an iron particle technique, in shown in Fig. 2.

The diagram shown in Fig. 3 illustrates in simplified form the video recording system. The magnetic tape is transported from the supply reel to the takeup reel at a speed of 15 inches per second. The supply reel is located at the top of the panel as shown in Fig. 1. Reels as large as 14 inches in diameter can be accommodated. A one and a half hour supply of tape can be wound on such a reel. In the span between the supply and take-up reel the following actions occur to the magnetic tape during signal recording.

Sequence of Magnetic Heads

Shortly after leaving the supply reel, the tape passes over a double-gap erase head where any previous magnetization is erased over its entire width. It next passes by the high speed rotating magnetic head wheel. As indicated earlier, the magnetic heads mounted in this wheel slide across the tape in successive "swipes" thus leaving transversely recorded tracks. To assure intimate contact between the magnetic heads and the tape, a concave shoe having the proper radius of curvature is brought to bear on the base side of the tape to form the tape and push it tightly against the magnetic heads. The head wheel rotates at a speed of 14400 revolutions per minute, or 240 revolutions per second. This speed is held very constant by a servo control system that compares a 240 cycles-per-second signal that is generated by a tone wheel on the motor shaft with a 240 cycles-per-second reference signal which is derived from a TV synchronizing signal generator, and applies speed control to the motor by means of a magnetic brake to achieve agreement between the two signals. Meanwhile, a short distance along the tape in the direction of the take-up reel a small recording head records a control signal on a track placed along the edge of the tape nearest the tape transport panel. The control signal is a 240 cycles-per-second signal derived from the head motor tone wheel. Still farther along the tape path are a group of audio magnetic heads. The first head is an erase head which removes the transverse recorded tracks in the area to be occupied by the program sound track. Next is the program sound recording head followed by a reproduce head which is used for simultaneous playback monitoring.

Next along the tape path is the tape capstan. It provides the prime moving force for longitudinal motion of the tape. The tape is friction-coupled to the capstan by a pressure roller forced against the opposite side of the tape. The capstan speed is held constant by locking its 60 cycles-per-second driving power to the vertical drive output of the TV synchronizing signal generator. Once past the capstan the tape is guided to the take-up reel.

The Recorded Signal

The signal recorded on the video tracks is not direct video, but a modulated r-f signal. Fig. 4 shows the input video signal being applied to a frequency modulator, the output of which is an r-f signal that is applied to the recording heads after amplification by the recording amplifiers. The r-f signal spectrum extends from approximately one megacycle to approximately 6.5 megacycles. A minimum of the lower first order sidebands are retained but essentially all of the upper sideband is suppressed.

When a recorded tape is played back the process is in general the inverse of recording. The erase heads are, of course, not energized. The high speed head wheel motor is again referenced to the synchronizing signal generator by servo control. However, the capstan drive is servo controlled by comparing the control track signal with a reference generated by the head wheel motor tone wheel and then governing the capstan motor speed to keep the two signals in close agreement. Thus the position of the tape at the head wheel is controlled to cause proper tracking of the magnetic heads on the recorded tracks during playback. To assure lip synchronization of the reproduced sound and picture the same audio head is used for playback as was used for initial recording.

Since the head wheel motor speed is 240 revolutions per second, there are 8 revolutions per 1/30 second, or one TV frame period. Thus 32 transverse tracks will be recorded per TV frame or per 525 horizontal scanning lines. Each transverse track on the tape therefore will contain an average of 16.4 TV lines of picture information. Actually the tape tracks are somewhat longer so as to provide an overlap of information from track to track. These succesive groups of signals must be precisely switched to the output program line to reconstitute the recorded signal. Fig. 4 shows the steps followed in reconstituting the signal on playback. The signals from the individual playback heads are independently amplified. At this point the differences in sensitivity and frequency response which are largely due to differences in magnetic heads are essentially eliminated by individual channel equalization. In the first

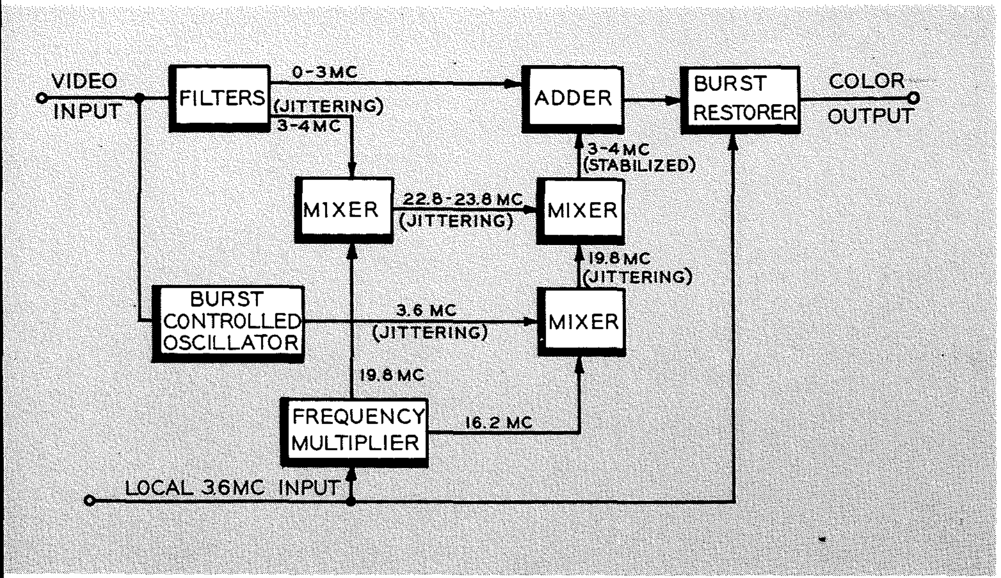


Fig. 5—Detail of the Color Phase Corrector block in Fig. 3. This system is successful in correcting small timing errors.

switching unit head channels #1 and #3 are alternately switched to one output line while channels #2 and #4 are alternately switched to another output line. Final switching occurs in the next unit where the switching transitions are caused to occur during the first horizontal sync pulse which follows the opening of a gate. The gate is obtained from the head motor tone wheel at a time when the position of the associated magnetic head leaves slightly more than one TV line to be scanned before it loses signal. The r-f signal reaching the FM demodulator is thus continuous (except for slight discontinuities at the head-to-head switching points). The demodulated signal is a replica of the input in the case of a monochrome signal except for the head switching transients which occur during each sixteenth or seventeenth successive horizontal sync pulse. The reconstituted video signal is next passed through a sync restorer unit which cleans up the sync pulses. For monochrome signals, no further processing is required.

Processing the Color Signal

The speed of the head wheel when reproducing the recorded signal is maintained sufficiently constant to introduce very little phase shift in the color subcarrier during any given TV line. However, the phase relation in a succession of color subcarrier bursts is subject to spurious shifts due to slow, minute variations in head wheel speed and small errors in the quadrature relation of the playback heads. If, as is usually the case in color TV receivers, the local subcarrier oscillator is locked to the incoming subcarrier bursts in a manner that averages many bursts, the demodulated color signal would display hue errors as a function of the timing inaccuracies. At the present state of the speed control art, the resulting picture would be unusable. However, the system shown in Fig. 5 is used quite successfully to correct for the small timing errors and thus eliminate the related color distortion. The basic technique is to cancel out time "jitter" in the chrominance signal by translating it to a higher frequency spectrum and then heterodyning this translated signal with a signal which also contains the jitter and is of such a frequency that the difference signal frequencies fall back into the original frequency band. If this signal is derived from a signal recorded on the tape, it will contain the same time jitter effects as those in translated chrominance signal, but the difference signal obtained by heterodyning will be free of the jitter because the errors have been cancelled by subtraction.

The video input signal, which is jittering slightly with respect to correct timing, is divided into two frequency bands by filters. The higher frequency band contains the chrominance information. This 3 to 4 mc band of signals is translated to a 22.8 to 23.8 mc band by mixing it with a 19.8 mc signal. The 19.8 mc signal is obtained by multiplication of a local crystal subcarrier oscillator. The signal in the 22.8 to 23.8 mc band still contains the time jitter.

The reference signal is the color subcarrier burst which conveniently is an inherent part of the color video signal. However, the subcarrier burst must be used to precisely control a local oscillator that can provide a continuous subcarrier. By using a burst-controlled oscillator which is synchronized by each burst and sustains the oscillation for the remainder of the TV line, its output subcarrier is effectively step modulated a line at a time in accordance with the time-jitter present. This jittering signal is translated to 19.8 mc by mixing it with a 16.2 mc signal which is also obtained by multiplication from the local color subcarrier signal. This 19.8 mc, of course, still contains the time-jitter. Next, the jittering 22.8 to 23.8 mc signal is mixed with the jittering 19.8 mc signal which produces a difference sideband signal of 3 to 4 mc in which the jitter has been cancelled. The time-stabilized 3 to 4 mc signal is then added to the 0 to 3 mc luminance signal to reconstitute the color video signal. A burst restorer unit reinserts a new subcarrier burst to insure a clean, well shaped, burst on the output color signal.

CONCLUSION

The successful developments in this project are another example of the ability of RCA to concentrate a great wealth and diversity of talent on a difficult and complex problem. Many engineers outside of Audio and Mechanical Devices Engineering were called upon for their specialized talents, and these contributions, along with the intensive engineering effort within the consigned group, brought about a satisfactory solution to a truly challenging task. Special credit is due the RCA Laboratories for the color processing technique.

AUTOMATION IN RCA'S TELEVISION MANUFACTURING

by **VANCE B. GEYER**
Administrator, Manufacturing Engineering
RCA Victor Television Division
Cherry Hill, N. J.

When the subject of automation was first broached in the RCA Victor TV Division it ran the gamut of questions usually directed toward a new idea. "Will it save money, and if so, how much?" "What is involved?" "When can we begin?" "To what degree can it be economically incorporated?" "Who will be affected?" These are but a few of the questions which had to be answered before the concept of automation became a reality in the manufacture of tv instruments. The answers are reflected in various aspects of automation existing in our plants today.

A major phase in the automation of RCA's television manufacturing is the fabrication of printed circuit boards and the assembly of various components to these boards.

Reduction of costs in the manufacture of these boards was the prime factor considered by the TV Division in making its decision to initiate automation in its assembly plant. The approach was cautious starting with the fabrication of only a portion of its requirements of printed wiring boards. New techniques were tried and developed until it was found that we could produce the boards less expensively than our suppliers.

By way of definition, the TV Division's concept of automation is "the substitution of automatic machine operations for manual operations in the fabrication of and/or the assembly of the various parts comprising the completed television instrument." A printed circuit board is "A copper-clad laminate on which a wiring pattern is etched."

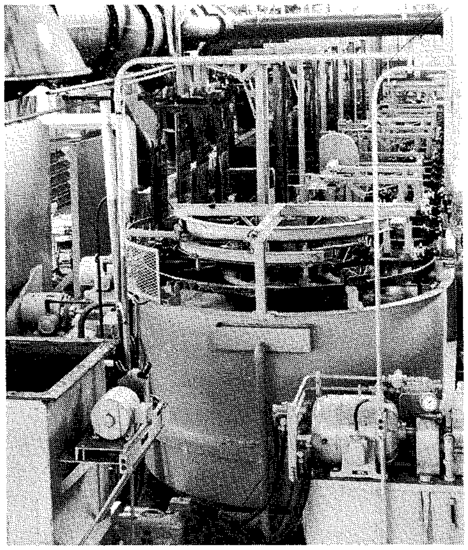


Fig. 1—A considerable investment in automatic equipment was required to automate the etching operations.

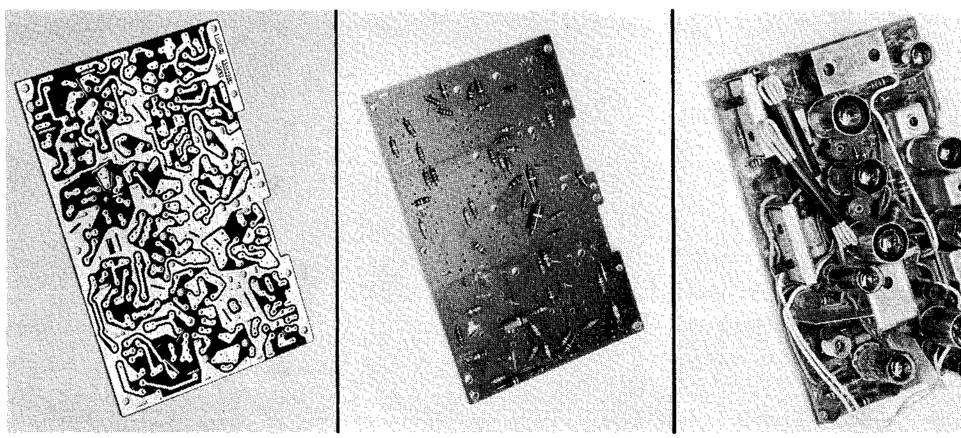


Fig. 2—Successive steps in a printed circuit panel. On left is a printed circuit ready for component insertion. Center view shows the reverse side of this board with those components which are now inserted automatically. Right-hand view shows a completed board.

FABRICATION OF PRINTED WIRING BOARD

In the fabrication of these boards, performed at our Indianapolis plant, the wiring pattern is first printed on the copper surface of the laminate board with an acid-resist ink. The boards are then automatically carried through a series of etching tanks (See Fig. 1) containing solutions of ferric chloride of increasing concentration. The ferric chloride removes all of the copper not protected by the ink, thus producing the desired wiring pattern. (A typical pattern is shown to the left in Fig. 2.) In the last tanks in the series of this process, a cleaning operation is performed by ultrasonic vibrations in a chlorothene bath to remove the excess acid-resist ink and other contaminating substances. The remaining operations in the fabrication of the "raw" board consist of cutting to size and piercing the necessary holes for component assembly and chassis mounting.

AUTOMATIC ASSEMBLY

At the present time only a few types of components are adapted to automatic insertion in printed boards. These are solderless (or wire-wrap) terminals, eyelets, $\frac{1}{2}$, 1, and 2-watt resistors, and jumpers. (Components in center picture of Fig. 2 were automatically inserted.) The implanting of wire-wrap terminals is automatically performed on a machine which inserts up to twenty wire-wrap terminals in one stroke at a rate of 850 to 900 printed circuit boards per hour.

Resistors are automatically assembled on one of two types of conveyor systems. One is manufactured by the United Shoe Machinery Corporation (See Fig. 3); the other by the Admiral Corporation. In operation, both of these systems feed a specially packaged component into an insertion head. Using a $\frac{1}{2}$-watt resistor as an example, the insertion head cuts the leads to the proper length, inserts the resistor in the proper holes in the board, and clinches the excess lead against the copper pattern on the under surface of the board. These operations require precise positioning of the printed circuit board under the insertion head, since the holes are only .008″ larger in diameter than the lead wires. This positioning is accomplished by an in-line conveyor system using pallets for the United Shoe Machinery Corporation conveyor. The Admiral conveyor uses a track of slotted rails to support the board in an exact location in relation to the conveyor belt.

AUTOMATIC INSPECTION

An automatic inspection device has recently been installed on the Admiral conveyor system. This device inspects for the assembly of all the automatically inserted parts and then separates the complete and incomplete boards.

THE MERRY-GO-ROUND CONVEYOR

The completed boards are then placed on the pallet of another conveyor system known in the plant as the "merry-go-round" (See Fig. 4). On this conveyor the remainder of the components are hand assembled on the board, and a soldering flux is applied automatically by the improved automatic flux-flowing method. The copper pattern and the leads on the board then receive in succession, an application of solder by the dip process, an application of wax, and finally, another application of solder. The soldering and waxing operations are performed automatically as the board rides on the pallet carried along by the conveyor (See Fig. 5). Inspection of the completed board follows after which the testing operations are performed. These last two operations are usually manual in nature. However, on some types of boards the testing is done automatically.

OTHER ACTIVITIES IN AUTOMATION

Other activities of the RCA TV Division involve the use of automatic processes. Spraying of cabinet finishes and application of a wood grain finish to masonite cabinets is done automatically in the Monticello, Indiana, cabinet plant. In the Bloomington plant a conveyor collects the cartoned instruments from each assembly line onto a single conveyor leading to the finished goods warehouse. Photocells control the flow of instruments from the individual conveyors to the collecting conveyor, releasing the packages only if a clear space is available on the warehouse conveyor.

In the Findlay, Ohio, components plant, the use of automatic machinery is limited at the present time to the winding of high voltage transformer coils, and to the winding and forming of yoke coils used in RCA television instruments.

Another phase of automation presently under consideration in the TV Division is that of automatic test or alignment. Some of the basic princi-

Fig. 3—System developed by the United Shoe Machinery Corporation automatically positions the printed circuit board for the assembly of components.

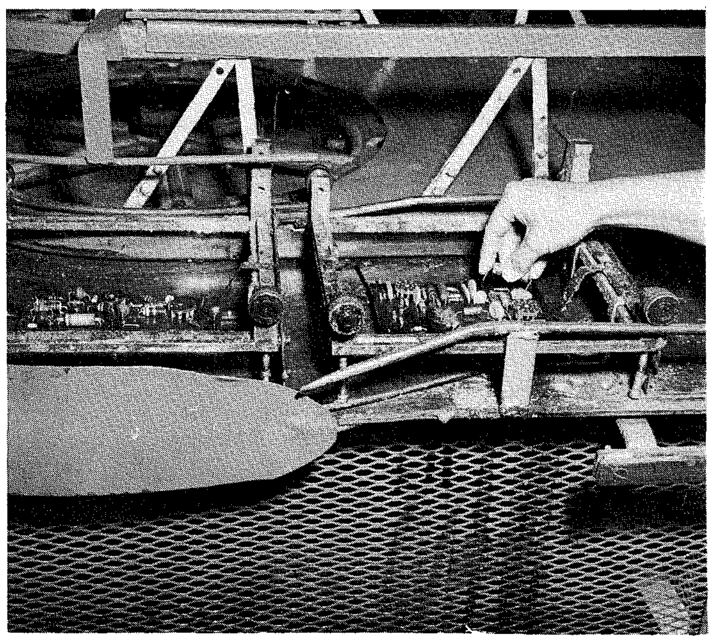


Fig. 4—View of a portion of the merry-go-round conveyor equipment where remainder of components are hand assembled on the printed boards.

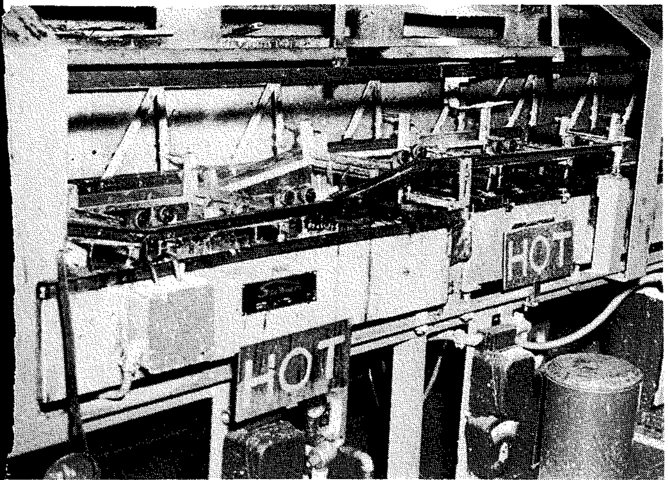


Fig. 5—All components are soldered to the printed circuit in one operation. Conveyor tracks are depressed to pass printed wiring surface through a solder bath.

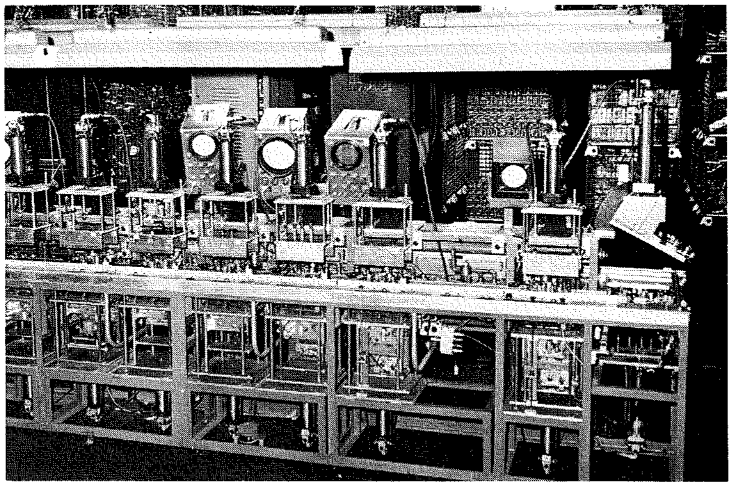


Fig. 6—Testing mechanism in use on printed circuit boards. Assemblies are automatically passed through inspection, testing, and alignment positions.

ples of the testing mechanism developed by RCA Laboratories at Princeton have been utilized and some success has been shown in the alignment of certain types of circuits on printed circuit boards.

In the Indianapolis plant a new inspecting, testing, and alignment conveyor system, as shown in Fig. 6, has been installed for the 17″ portable printed circuit board. The feed mechanism automatically moves pallets, with the contained board, through five preheat stations and seven test stations at the rate of 180 per hour.

In operation, at the present, the following sequence is followed:

1. A printed circuit board is placed on a specially designed pallet four stations ahead of the first alignment station, permitting an eighty second tube warm up.
2. First station: i-f link test. (semiautomatic)
3. Second station: sound driver test. (automatic)
4. Third station: input test. (automatic)
5. Fourth station: sound quadrature test. (semiautomatic)
6. Fifth station: picture i-f alignment test. (automatic)
7. Sixth station: gating test. (semiautomatic)
8. Seventh station: picture set-up test. (semiautomatic)

If the board has passed all of the inspections for missing or damaged parts, plus the testing and alignment procedures, it is automatically removed from the pallet into a container. If it failed to pass one of the mechanical or electrical checks, it and the pallet are automatically transferred to the other side of the conveyor for trouble-shooting or repair.

DEGAUSSING OF COLOR TV RECEIVERS

In the test set-up for color TV receivers at the Bloomington plant, automatic degaussing is performed on each instrument as it travels on the conveyor system. Degaussing is the demagnetization of all of the metallic components of a color TV receiver. It is accomplished by passing the receiver through a field of alternating current just prior to alignment. The receiver is aligned in an area of magnetic field having both strength and direction capable of counteracting the force of the earth's magnetism.* This reduces the possible receiver alignment problems by about fifty per cent.

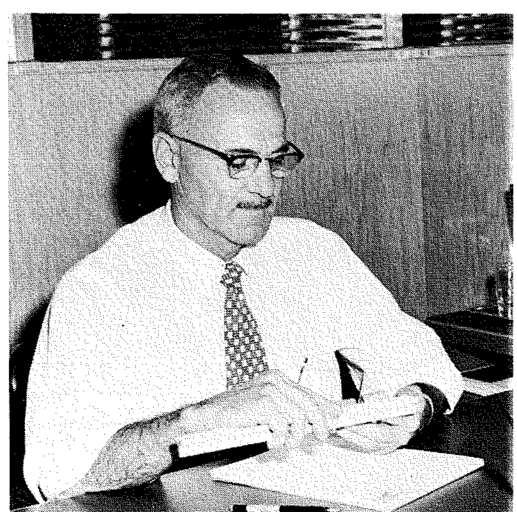
* See B. R. Clay, "The Effect of Magnetic Fields on Color Television Performance," *RCA Engineer*, Vol. 1, No. 5.

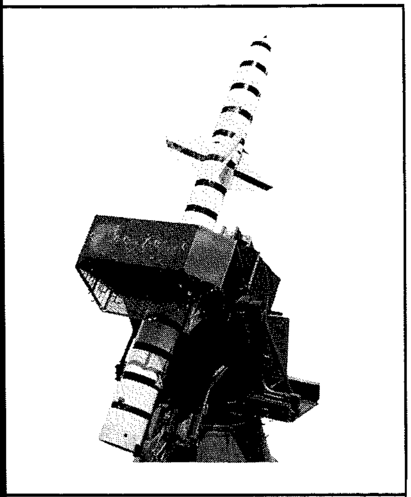
STANDARDIZATION

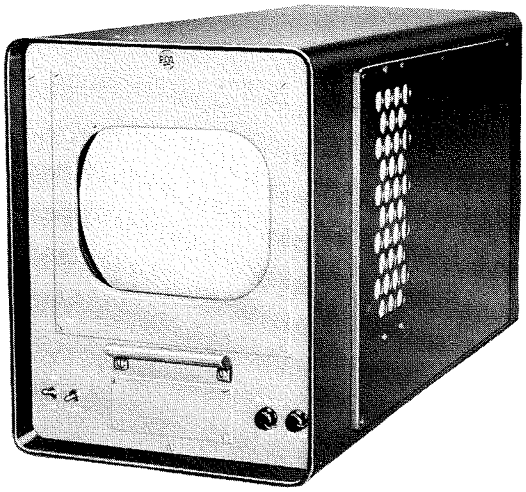
Our design engineers became concerned in the standardization and selection of parts and their location in order to meet the closer tolerances required in part size, contours, and component location in the TV instrument. Engineers and suppliers are required to collaborate as closely as possible in order to meet these requirements at the same time they work to develop new parts capable of being automatically assembled. These new parts must be adaptable to current machinery with the least possible modification. Machinery, on the other hand, is continuously being developed to utilize multiple insertion techniques.

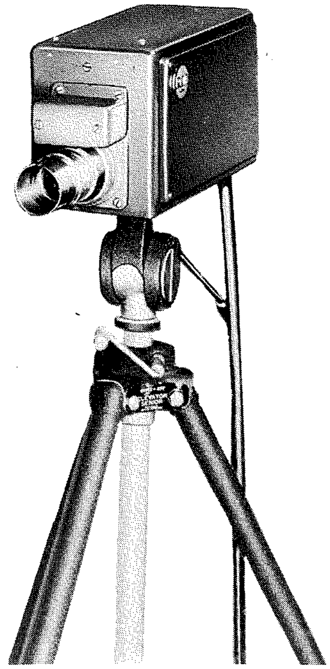
In conclusion, the TV Division is quite happy with the results of automation — improved quality, greater reliability, and a more uniform product— which have accrued to its credit, and plans to explore to the ultimate the application of automation in every phase of its activities.

VANCE B. GEYER attended Indiana University at Bloomington, Indiana, from 1935 to 1939, majoring in chemistry and minoring in physics. Previous to employment by RCA in April, 1943, he held the position of Product Development Engineer at the Hays Corporation of Michigan City, Indiana. Various positions previously held with RCA at the Bloomington plant were Process Engineer, Cost Reduction Coordinator, Methods Engineer, and Manager, Methods Development and Work Simplification. In the last two positions he was associated with the program of automation from its inception into RCA's plans. He was transferred to Cherry Hill TV Division on April 1, 1956, as Administrator, Manufacturing Engineering Administration.









CLOSED-CIRCUIT TV IN MISSILE TESTING

L. E. ANDERSON and R. F. BIGWOOD

TV Systems Engineering
Industrial Electronic Products
Camden, N. J.

Closed-circuit television (CCTV) is capturing the imagination of people in diverse fields. Basically this interest stems from two facts: (1) television makes it possible for separated groups, large or small, to see the same things at the same time, (2) television permits remote viewing of inaccessible areas.

In the first area, the principle application for television (aside from broadcast entertainment) is in the field of education — for schools, business organizations, hospitals, and the military services.

In the second area, potential applications for remote viewing are so numerous as to be limited only by the ingenuity of the users. A specific application, among the earliest to intrigue the imagination, is that of observing at a convenient, remote location a dangerous or otherwise inaccessible operation. This solves the sometimes impossible problem of placing a human observer at the point of action.

THE MISSILE FIELD

The mushrooming activity in rocket-powered missiles reveals a definite and growing need for CCTV in both experimental and operational fields. Considerable effort has been expended on the use of CCTV in this field, and some discussion is permissible.

Television is useful during three periods in the firing process of a missile:

(a) Handling and loading in the "prelaunch" period

(b) Close-up observation during launching

(c) Tracking during initial flight

Generally, the missile is brought from a remote fabrication point and hoisted into a vertical firing position on a launching platform or pad. A mobile crane on tracks is then moved into place beside the missile and several platforms are extended to and around the body of the missile to permit access to the loading ports and hatches built into the missile. Experimental nose cones, simulated warheads, flight telemetering equipment, guidance and control equipment and, finally, fuel must be attached to or loaded into the missile. All these activities occur during pre-launching time. Because of this, space limitations and existence of a certain degree of danger, it is desirable to provide remote viewing through the use of CCTV. Trainees and other qualified personnel who may eventually handle similar missiles on an operational basis, comprise the remote viewing audience.

AN "EQUIPMENT SETUP"

Fig. 1 is a layout (somewhat out of scale) illustrating several typical features of missile launching sites. Metallic conduits installed vertically on the crane, terminating in plug boxes at the base and other levels throughout its height, provide TV cable paths from the ground to any convenient extension platform. With cameras connected and plugs attached at the base of the crane, the camera cables run to the nearest protected control area which may be several hundred feet from the launching pad, depending on the size of missile handled. The camera on the crane can be carried by a technician so that it "looks over the shoulder" of other technicians who are handling and adjusting equipment or loading special fuels. A closeup view is thus provided at viewing monitors remote from the relatively small and critical work areas.

In preparation for launching, cameras located on platform extensions are disconnected. Interconnecting plugs at the base of the tower are removed, and the crane is wheeled away from the missile. Closeups of the major fuel handling and loading are now in order. Views of this operation can be obtained from a dolly-mounted camera on the pad, manually operated by someone sufficiently familiar with activities to get informative shots, yet away from critical operations. While "crane" cameras require only one lens with an optical or mechanical viewfinder, the "pad" cameras should be equipped with a viewfinder and zoom lens or lens turret.

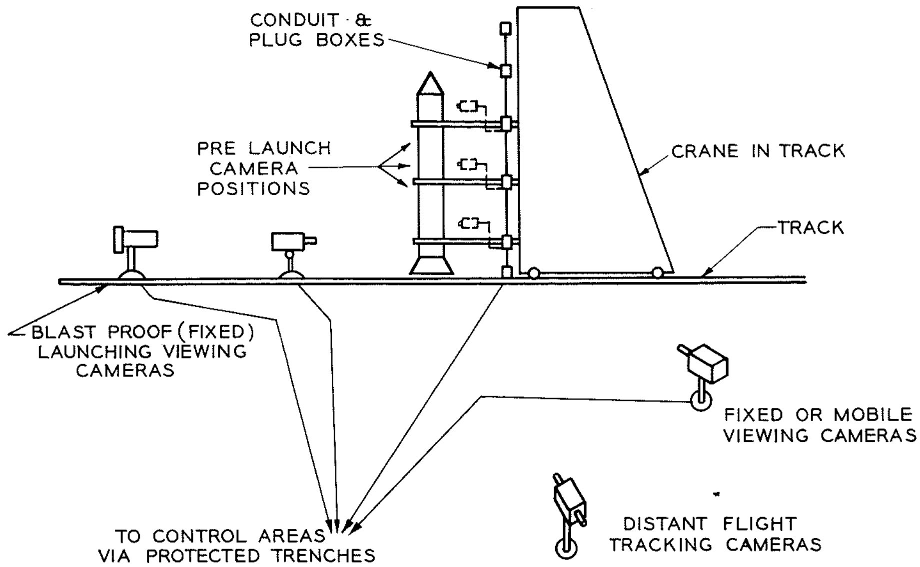


Fig. 1—A typical missile launching site showing TV applications.

EXPENDABLE CAMERAS

In experimental firings it may be desirable to retain a view of parts of the rocket motor up to and including ignition time. This could be provided by an expendable camera mounted within the shell of the missile. Discovery of a malfunction just prior to ignition, yet with time for corrective measures, represents savings many times the cost of expendable cameras.

Of course, at firing time no one is permitted on the launching pad. Freely movable cameras cannot be left unprotected, and must be kept many yards away from the larger missiles. Fixed-view cameras, firmly mounted, are used to observe motor action at time zero. To prevent camera damage, blast-proof housings are provided at close-in locations. Because of the clouds of smoke and flame at firing time, not much can be seen on the launching pad except at the brief instant of ignition, yet even this quick view is of some importance. During certain tests, it is desirable to have views of the missile at points away from the nearest protected control point.

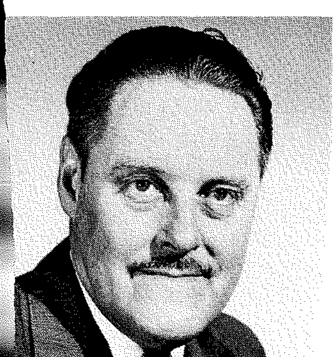
Upon take-off, a TV viewing system, with manned tracking cameras located several thousand feet from the launching site, gives an overall instantaneous view of the missile in its early stages of flight. This information is of considerable value to many people involved with the testing and launching process, and TV permits distribution to those who are not able to take advantage of theodolite or telescope tracking. In general TV flight tracking augments data provided by radar controlled computer-plotter machines.

The CCTV system is also useful under static testing conditions where a complete missile is held by a tower-like structure while the motor is run through a firing cycle. Closeups of parts of the motor and flame-observation by color cameras are of considerable help to research personnel. During research and development, many components and materials are subjected to flame and heat tests by generators which are really small rocket motors. The cameras in this case are close to both the motor flame and test samples and as a result are subjected to extreme noise levels. Tube microphonics render the picture useless under these conditions unless acoustic shielding or isolation is applied to protect the camera.

Usually one camera, with remote pan and tilt features plus a zoom lens, may serve a dual purpose. First, it may be used for surveillance to make certain that all personnel are clear of the immediate firing range, and that all other general preparations have been completed. Secondly, it tracks the missile during take-off and flight. These functions are carried out either for daylight or night firings.

CONCLUSION

Basically, in missile work, a CCTV system satisfies the requirements for remote viewing of dangerous processes and simultaneously acts as an educational tool serving many who could not possibly be accommodated in critical work areas. With an ever increasing number of experiments and test firings being conducted at the vast launching and test sites, this versatile visual aid may be expected to keep pace in the job of supplying invaluable, instantaneous information to protected control areas, remote laboratories and safety coordination centers.



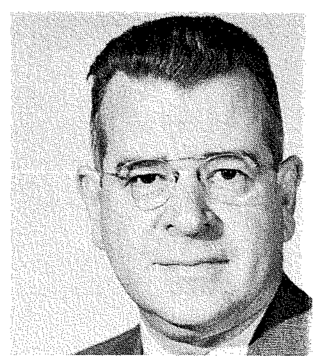
LANNES E. ANDERSON received his B.E. degree in E.E. from Washington State College in 1930. In July 1930 he joined RCA, and was engaged in the design of Superheterodyne receivers, components, microphones and test equipment. Since 1945, he has been involved in TV station planning and equipment design.

He was instrumental in the pioneering of the first low-power TV station at the Limestone Air Force Base at Limestone, Maine. He has also been in charge of planning domestic and foreign TV stations, including several in Japan and South America. Mr. Anderson assisted in the installation and testing of the first commercial TV station in London, England. His most recent activities have been in the field of closed circuit TV applications, both in monochrome and color.

R. F. BIGWOOD received his B.S. degree in Electrical Engineering from the University of Vermont in 1931. From graduation to 1942, he was employed in AM broadcasting, first with an independent station, then in 1938 with NBC in New York. During World War II, he was engaged in research on underwater sound equipment.

After 1946, he was for two years in Audio Engineering with The American Broadcasting Company, and from 1948 to 1955 was General Facilities Engineer for The Dumont Television Network.

Mr. Bigwood joined RCA in January 1956 in TV Systems Engineering.

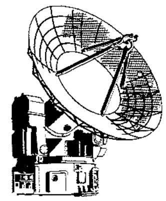


"TALOS"—AN ADVANCED SURFACE-TO-AIR GUIDED MISSILE SYSTEM

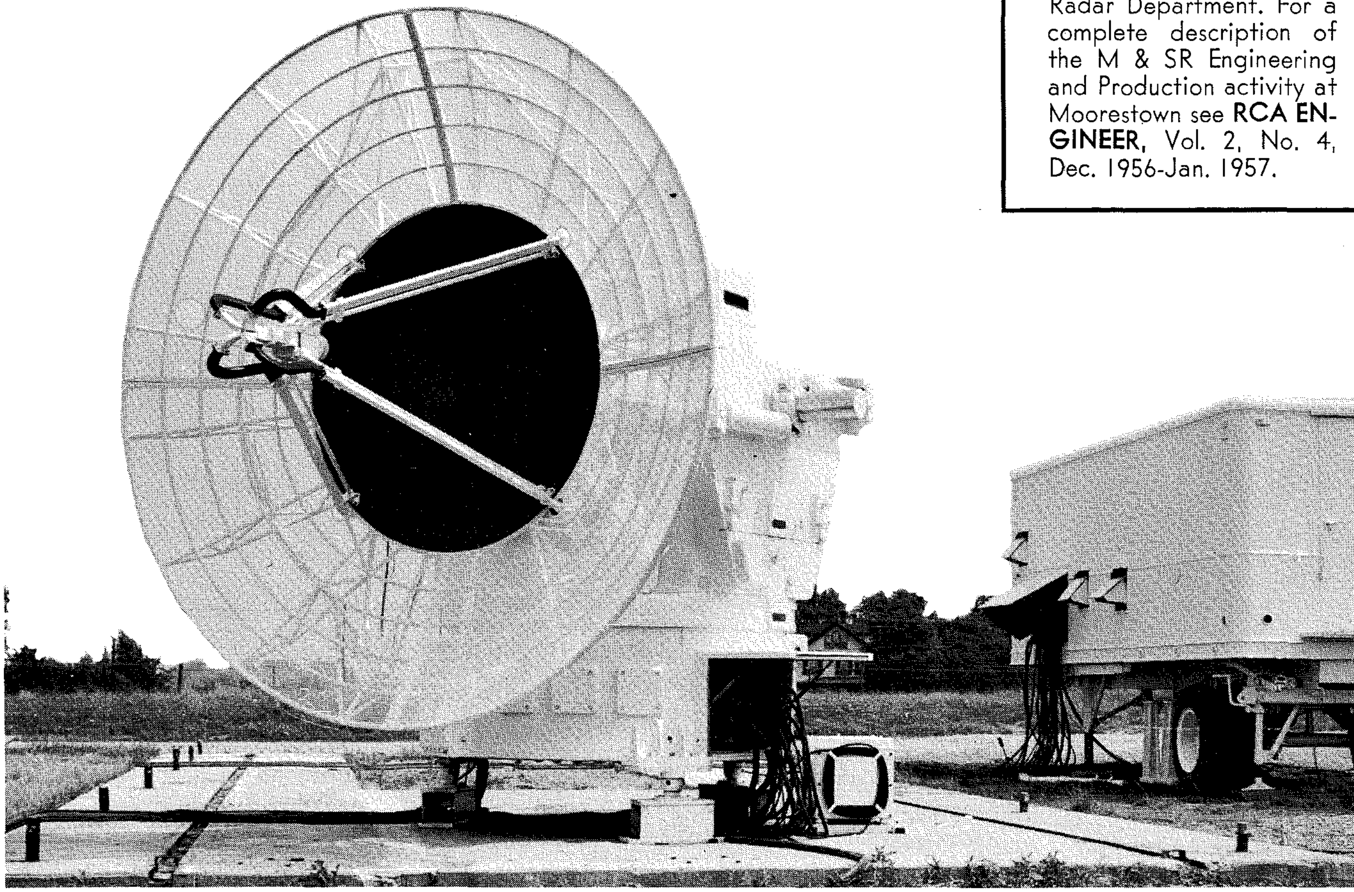
by **HENRY W. PHILLIPS**
Coordinator, Talos Projects
Missile and Surface Radar Dept.
Defense Electronic Products
Moorestown, N. J.

Prototype Talos Defense Unit at White Sands Proving Ground, New Mexico. The Operations Building containing Fire Control Equipment, Computers, Radar Transmitters and Power Plant facilities is shown on the left. A Missile Assembly Building and a Launching Pit with an Automatic Launcher and a partial missile magazine are on the right. Talos Missiles with either high-explosive or nuclear warheads can be launched at a high rate of fire. The missile can travel at supersonic speeds and at an altitude higher than any known bomber can reach.

Automatic Talos Launcher shown with a specially instrumented Talos Missile. Each missile is stored in a reinforced concrete storage cell within circular magazines. During a tactical engagement, signals are received at the launcher, which automatically rotates to the proper missile storage cell. A cart runs from the launcher into the cell, picks up the missile and transfers it to the launcher. The missile remains on the cart while the launcher automatically slews and elevates to the proper position for firing, based on computed information indicating the target position. At the proper time the firing signal is automatically received at the launcher and the missile is fired to intercept the target. The Launcher was fabricated for RCA by American Machine and Foundry Company.



Editor's Note: In this article, the author brings the reader up-to-date on the status of TALOS DEFENSE UNIT which was designed, developed and produced by the Missile and Surface Radar Department. For a complete description of the M & SR Engineering and Production activity at Moorestown see **RCA ENGINEER,** Vol. 2, No. 4, Dec. 1956-Jan. 1957.



Precision Instrumentation Radar—AN/FPS-16. Developed over a period of 10 years, this reliable, long-range radar provides a means for advanced operational features in the Talos Defense Unit.

A PROTOTYPE TALOS Defense Unit has been completed at White Sands Proving Ground by RCA and delivered to the Department of Defense. Representing far more than just the physical building and equipment resulting from 2½ years of concerted effort—it symbolizes the rapid advances being made in Electronics.

Such progress is aided by new design and production techniques, electronic controls, automatic machinery and low cost, rapid production. The combined effect is reflected in improved designs of computers, data handling equipment, radars, tactical fire-control centers and finally missile-guidance systems such as "Talos."

TALOS STARTED IN 1955

Early in 1955 RCA was awarded the prime contract to develop a Tactical Talos Land Based System, and to build the Defense Unit at White Sands. This presented a challenge to demonstrate the application of new techniques to an important missile weapon system for defense. It provided an opportunity to use the "Project Approach" whereby people in highly specialized skills, including technical systems engineers, could demonstrate how such a major system could be developed, designed and constructed in a minimum of time. It also provided an opportunity for our subcontractors to apply their skills in developing and producing an automatic missile launcher and other components.

WHAT IT IS

The Talos Land Based System is an automatic defensive, surface-to-air weapon system which has as its primary function the efficient protection of our military bases and industrial centers against air threats—both subsonic and supersonic. The weapon system, to contribute effectively to the survival of our Nation in event of enemy attack, must kill enemy targets and provide maximum protection at a minimum investment, using a minimum of operating personnel.

Three major factors contributing to efficient protection are *coverage*, *rate of fire* and *kill probability* per missile salvo.

COVERAGE depends upon both range and altitude. The range of Talos is sufficiently long that each Defense Unit around a city or military base can participate in engaging a threat from any direction. This range, coupled with high- and low-altitude capabilities, gives Talos the greatest coverage of any local defense system in existence.

A HIGH RATE OF FIRE is attained by using early warning information from radar networks for midcourse guidance and by time-sharing of major components of the system. This is referred to as multiplexing.

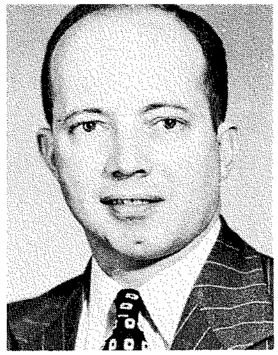
Multiplexing makes it possible for one Talos Defense Unit to engage various targets simultaneously with many missiles in the air at the same time. It can continue to fire single and multiple missile salvos at a high firing rate for an extended period of time.

HIGH KILL PROBABILITY is assured by high overall system accuracy and warhead lethality using either high explosive or nuclear warheads.

HUMAN ENGINEERING

In the design of the Talos Defense Unit extensive effort has been devoted to the application of human engineering techniques. The Fire-Control Center, heart of the Talos Defense Unit, is manned by only a few people at human-engineered consoles which provide information displays so that the operator can easily observe and monitor the operation. The main fire-control console shows a continuous picture of the status of a multitude of engagements simultaneously. To provide an effective display, RCA has used a three-color video display screen.

The Talos Defense Unit includes automatic personnel exercising and system checkout equipment for the overall system, and automatic checkout equipment for the missile. The automatic personnel exercising equipment assures maximum operator training, and maximum system readiness in event of an attack. The personnel exercising portion of the system uses a variety of tactical problems, predetermined and recorded on tape. The tape is played back to feed simulated tactical engagement data to the system. The system responds automatically in the same manner that it would during an enemy attack. Operators completely learn the operation under various conditions, thus the performance of equipment can be checked. The automatic system and missile checkout equipment provides for rapid testing of the complete installation.



HENRY W. PHILLIPS received his M.E. degree at the University of Virginia in 1940, then finished an advanced training program at General Electric. During World War II, he worked at G.E. in a technical capacity in the Aeronautics and Ordnance Systems Division. In 1946, Mr. Phillips joined American Machine and Foundry where he became head of engineering for the Buffalo plant. In 1949, he joined the Knolls Atomic Lab at G.E., where he contributed to the experimental Power Breeder Reactor Program. In 1951, he became chief staff engineer for F. H. McGraw & Co., construction contractor for the U-235 plant at AEC Paducah Area.

In 1953, Mr. Phillips joined RCA to work in Guided Missiles and associated fields. He was assigned Coordinator for Talos Land Based Systems Program in 1954. He is a licensed Professional Engineer in New York, New Jersey and Kentucky; a member of Tau Beta Pi and National Society of Professional Engineers. He is also a member of ASME, ASNE, and Armed Forces Communications and Electronics Association.

ADVANTAGES OF TALOS

Some additional advanced features of this system are as follows:

1. *Missile Interchangeability:* The Talos Defense Unit for the Army uses the Talos missile which is identical to the missile which was developed by Applied Physics Laboratory of Johns Hopkins University and produced by Bendix for use by the U. S. Navy for shipboard Talos installations. The missiles use either high explosive or nuclear warheads. The joint use of the same missiles and warheads by the Army and the Navy for land and shipboard systems results in improved economy of the overall Department of Defense program.

2. *Automaticity:* The Talos Defense Unit is capable of automatically handling, loading, and launching the missile which eliminates the need for personnel in the launching area. In full automatic operation, the Talos Defense Unit operators merely observe and monitor performance.

3. *High Accuracy:* By using precision radars, electronic computers, programmed beam-riding missile guidance and a precise missile homing seeker, extremely high accuracy is achieved at short and long ranges and high and low altitudes. The Talos Tracking Radar uses RCA's precision, long range, instrumentation radar (AN/FPS-16) . . . tested by U. S. Bureau of Standards and found to be the most accurate radar in existence.

4. *High Reliability:* Reliable components, redundancy, multiple data channels and automatic fault bypass features assure high reliability.

5. *Maximum Safety:* The Talos Defense Unit provides a maximum of safety to operators as well as to nearby installations. Missiles can be programmed to provide for boosters to fall in selected areas.

6. *Future Outlook:* The Talos system provides for extension of capabilities with a minimum of modification to assure continued effectiveness against both present and future hostile threats.

EVALUATION OF TALOS

The Talos Defense Unit at White Sands is a partial tactical system constructed to demonstrate the features required in such an important defense system. RCA is proceeding under the direction of Army Ordnance to demonstrate and evaluate Talos. RCA Engineers are confident that all of its design features, some of which have been mentioned above, and others which have been omitted for security reasons, will be of great value. Several launcher firing tests have been successfully made and final acceptance tests completed.

All of the military people in the Army, Navy and Air Force, the RCA personnel and our many subcontractors who have worked on the Talos project have certainly met the challenge presented to them in early 1955 . . . by developing and constructing the prototype installation in 33 months.

THE MEGACODER

A High Speed, Large Capacity Microminiature Decoder for Selective Communication

By **HARRY KIHN and WILLIAM E. BARNETTE**
RCA Laboratories
Princeton, N. J.

INITIAL		ATTAINED
10,000	NO. OF CODES	>1,000,000
250	CODES PER MINUTE	>4,000
10 MA AT 7.5 V	POWER REQUIREMENT	8 MA AT 7.5 V
.4 MA	STANDBY CURRENT	.5 MA
1 CU. INCH	VOLUME	<1 CU. INCH
SPEAKER OR BUZZER	SIGNALLING MEANS	WRIST ALARM BUZZER
MODULAR	CONSTRUCTION	MODULAR
SIMPLE	CODE CHANGE	STANDARD PLUG IN BOARDS

Fig. 1—Micro-miniature decoder specifications

INTELLIGENCE	SELECTION MEANS	MECHANIZATION
FREQUENCY BURSTS F_1 F_2 F_3 --- F_n	MECHANICAL RESONANCE	RESONANT REEDS
	ELECTRICAL RESONANCE	LC TUNED CIRCUIT
	ELECTRICAL RESONANCE	RC BRIDGE OR FEEDBACK
VARIABLE PULSE DELAY T_1 T_2 T_3 --- T_N	DELAY BETWEEN REFERENCE PULSE AND CODE PULSE.	ELECTRICAL ARTIFICIAL DELAY LINE OR ACOUSTIC DELAY LINE.
PULSE CODE MODULATION	DISCRETE COMBINATION OF POSITIVE AND NEGATIVE PULSES	TRANSISTOR-MAGNETIC CORE CIRCUIT. TRANSFLUXOR COINCIDENCE CIRCUIT. TRANSISTOR FLIP-FLOP CKT. FERRO ELECTRIC STORAGE CIRCUIT.

Fig. 2—An analysis of three decoder systems

THE NEED TO EXTEND mobile communications to personal paging without restricting the movements of the subscriber has become increasingly important in recent years. Applications of selective calling in hospitals, factories, aircraft communications and remote and automatic control of machine functions has underlined the need of a high-speed, high-capacity device of small dimensions, low power consumption and high reliability. The limited availability of radio channels has emphasized the requirement of high speed and large subscriber capacity. These criteria are absolutely essential if a system be devised which is capable of future rapid growth as evidenced by the history of the telephone and mobile communications in general.

PROPOSED PAGING SYSTEM

In Fig. 1 are shown some of the more important specifications for a contemplated paging system. Approximately two orders of magnitude of improvement was required in speed and size over existing equipments. Although the limitations of noise affects the ultimate signalling speeds, the system and equipment must be capable of future expansion with changes only in transmitted power, improved receivers and the number of decoder elements. An analysis of three modulation systems which could perform the decoding functions is shown in Fig. 2. The intelligence to be transmitted is in column 1, the selection means in column 2 and the mechanization or the circuitry of the function of column 2 is listed in column 3.

ANALOGUE SYSTEMS CONSIDERED

The "Frequency Burst" method is most commonly used primarily because resonant reed decoders are old in the art and have been available as components for many years. This system involves the combinatorial use of m burst of discrete frequencies $F_1, F_2, F_3 \cdots F_N$, generally in the audio range and of sufficient duration to excite and cause to oscillate some type of mechanical or electrical resonant circuit. This modulation lends itself to normal voice channel transmission, but means must be provided to insure that sustained voice tones or harmonic distortion do not actuate the decoder. The coding capacity or the number of possible distinct codes, C_f, depends on whether the resonant elements are actuated simultaneously or sequentially. In the latter, a storage element is required, such as a relay or RC circuit to carry over to the end of the transmission the information sent at the start. If N = total number of resonators available (electrical or mechanical) and m units are used in each decoder, the coding capacity $C_f = N^m$

For $N = 10$ and $m = 4$, $C_f = 10{,}000$
$N = 22$ and $m = 3$, $C_f = 10{,}648$

In the simultaneous system C_f

$$C_f = {}_NC_m = \frac{N!}{m!\ (N-m)!}$$

For $N = 10$ and $m = 4$, $C_f = 210$
$N = 41$ and $m = 3$, $C_f = 10{,}660$

Since the physical size of reed decoders militates against the use of more than 3 units it is evident that for 10,000 codes, 22 resonators are required in a sequential system whereas for the simpler simultaneous system 41 frequencies must be available.

Other approaches to the problem are the use of inductance capacity (LC) filters and resistance capacity bridge or feedback circuitry. Since the frequencies must be precisely controlled and since these are in the audio range, the components including delay means are too large indeed for personal paging use.

The second system involves the use of the variable delay between a reference pulse and a coding pulse, with a pulse coincidence circuit as the correct code indicator. Here combinations of T_1, T_2, T_3 - - - T_N are used to produce the required code capacity. Similar considerations obtain here as in the "Frequency Burst" system for sequential and simultaneous operations including the need of storage in the sequential delay system. Since the coding delays are of the order of milliseconds, both lumped circuit and piezoelectric precision delay lines occupy too large a volume. Delay in solid state devices, including transistors, depends both on amplitude and temperature, hence these are not yet suitable for large capacity decoding.

DIGITAL SYSTEM SELECTED

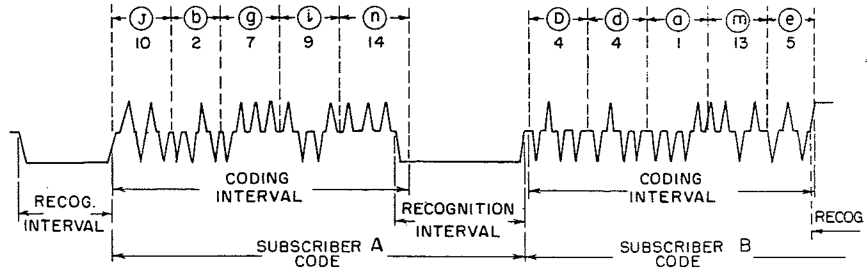
A digital system using a binary code with pulse return to zero was adopted. Digital systems have a basic advantage in accuracy over analogue systems such as the two described above. The price paid for accuracy is the increased complexity and number of elements to attain the desired coding capacity. The modulation consists of a discrete combination of positive and negative pulses which produce a coding capacity, $C_d = 2^N$ where N = number of pulses. The transistor-magnetic core mechanization was used for the Megacoder. The Transfluxor coincidence circuit required excessively large currents. The all-Transistor Register had excessive standby current and twice the number of transistors of the adopted system, and the Ferroelectric Storage System required voltages of the order of 30-40 volts which eliminated its use with power supplies under 10 volts.

In Fig. 3 is shown the modulation waveforms of two subscribers' codes in time sequence. Here a 20 digit bipolar binary code is used, effecting a subscriber capacity of 2^{20} or 1,048,576 codes. A table is shown relating subscriber capacity with the number of coding pulses from $N = 4$, equivalent to 16 subscribers, to $N = 24$, which allows 16,777,216 subscribers to use a single radio channel. The complete call consists of a coding interval using bandwidth-limited bipolar coding pulses and a readout or recognition pulse whose duration is approximately ½ the total coding interval, or sufficiently long to allow separation of this pulse from an all-positive or all-negative plulse by simple circuitry. The polarity of the recognition pulse may be either positive or negative so that its leading edge may serve as one of the coding digits as shown. The subscribers call number may be assigned on a binary numbering system consisting of 5 groups of 4 pulses representing 2^0, 2^1, 2^2, 2^3.

The use of both polarity pulses has the advantage of providing N shifting or clock pulses regardless of code, thus eliminating the need of an internal synchronized oscillator in each receiver. The transmitter thus effectively supplies the "Clock" or "Synchronizing" signals for thousands of receivers which simplifies their design and reduces their cost.

A modification of the readout signal so as to more nearly equalize the net charge is shown in Fig. 4a. This is an oscillogram of two test codes incorporating a bipolar readout pulse, the reverse excursion serving to compensate for the d-c component of the true readout pulse. This waveform requires more time per code and added circuitry to allow the use of reversed polarity readout pulses.

To conserve channel bandwidth and simplify the modulation problem, pulses



NUMBERS OF CODING PULSES n	SUBSCRIBER CAPACITY = 2^n
4	16
8	256
14	16,384
16	65,536
20	1,048,576
24	16,777,216

Fig. 3—Modulation waveforms of two subscribers' codes in time sequence

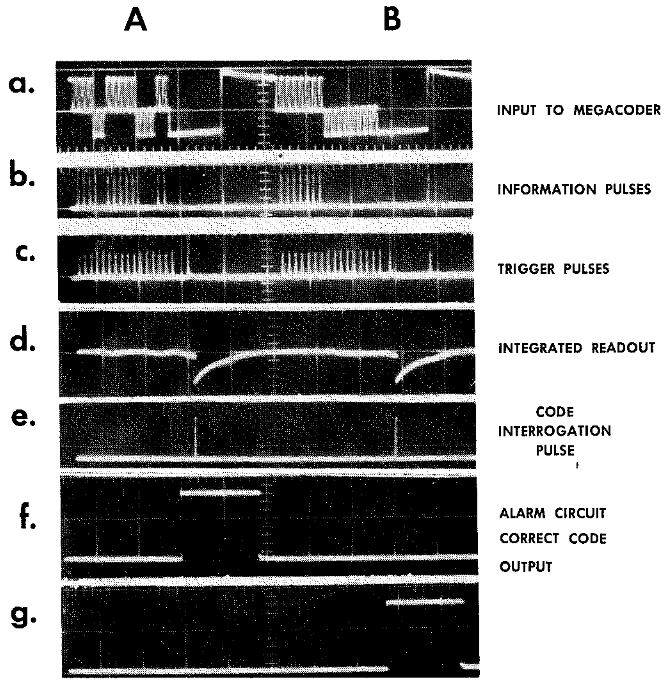


Fig. 4—Oscillograms of key waveforms of the Megacoder.

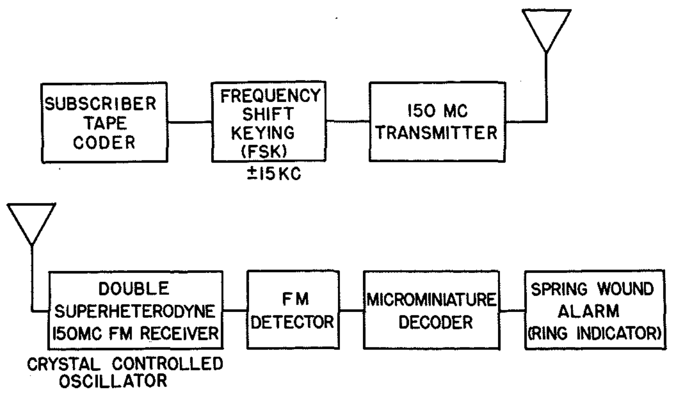


Fig. 5—Block diagram of the selective call communication system

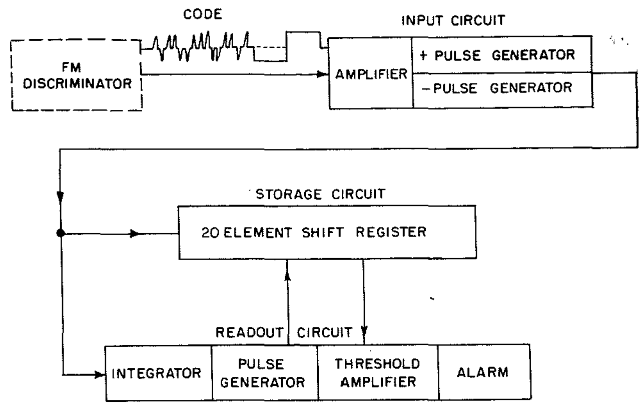


Fig. 6—Megacoder block diagram

approximating half cosine waves may be advantageously used. For a .3-kc bandwidth, 1 millisecond pulses (at the base) will not cause sufficient undershoot to introduce coding errors. For the Megacoder, a 19-millisecond coding interval plus an 18-millisecond bipolar readout pulse will allow a coding speed of approximately 1600 codes per minute. For unlimited bandwidth the ultimate coding speed depends on the transistor alpha cutoff frequency and core switching time. For the megacoder this approaches 20,000 codes/min.

COMPLETE SYSTEM DISCUSSED

In Fig. 5 is shown a block diagram of the complete system. A 150-mc FM transmitter is modulated ± 15kc by the digital modulation waveforms previously described and the signal radiated from a centrally located elevated antenna. The 150-mc pocket-sized RCA-CPC-R1 receiver developed by Communications Engineering of IEP incorporates both the decoder and a call alarm to indicate that the subscriber is paged.

In the Megacoder block diagram (Fig. 6) the FM detector output is fed to a preamplifier which provides the necessary voltage levels in the transistor-magnetic core circuitry and prevents pulse waveforms generated in the decoder from feeding back into the receiver. The positive and negative pulses are separated and each serves to generate an identical polarity extremely short pulse (3μsec). These pulses rather than the millisecond—wide signalling pulses are used throughout the decoder because of reduced battery drain, and simplicity of providing necessary signal delays in the operating cycle. Additionally the short pulses provide greater output from magnetic core circuitry, insure non-dependence of decoder performance on received signal amplitude and allow high signalling speed. This technique has been made feasible by the short switching time of the magnetic cores. The positive pulses are used as *ONE's* (Information) and the summation of the negative and reversed positive pulses serve as negative unipolar shifting (Trigger) pulses.

Both the Trigger and Information pulses are fed to a transistor-core shift register which change the magnetic states of miniature ferrite torroidal cores corresponding to the combinatorial arrangement of positive and negative pulses of the received signal. When the coding period is ended, the magnetic state of the cores is identical to the received signal pattern, regardless of previous signals or state of the register. The subscriber internal code consists of variation of the polarity of interconnection of readout windings on each of the twenty shift register cores. The code may easily be changed by use of plug boards or by soldered interconnections. The readout pulse following the coding interval activates an interrogation circuit which effectively compares the magnetic state pattern stored in the register with the winding polarity pattern. If there is absolute coincidence in every core which is the case for the correct code, a large current pulse flows in the circuit. If one or more cores have a magnetic polarity different from the readout winding polarity the current is reduced. The received signal readout pulse is separated from the coding pulses in an "Integrator" which drives a "Readout Pulse Generator" connected in series with the readout windings of all the shift register cores. The generator pulse output current whose amplitude is a function of the degree of coincidence between the signal code and internal code is impressed on the "Threshold Amplifier." The latter serves to accentuate the difference between complete identity and near identity (one or two pulses different from the correct pattern). The output of the Threshold Amplifier drives a monostable multivibrator in whose output circuit is a fast-acting magnetic solenoid alarm device which calls the subscriber's attention to having been paged.

SHIFT REGISTER

The shift register is considered first because the basic microminiature shift and storage element developed for this use also serves in both the input and readout circuitry.

The use of a core-diode shift register for storage of information in computers is well known. The shortcoming of this method is the loss of power across each diode which has a high forward impedance at the small voltages involved. This results in a decreasing reliability of core setting with increasing number of stages. Furthermore the transfer of state must be done by the trigger pulse which must be sufficiently large to insure complete transfer from the ONE to the ZERO state.

In Fig. 7 is shown one stage of the shift register used in the Megacoder. This encapsulated element .017 cu. inches in volume consists of an 80 mil ferrite core including five windings, a 2N105 transistor, a resistor and capacitor. Also shown is a typical hysteresis curve B vs. H illustrating high remanence magnetization and a curve of permeability $\mu = K\ dB/dH$ vs. coercive force, H. This latter characteristic is an important consideration in the method of information transfer and readout used in the Megacoder.

In Fig. 8 are shown two stages of a shift register and oscillograms of pertinent electrical parameters. To illus-

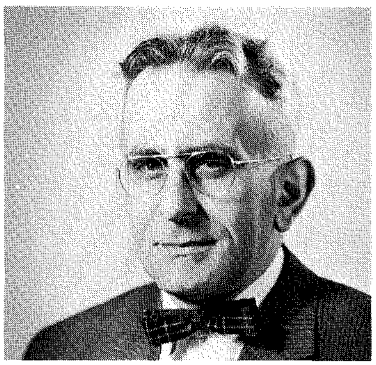
HARRY KIHN received the B.S. degree in electrical engineering from the Cooper Union Institute of Technology in 1934 and the M.S. in E.E. from the University of Pennsylvania in 1952.

Following engineering work for various prominent companies, he joined the RCA Manufacturing Company in Camden in 1939 and engaged in the New York Television Field Test, becoming part of the Receiver and Circuit Development Section in 1940. Transferred to Princeton with the formation of the RCA Laboratories, he engaged in research on military devices. This was followed by extensive work in television receiver circuitry.

He participated in the early development of teleran, air navigation systems, and data transmission systems, and took part in the development of the compatible color television system for the Washington, D. C., field tests. In 1953 he transferred to the Systems Research Laboratory where he engaged in Millimeter Wave High Resolution Radar research developing r-f and i-f components and radar system integration.

He is now directing research in pulse code and digital communication and computer systems and military systems research.

Mr. Kihn is a Senior Member of IRE, a member of Sigma Xi and a member of the Operations Research Society of America. He has about 15 issued patents and a number pending in many fields of radio and electronics.



WILLIAM E. BARNETTE matriculated at the University of Delaware in 1947. His studies were interrupted by a period of service with the U. S. Army, after which he returned to the University and received the B.E.E. degree in 1953. In June of 1953 he joined RCA Laboratories. In 1954, he was assigned to work in the Systems Research Laboratory, where he engaged in developing linear and logarithmic i-f amplifiers. Currently he is doing research in pulse code, digital communications and computer systems. Mr. Barnette is doing part-time graduate work in Electrical Engineering at Princeton University. He is a member of the Institute of Radio Engineers.

trate the principle of operation assume that a *ONE* had been set into the left hand core 1 by a current pulse in the information winding. At this point of the magnetization curve (Fig. 7) the core permeability is very low, hence, the coupling between the collector and base winding of the transistor is insufficient to cause oscillation. When a trigger pulse, I_t, appears in the trigger winding the magnetic operating point moves along the hysteresis curve so as to increase the permeability to the point where the feedback is sufficient to start oscillation. The collector current flows in such a direction as to reinforce the change of state begun by the small trigger pulse and oscillation amplitude increases as the maximum permeability is traversed and finally ceases as the large transistor current flowing I_c drives the core to low coupling in the ZERO state. It is evident that I_c is a very narrow pulse of approximately 3 μsec.

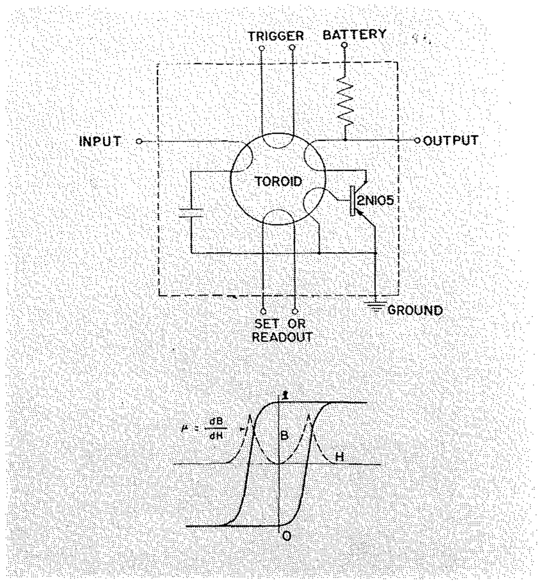


Fig. 7—One stage of the shift register used in the Megacoder

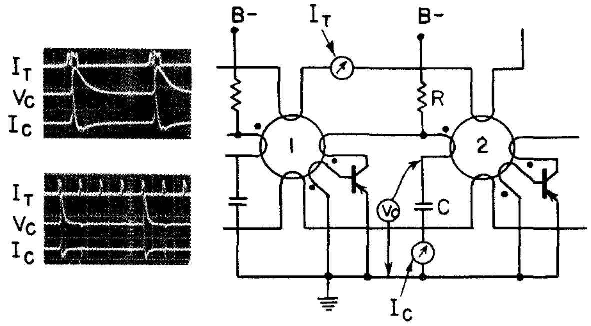
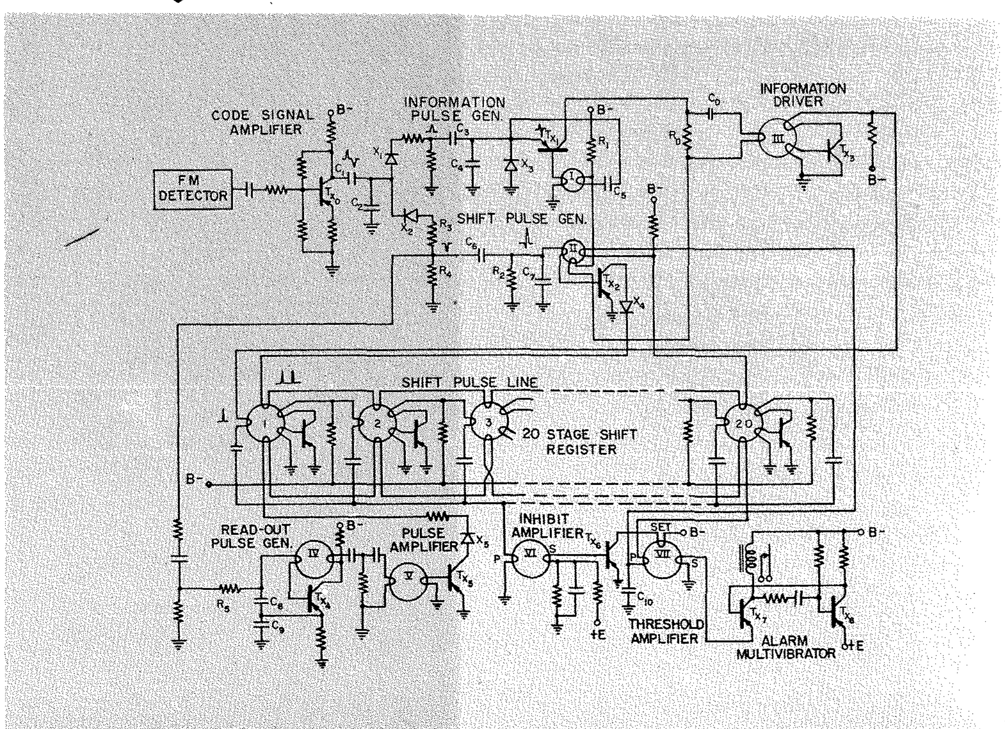


Fig. 8—Two stages of a shift register with voltage and current waveforms

Fig. 9—Schematic diagram of the complete Megacoder



duration. The transistor current during conduction is supplied mainly by the capacitor and only to a small extent by the battery, thus almost completely discharging the capacitor as shown by V_c. At the cessation of transistor conduction, the capacitor is recharged through the resistor, which charging current, shown negative in Fig. 8, serves to set the following core to a *ONE* state. The latter state is maintained until the incidence of the next trigger pulse at which time the same cycle is repeated for core 2, thus transferring information from core to core at each occurrence of a trigger pulse. If a core is originally in the *ZERO* state no oscillation results upon being triggered. In the lower oscillogram are shown the waveforms for a 4-stage shift register whose output is fed back into the input to produce cyclic information transfer.

This type of shift register has proved very successful because of the small trigger drive required, extremely low power consumption, reliable setting and no reasonable limit to the number of stages. The latter advantage results from the power regeneration in each stage by means of one transistor rather than the use of two equally expensive diodes.

MEGACODER AS PART OF SYSTEM

In Fig. 9 is shown a schematic circuit diagram of the complete Megacoder arranged to correspond to the block diagram shown previously. The code signal preamplifier incorporates negative feedback for temperature stability and an output filter for optimizing signal to noise performance. The information (+) and trigger (−) pulses are separated and each fed to a transistor-magnetic core pulse generator, thus converting the broad signalling pulses into 3 μsecond processing pulses. The information pulses are fed to the first stage of the 20-element shift register, while the negative and reversed positive pulses are fed into the series trigger line of the shift register. If the readout pulse is negative the integrator circuit is fed by voltage pickoff after the negative diode, and similarly from the positive diode for a positive readout. The integrator circuit drives a transistor-core pulse generator such that when a voltage threshold has been reached, this circuit fires, producing a very narrow pulse in series with all the readout windings of the shift register. Each of these windings is brought out to a miniature terminal board and the polarity interconnection of these windings constitutes the subscriber's code. The comparison of the coercive force polarity and the magnetic state of each core due to the received code constitutes the logic of the system as described previously. If coincidence occurs due to the reception of a correct code, the magnitude of the resulting pulse current is sufficiently large to exceed the threshold of a very square core of large coercive force, whose primary winding is in series with the shift register readout windings. The secondary of this Threshold Amplifier core is connected to the quiescent emitter of a transistor monostable multivibrator in whose collector circuit is a fast-acting relay which actuates a spring-wound alarm. Therefore with the reception of a correct code the alarm circuit is instantaneously set off and can be so adjusted that manual turnoff is necessary. In order to insure that the alarm be not activated during the coding interval, the return-to-ground line of all the discharge capacitors of the shift register is in series with a winding on the inhibit amplifier core. The polarity of this winding is so arranged that capacitor current due to core switching inhibits circuit actuation. In Fig. 4 are shown oscillograms of key waveforms of the Megacoder, the input voltage, information pulses, trigger pulses, the integrated readout pulse, the code interrogation pulse and the alarm multivibrator output circuit waveforms for two subscribers' correct codes. In Fig. 4f the Megacoder is set to respond to the code signal at the left of 4a, and 4g responds to the right hand signal of 4a.

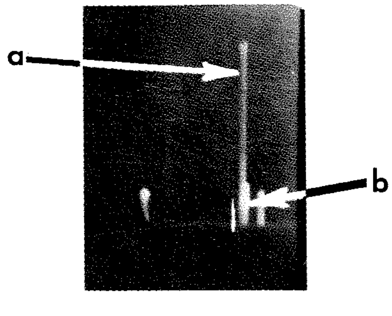


Fig. 10—Alarm multivibrator input. (a) shows correct code and (b) shows incorrect code with 1 bit error.

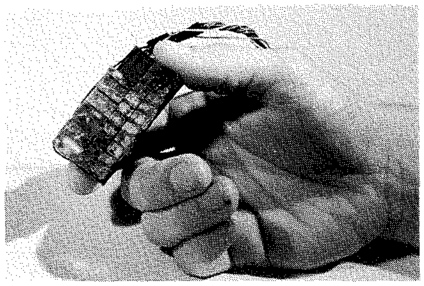


Fig. 11—The modularized Megacoder

Fig. 10 shows the input to the alarm multivibrator for a correct code and an incorrect code of 1 bit error. The amplitude ratio is approx. 12db and increases with greater divergence between correct and incorrect codes.

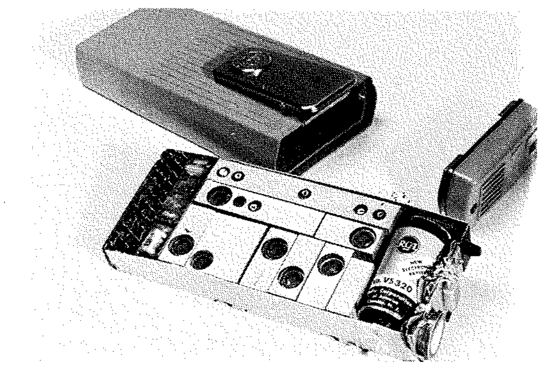


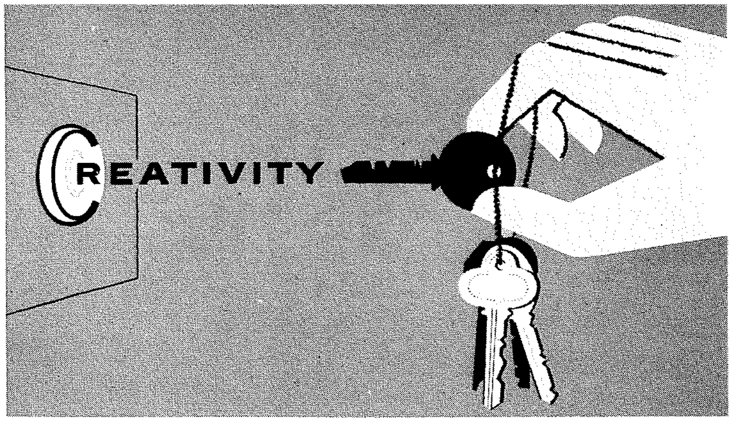
Fig. 12—The Megacoder incorporated in a RCA-CPC-R1 receiver

Fig. 11 is a photograph of the modularized Megacoder and Fig. 12 shows the latter incorporated in a miniature RCA-CPC-R1 receiver developed by Communication Engineering of IEP. Several hundred hours of operation have been obtained under widely varying signal conditions with only a change in battery required. The Megacoder and more advanced decoders under development at the Laboratories are still experimental devices and their success in obtaining large-scale production and trouble-free performance will depend in great measure on the efficacy of their product design in the manufacturing division of RCA. The close cooperation between the Product Division and the Systems Laboratory made possible the progress described herein.

ACKNOWLEDGEMENT

The Megacoder and Digital Signalling System program has benefited greatly from the efforts and contributions of the RCA Product Divisions particularly the IEP Manager of Communication Planning who originally presented the problem to the Laboratories, and the engineers of the Communication Engineering section who worked closely with our research group in Princeton. Assistance was provided by the Advanced Development section of IEP in the form of novel test equipment and field evaluation of digital communication. The Surface Communication section of DEP participated in early discussions. Excellent cooperation was had from the Materials Laboratory at Needham Heights and the Semiconductor Division at Somerville. At the David Sarnoff Research Center Dr. G. H. Brown initiated the program and valuable assistance was provided by the Magnetics and Dielectrics Laboratory, the Computer section, the Semiconductor Devices group, the Model Shop and Tube Assembly personnel.

Particular mention should be made of the guidance and encouragement of the consultant to the microminiature program, Dr. A. N. Goldsmith.



WILL YOUR KEY UNLOCK THIS DOOR?

(Part II of a Series on the Subject of Creativity)

Editor's Note: Because of reader interest, we are publishing the feelings of RCA engineers on the subject of Creativity. To do this, we have enlisted the help of the Committee pictured on this page, as well as the assistance of our Editorial Representatives in all areas of the Company. Statements appearing in this series on Creativity represent the engineers' personal views, uncolored by the abundance of "expert" opinion available on the subject. We hope you will find these expressions thought provoking and interesting. Submit your ideas on the subject to your nearest Editorial Representative!

To help "sparkplug" the Series on Creativity, initial plans were made by committee members shown here, l. to r.: D. G. Garvin, Lancaster; J. F. Hirlinger, Harrison; P. C. Farbro, Camden; Dr. H. J. Woll, Camden; J. J. Newman, Camden; L. H. Good, Camden; C. M. Sinnet, Cherry Hill; and G. W. King, Moorestown.

IS THE FORMULA YOUR MASTER?

By

G. R. Fadner

Tube Division
Lancaster, Pa.

Creative individuals must recognize the limitations of formulas as they attempt to solve the many complicated technical problems facing industry today. Too often a solution is effectively pigeon-holed because it doesn't fit the formula.

Before we analyze new concepts or ideas on the basis of existing formulas, we must consider very carefully if all the conditions of the formula fit the problem at hand. Very often the device itself can determine the law it obeys through carefully planned experiments.

Formulas should be an engineer's tool, not his master. When someone says it can't be done, try it. Remember, if the solution you are seeking were predictable by the formula, it's a good bet it would have been achieved long ago.

CREATIVITY IS ART

By

Harold E. Haynes

Industrial Advanced Development
Industrial Electronic Products
Camden, N. J.

I often recall the admonition of a college English professor, that in judging a literary work one should ask three questions; first, did the author have a clear objective, second, did he achieve it, and third, was the objective worthwhile? This yardstick continues to impress me as an engineer, for I believe it applies to any type of creative endeavor, engineering as well as "the arts." Scientific creativity, a blend of skill, inspiration, and experience, shares many of the attributes of artistic creativity.

But two of these three questions do not relate directly to the *execution* of the work at all. They ask, rather, whether the purpose was clear and valid, since deficiency here can vitiate the whole effort. The creative engineer should never neglect to establish his aims clearly and to establish their validity. And far from "cramping his style," these disciplines will actually (and perhaps unexpectedly) channel his energies more productively. In following them often lies much of the effort and the merit of an outstanding creative work.

THE CREATIVE ENGINEER

By

W. E. Newman

Mechanical Engineering
Defense Electronic Prod.
Moorestown, N. J.

It may be that "All men are created equal" but some are endowed with special talents.

These special talents develop into outstanding achievements under appropriate educational and environmental conditions. A suitable environment, association with people of similar interests, and the availability of adequate facilities unquestionably help to stimulate development of rudimentary ideas. However, even without this the truly creative person will overcome any obstacles to accomplish his objective. He is resourceful, original, persevering, and inquisitive. Notable, and of great importance is his refusal to accept things as they are.

My advice to young engineers is to use their academic training by adapting the abstract theories learned, to practical application. An idea can be valuable whether patentable or not. In fact, many outstanding creations for a new product design are combinations of ideas already known.

Bear in mind that creativity is measured by accomplishment. *Mr. Newman has 28 years of RCA experience, 17 U. S. and 32 foreign patents.—Ed.*

IDEA GROWTH

By
Marshall Kidd
TV Advanced Development Eng.
RCA Victor Television Division
Cherry Hill, N. J.

The growth of an idea is in many ways analogous to the growth of a plant. The requirements are a seed, a fertile environment and if superior characteristics are desired, hybridizing may be tried. Ideas come from individuals, but the group can provide a fertile environment in the form of stimulating discussions. The many techniques of handling the individual-group relationship correspond to such things as fertilizing, soil conditioning, hormone treatment and cross pollination. Industry is interested in superior ideas so that methods of hybridizing of ideas are desired. Brainstorming is a current technique which is getting results but it is probably not the ideal approach. Creativity, like the growth process, may never be understood completely but certainly the contributing factors can be isolated and used effectively.

COLD WATER VS. CREATIVITY

By
Nelson D. Scheib
Numerical Analysis Group
Missile & Surface Radar Engineering
Moorestown, N. J.

The greatest enemy to new ideas is an unconscious mental inertia which resists change. All too often, a good idea is killed in its infancy because it failed to survive the initial onslaught of "I don't think it will work."

Engineers, because of their training, instinctively examine all ideas under the test of practicality. This leads to a state of mind that first tries to find out what is wrong with the idea before finding out its good points.

To encourage Creativity, we should reserve our criticism until we are deluged with possible solutions to a problem. Only then should a critical analysis be made. We may find parts of worthless ideas that can be combined into a workable solution.

Almost any theory can be "proven" impractical before it is tested. "The bumblebee's wings cannot support the weight of its body."

USEFUL CREATIVITY?

By
J. J. Newman, Mgr.
New Products and Market Develop.
Components Division
Camden, N. J.

While the current flare of attention to ways and means of generating new ideas can hardly be called a waste of time, it is poorly directed effort. Ideas are cheap. *Practical, useful* ideas are not so cheap, particularly after they have been *proven* to be practical and useful. It is this stage of proving and applying an idea that needs the most and receives the least attention under the heading "Creativity."

We badly need study and instruction in techniques of evaluating ideas, of communicating ideas, and of selling ideas. Any light shed on idea creation is useful illumination, but other areas are so much darker it seems a pity our writers, teachers, and thinkers are shining their bright lights into the wrong corner. *Mr. Newman has an intense interest in the general topic of creativity—See article in Vol. 3, No. 2—Ed.*

OPPORTUNITY

By
F. L. Putzrath
Special System and Develop. Eng.
Defense Electronic Prod.
Camden, N. J.

To stimulate Creativity, the individual must have the . . .

- opportunity to develop experience in a variety of not too closely related fields of endeavor,
- opportunity to repeatedly feel the need of invention in a particular problem,
- opportunity to become acquainted with the present knowledge in the problem area,
- opportunity to let the subconscious work in periods of apparent disconcern with the project,
- opportunity to have periods of relaxed thinking time completely isolated from outside as well as personal distractions such as physical discomfort, drowsiness, hunger, family problems, etc.,
- opportunity to repeatedly and thoroughly discuss, review, and evaluate his ideas with other people of at least equal knowledge in the problem area.

AWARENESS OF NEED

By
A. Lisicky
Missile & Surface Radar Engineering
Moorestown, N. J.

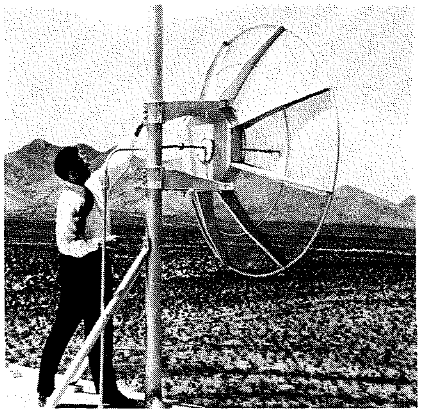
The definition of creativity will vary according to the individual. I feel that it is more important to recognize the probable process or procedure followed by a creative individual than it is to attempt to define creativity. Primarily, in one way or another, the creative individual must be aware of a need to do something which has not been accomplished previously or which can be performed in a simpler, less expensive manner with the use of different techniques. The old saying "Necessity is the mother of invention" still applies.

Coupled with being aware of the need, the creative individual must recognize the limitations which will be associated with his design. In other words, he must decide on a suitable set of specifications, if these are not already given to him. The most difficult step in the process is the actual creation or design. Experience in the particular field of interest becomes the most important asset of the individual. However, if he lacks experience he does the next best thing which is to conduct a search on the subject and to consult with those who have had experience.

CREATIVITY

By
E. W. Herold
RCA Laboratories
Princeton, N. J.

Creativity in science and engineering means taking a mental "giant step" ahead, when most of your peers are taking ordinary steps. It doesn't require a complete knowledge of the subject and, in fact, too much familiarity can even be a handicap. But it does require hard work at assembling and sifting ideas. Do with your ideas as you would in fishing: aim to catch the big fellow, throw the little ones back in, and have patience. Above all, don't believe the man who tells you the pond is fished out. When a theoretical chap proves something can't be done, don't quarrel with his theory. But examine his premises and assumptions carefully, then violate them in your thinking. When you do an analysis of your own, do your best to find reasonable assumptions which give a positive, not a negative result. Finally, if you succeed in the creative process, don't think the job is over. It often takes a greater effort to mature the brain child than it did to produce it in the first place, but the rewards are correspondingly greater.



SYSTEM CONSIDERATIONS IN MULTICHANNEL FM RADIO RELAY DESIGN

By **H. S. WILSON**
Communications Engineering
Industrial Electronic Products
Camden, N. J.

ANALYSIS OF MICROWAVE system design involves many facets of communication engineering knowledge. The performance limits of each equipment must be understood before an accurate appraisal of the system capabilities can be obtained. It must be recognized that each proposed system has unique problems, with no magic formula for solution. Equipments may be thought of as a "volume" into which all operating parameters must fit. Several of these parameters may be varied, resulting in a loss or gain in particular operating characteristics. It is the purpose of this paper to present in one place a number of the considerations leading to an understanding of communication system design problems.

DESIGN LIMITATIONS

Since it is usually impractical to design pieces of equipment to optimize every possible requirement, the system engineer must juggle the remaining variables under his control to achieve the desired overall system performance.[1,9] In the initial design stage, receiver bandwidth can be established in accordance with the required modulation bandwidth. When the bandwidth becomes wider, the r-f input signal must be stronger to give comparable results. However, there are definite limitations on the ultimate reduction of receiver noise. The FM improvement threshold also bears a fixed relationship to the receiver bandwidth and noise figure.

Total transmitter output power depends upon frequency and type of transmitting tubes employed. The design of the transmitter must be integrated with the receiver design to provide an adequate system gain. In original design, a compromise is reached on receiver bandwidth, receiver noise figure, and transmitter output power to produce a system with the most favorable operation and economy. The system engineer can now use these fixed conditions in establishing such communication parameters as the required number of channels, signal-to-noise, and loading conditions.

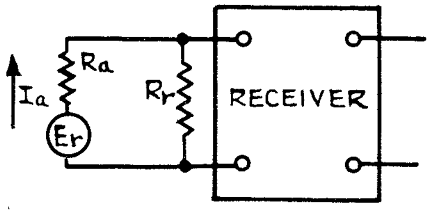


Fig. 1 — Antenna Circuit Diagram.

RECEIVER CHARACTERISTICS

The subjects of thermal noise, equivalent noise input (ENI), receiver noise figure, and FM improvement threshold frequently arise in analyzing microwave relay systems. The fundamentals of these aspects of system design are covered in the following paragraphs.

THERMAL NOISE—The type of noise called impulse noise (static, ignition, etc.) has no significant content in the ultra-high frequency spectrum under consideration. Thermal noise or fluctuation noise extends over the entire frequency spectrum and is the controlling noise source.

Thermal noise results from the incessant electron activity occurring in a resistor. The noise voltage produced by a resistor R at an absolute temperature T in bandwidth Δf is given by:

$$E^2_n = 4RKT\ \Delta f \qquad (1)$$

where

$K =$ Boltzman's constant and is equal to 1.38×10^{-23} Joules per degree Kelvin

$T =$ absolute temperature of the resistor (degree C + 273)

$E^2_n =$ square of thermal noise rms voltage.

$\Delta f =$ Bandwidth under consideration in cycles.

$R =$ Value of resistor in ohms.

A nominal value of T, the effective temperature of space, in several publications is given as 17°C. However, recently the EIA (formerly RETMA) Ad Hoc Microwave committee adopted 27°C as a practical value. (300° Kelvin.)

Since most calculations regarding noise are handled as power values, it is necessary to change the thermal noise voltage to watts (P_n). A schematic of an antenna circuit is shown in Fig. 1.

The power can be given as

$$P_n = KT\Delta f \qquad (2)$$

Note that thermal noise power is dependent only on the bandwidth variable. Utilizing the constants already discussed we may simplify equation (2) for general use.

$$P_n = 1.38 \times 10^{-23} \times 300 \times \Delta f$$

$$P_n = 4.14 \times 10^{-21} \times \Delta f$$

Thermal noise power in dbw

$$= 10 \log 4.14 \times 10^{-21} \times \Delta f$$

$$= -203.8 + 10 \log \Delta f \qquad (3)$$

To establish the thermal noise developed in the particular system under consideration, substitute the i-f bandwidth of the receiver in equation (3).

RECEIVER NOISE FIGURE—There is no "ideal" receiver with a noiseless input impedance as assumed above. Therefore, the receiver noise figure will be a measure of the actual noise contributed by the receiver. For a given carrier-to-noise input, the receiver noise figure is represented by the ratio between *antenna input carrier-to-noise* and *carrier-to-noise output*, measured ahead of all non-linear devices.

In the non-existent ideal receiver, noise would only be developed in the

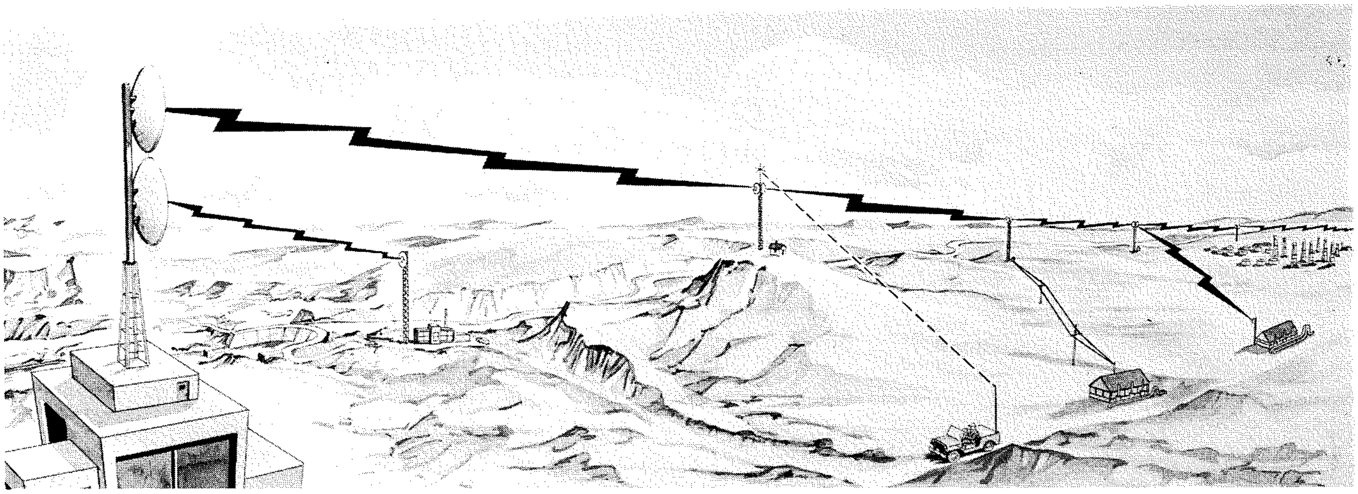


Fig. 2 — Artist's conception of a typical microwave communication system connecting a city office location to outlying production and maintenance facilities.

input impedance, R_r. With this input matched to the antenna impedance, R_a, a thermal noise would result, equal to that developed in the antenna. Thus, the receiver-noise figure would be 3 db, less than that obtained in actual practice.

Reliable figures can only be obtained by actual measurement. The usual technique is to terminate the receiver input with a resistance equal to the associated antenna impedance. Output noise power is then observed on a measuring instrument usually connected to the receiver at the i-f output ahead of all non-linear stages. A noise generator is then used to drive the receiver until the receiver noise output is doubled. By using the noise generator output and calculating the thermal noise from the receiver bandwidth, it is possible to arrive at a noise figure for the receiver.

Equivalent Noise Input—(ENI) The term ENI refers to the absolute power developed in the receiver by thermal noise agitation in the antenna radiation resistance, plus the inherent noise contributed by the receiver. It is basically the r-f input signal required to raise receiver output power (measured at a linear point in the receiver) to a figure just double that obtained for a "no-signal-input" condition.

FM Improvement Threshold — The threshold of a microwave system is the received power required to realize the wideband improvement. The term FM improvement threshold applies to the receiver input signal level, above which the full theoretical FM signal-to-noise improvement is obtained. This is sometimes said to be the signal at which the instantaneous peak noise voltage is equal to the peak carrier voltage. However, other factors such as limiter efficiency, limiter time constant and discriminator balance also influence the threshold level.

Fluctuation noise is the controlling noise source in ultra-high frequency work, with peak noise values occurring on a probability distribution basis.[2] A peak-to-RMS ratio of 13 db will be exceeded not more than 0.006% of the time. A peak-to-RMS ratio of 10 db will be exceeded about 0.16% of the time. FM improvement threshold figures have been published as having occurred at values from 9 to 13 db, carrier-to-noise ratios.[3,4] Landon,[5] in his paper, uses a 9 db figure but in a footnote points out that some prefer a C/N ratio as high as 15 db. M. G. Crosby[6] uses C/N of 10 db.

Stumper,[4] in his study, assumes perfect limiters and discriminators and mathematically deduces the point at which the noise increase becomes non-linear. This occurs at a C/N ratio of 10 db (Fig. 3 illustrates this effect). Curves are shown for carrier-to-noise ratios versus noise output for i-f bandwidth/audio bandwidth ratios of 10, 5, 2, and 1 (see curves for a comparison of large and small ratios).

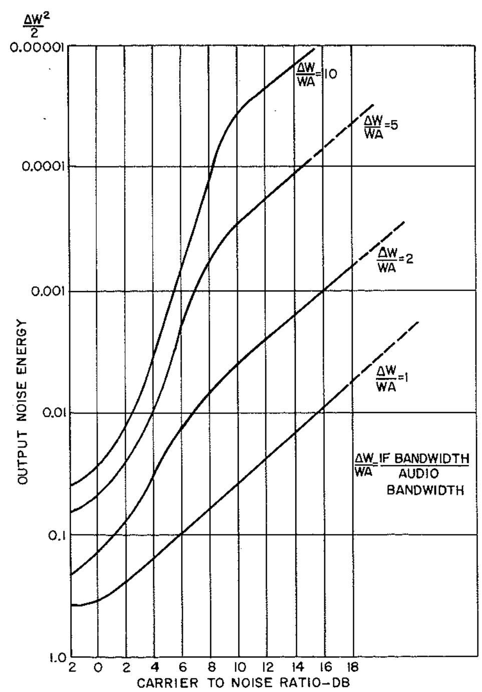


Fig. 3 — Curves demonstrating the effect on the FM threshold at a C/N ratio of 10 db for increasing ratios of $\frac{\text{IF bandwidth}}{\text{Audio bandwidth}}$

Multichannel communication systems have a high i-f bandwidth/audio bandwidth ratio. The operating conditions are designed to give adequate channel signal-to-noise at the FM improvement threshold, which is considered as occurring at a C/N ratio of 10 db in the theoretical case. As can be seen by the curve for $\Delta\omega/\omega a = 10$, Fig. 3, noise increases very rapidly as carrier is reduced to ratios below 10 db. Therefore, in multichannel work, the FM improvement threshold value is usually considered the limiting operational point. In practice, second order effects generally result in a threshold point less well defined than that indicated mathematically. So, empirical data is usually utilized (for example, 12 db).

R-F SYSTEM GAIN

The term "r-f system gain" refers to the "db" difference between transmitter output and receiver FM improvement threshold (or receiver sensitivity). System gain includes duplex coupling losses but not transmission losses or gains. R-F System Gain has never had an "accepted definition," but as we have used it here, it includes everything in the "system equipment," exclusive of transmission line losses or antenna gain. Propagation loss is treated separately.

For example, the values of a typical equipment might be:

Receiver thermal noise	= —136dbw
Noise figure (N)	= 12 db
Carrier-to-Noise ratio at FM threshold	= 12 db
Receiver Sensitivity	= —112dbw
Transmitter output	= +5 dbw
Duplexer filter losses	= 2 db

Therefore the R-F System Gain

$$= +5 - (-112) - 2 = 115 \text{ db}$$

SIGNAL-TO-NOISE RATIOS

Signal-to-noise ratio in a voice channel spectrum can be mathematically determined for any figure above the FM improvement threshold. This ratio is obtained from the summation of the carrier-to-noise ratio plus the bandwidth reduction improvement and the effect of the modulation index or FM improvement factor. The "per channel" signal-to-noise can be determined from:

$$S/N = 20 \log D/M \sqrt{BW/2A} \times C/N \qquad (4)$$

S/N = Signal-to-Noise Ratio in db
D = Deviation per channel
M = Modulating frequency of the channel
BW = I-F bandwidth in cycles
A = Audio bandwidth in cycles
C/N = Carrier-to-noise ratio in the I-F portion of the receiver (voltage ratio)

For a given frequency deviation, D, the modulation index D/M varies inversely as the modulating frequency. The effect on the channel S/N is to increase the noise with increasing modulating frequencies. Thus, higher channels will have a poorer S/N than lower channels, when a fixed deviation per channel is used. Most multichannel systems, therefore, have a pre-emphasis circuit at the transmitter and a de-emphasis network in the receiver. In order to keep crosstalk in the lower channels from becoming excessive, care must be exercised to maintain linearity when pre-emphasis is increased. In calculating S/N the characteristics of the equipment must be taken into account.

LOADING CONSIDERATIONS

Loading a multichannel system is a function of the statistical distribution of active voice channels based upon the number of voice channels in use. To reach a conclusion regarding the deviation assigned to each channel, two conditions must be met.

(1) The channel S/N cannot be less than a pre-determined value based on particular propagation characteristics.
(2) With the "per-channel" deviation required to meet (1), the total system peak deviation due to all active channels cannot be exceeded more than a specified percentage of the time.

Propagation reliability of a multichannel microwave relay circuit is usually specified in terms of the percentage of time that the channel noise at the receiver output may be allowed to exceed certain specific standards. Since this occurs only occasionally, the signal-to-noise may be permitted to reach a low value as long as it is still usable. For example, typical S/N at the FM improvement threshold is often 30 db. Depending upon the number of channels assigned to the system and maximum deviation capability of the system, this value can be varied over a wide range. The deviation per-channel to give the required threshold S/N has a very important bearing on the ultimate channel capacity of the system.

It is also necessary to consider the total loading on the system so that a basic channel deviation can be assigned. The total peak system deviation under the expected loading cannot exceed the deviation capability of the system more than a stated percentage of the time, usually 1%.

Multiplex channels loaded with voice traffic can be considered on a statistical distribution basis. A study by Holbrook and Dixon[7] considered the characteristics of multichannel speech.

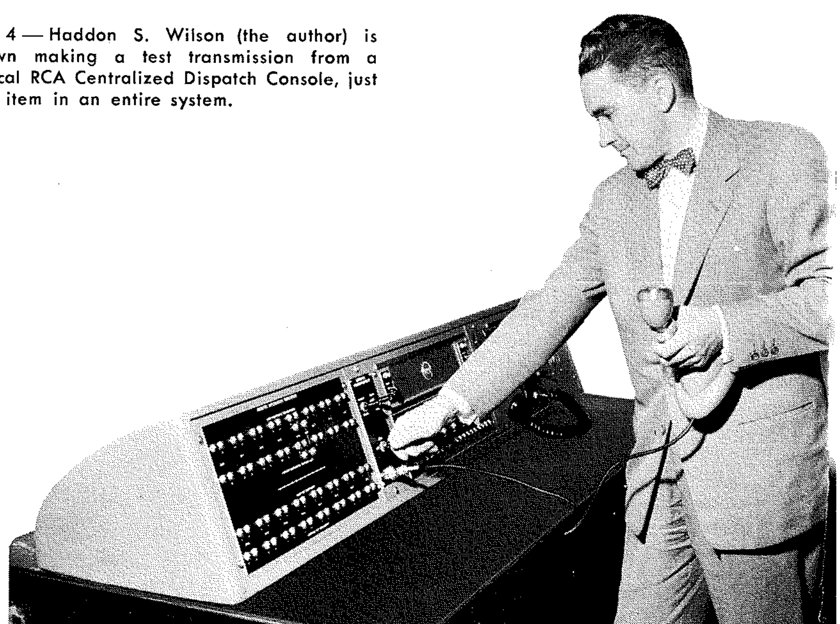


Fig. 4 — Haddon S. Wilson (the author) is shown making a test transmission from a typical RCA Centralized Dispatch Console, just one item in an entire system.

Holbrook and Dixon also found that the average talker had an average speech power of −10 db measured at a zero level point (toll circuit switchboard). A more recent study by V. Subrizi[8] establishes a change in the level of the average talker to −16 db relative to the zero-level point. This type of loading can be considered as light loading on an FM radio relay system. For example, at a zero level point, the average load on an active voice channel will be 16 db lower than the zero level from which the S/N is referenced.

In actual practice, a multichannel system may have signalling tones, voice channels, teletype and data transmission. Statistical loading due to each of these must be considered and the overall effect analyzed. In the simplest loading problem, only voice loading would exist.

The rms deviation of the system is the square root of the sum of the squares of individual channel RMS deviations when the number of channels is large. The peak factor added to the total rms deviation again is a statistical result based upon the number of active channels, i.e., the peak factor for 20 active voice channels is 15 db.

Peak deviation can be given:

$$D_P = PF\sqrt{\left(\frac{d}{R}\right)^2\left[\Sigma(P)^2\right]} \quad (5)$$

where: D_P = Peak system deviation.
d = Basic rms deviation of one active channel (no Pre-emph.).
R = Voltage ratio of zero level to loading level of voice.
P = Sum of squares of the voltage pre-emphasis of each active channel.
PF = Peak factor. (Voltage ratio referenced to the rms system deviation.)

Fig. 5 shows the pre-emphasis characteristic of a 300-kc baseband system having a pre-emphasis characteristic of 3.4 microseconds. This equipment was designed for a 72-channel system. For calculating the per-channel deviation, the spectrum can be divided into slots, 6 channels wide. The average pre-emphasis for each slot is used in calculating the peak deviation.

CONCLUSIONS

In preceding discussions there has been no attempt to present a rigid set of equations for solving system communication problems but rather we have attempted to cover a number of factors which must be understood before a successful solution can be derived. Other important areas of communication analysis such as fading, antenna gain, transmission lines and free space losses have not been discussed. This aspect has been analyzed by B. A. Trevor[1] and D. R. Marsh.[9]

Bandwidth, noise figure, transmitter power, required signal-to-noise, and number of channels in the system all have an important bearing on the design problem. For example, were the engineer to choose a wide-band receiver and assign a relatively high deviation per-channel, he would achieve a high signal-to-noise ratio per-channel at a specific C/N ratio. On the other hand, if he chooses a narrow-band receiver with a small deviation per-channel, he would have a poorer S/N per-channel for the same C/N ratio. In the first case, the FM improvement threshold would be higher, providing less margin for fading. This means that the wide-band system requires more transmitter power to maintain the same propagation reliability.

By use of proper criteria, the engineer can design a system for 24, 48, 100, 600 or more channels. The parameters for each system will vary and the complexity will increase as channel capacity and the variety of services increases.

BIBLIOGRAPHY

1. "Modern Analysis of Communication System Performance," B. A. Trevor, RCA ENGINEER, Vol. II, No. 2, Aug-Sept. 1956.
2. "Mathematical Analysis of Random Noise," S. O. Rice, B. S. T. J., Vol. 24, January 1945.
3. "Transatlantic Frequency-Modulation Experiments," Granlund and Argumba, Research Lab. Electronics, Sept. 1954.
4. "Theory of Frequency-Modulation Noise," F. L. H. M. Stumpers, I. R. E., Sept. 1948.
5. "Multiplex Transmission Systems," Landon, RCA Review, Sept. 1948.
6. "Frequency Modulation Noise Characteristics," Murray G. Crosby, I. R. E., April, 1937.
7. "Loadrating Theory of Multichannel Amplifiers," Holbrook and Dixon, B. S. T. J., October, 1939.
8. "A Speech Volume Survey on Telephone Message Circuits," V. Subrizi, Bell Lab Record, Vol. 31, Aug. 1953.
9. "Planning a Microwave Radio Relay Communication System," D. R. Marsh, RCA Communication News, Fall and Winter, 1956.

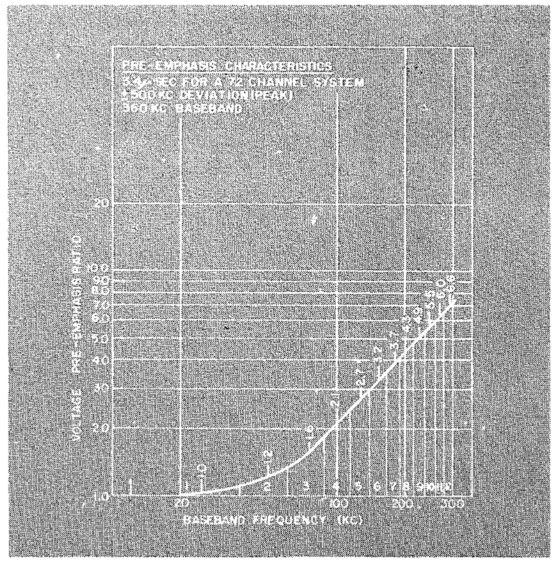
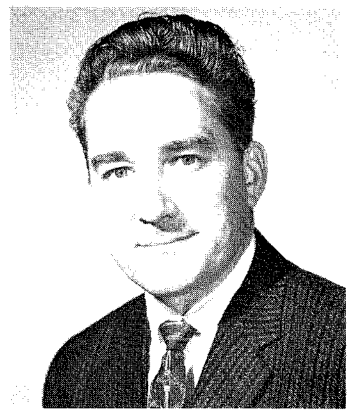
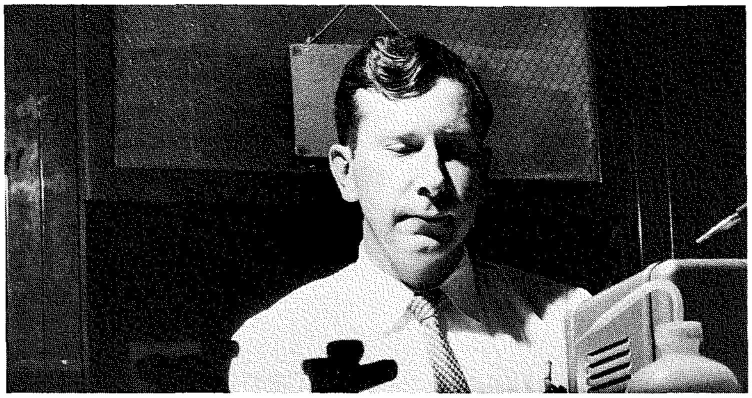


Fig. 5 — Preemphasis characteristics for a 72-channel system. Spectrum is divided into 6-channel slots to simplify calculations for peak deviation.



HADDON S. WILSON received the degree of B.S. in Electrical Engineering from Queen's University, Kingston, Ontario, in 1950. He joined the Canadian General Electric Company in their test course and in January 1951 transferred to that Company's Microwave Systems Engineering Group as a systems engineer. Since joining RCA in 1953, Mr. Wilson has been engaged in multichannel VHF and microwave relay systems design. He is an associate member of the IRE, AIEE and a Registered Professional Engineer in Ontario (Canada).



SAMUEL B. DEAL received the B.S. degree in Chemistry from Clemson College in 1943 and the M.S. degree in Chemistry from Ohio State University in 1948. He taught undergraduate chemistry for one year while attending Clemson College, and served as a graduate assistant while attending Ohio State University. He served in the U.S. Army Chemical Corps from 1943 to 1946, and is presently a Captain in the Army Reserve. He joined RCA in 1950 as a member of the Lancaster Chemical and Physical Laboratory of the Electron Tube Division. At present, he is Engineering Leader of the Analytical Group of the Laboratory.

Mr. Deal is a member of the American Chemical Society, the American Crystallographic Society, the Society for Applied Spectroscopy, the American Business Club, the Reserve Officers' Association, and the American Legion. He is also a member of one of the committees of the American Society for Testing Materials.

THE ROLE OF ANALYTICAL CHEMISTRY IN THE ELECTRON TUBE INDUSTRY

by

S. B. DEAL

Chemical and Physical Laboratory
Electron Tube Division
Lancaster, Pa.

CHEMISTRY IS ACTUALLY two sciences: analysis and synthesis. Analytic chemistry is the study of complex substances to determine their constituent elements; synthetic chemistry is the creation or reproduction of complex substances whose composition is either surmised or known.

Analytical chemistry, as a science, had its beginnings in the work of Lavoisier, in the 1700's. From then until approximately 1925 practically all analysis was performed by strictly chemical methods, with the aid of such tools as beakers, flasks, test tubes, Bunsen burners, and analytical balances. By 1925, developments in physics and electronics, and greater recognition of the close relationship between these sciences and chemistry resulted in the addition of the emission spectrograph, x-ray spectrometer, spectrophotometer, flame photometer, polarograph, and electroanalyzer as tools of the analytical chemist. In the years since 1925 these tools have been developed and improved in many ways that have increased their usefulness and application in analytical chemistry, and in the past 15 years, they have been responsible for many of the developments which have taken place in this field. The spectrograph, for example, is now the tool most frequently used in elemental analysis and production-control work. The x-ray spectrometer, on the other hand, is the mainstay of molecular analysis and materials research. The other instruments mentioned above complement and supplement these two or serve as ideal tools for the separations which constitute an important phase of analysis and are performed by a number of techniques including liquid extraction, electrolysis, ion exchange, and precipitation.

SCOPE

Both analytical and synthetic chemistry play extremely important roles in the electron tube industry. There is no doubt, however, that analytical chemistry has the greater application in this industry both in pure research and in the various activities connected with production. Most of the materials dealt with are inorganic and the work involves both qualitative and quantitative analysis.

Activities of the analytical chemist in the electron tube industry run the gamut from the purely theoretical to the routine practical. The terms "analytical chemist" and "analyst" are often incorrectly used. An analyst is one who, given a method or procedure for performing an analysis, is able to carry out the analysis. An analytical chemist, on the other hand, can not only perform analyses, but also is able to develop new analytical methods and techniques. Thus an analytical chemist is always an analyst, but an analyst is not always an analytical chemist.

A good analytical chemist must have a broad background and outlook. He or she (there are a number of very competent women in this field) must have an excellent knowledge of all branches of chemistry, a working knowledge of physics and electronics, and in addition, must have a high degree of skill in the use of the specialized instruments of all those fields.

In the electron tube industry, the work of the analytical chemist may be categorized as follows:

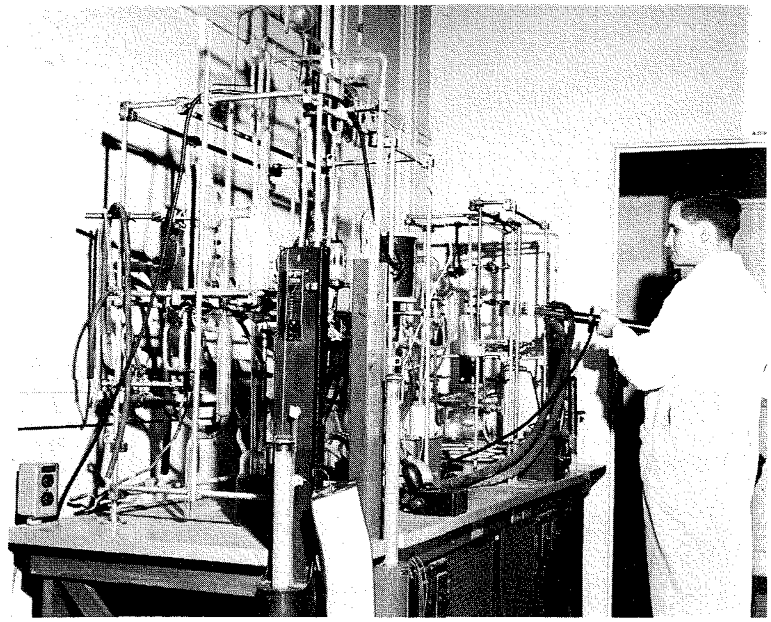
1. Methods and materials research.
2. Electron tube development.
3. Electron tube manufacture.

How analytical chemistry is utilized in each of these categories will be discussed in the subsequent sections.

METHODS AND MATERIALS RESEARCH

The principal subjects of chemical research and development in the electron tube industry include emitters, getters, glass, ceramics and other insulating materials, phosphors, phosphor applications and chemical processing techniques. In phosphor work, the function of analysis is first to determine the nature of materials that are to be duplicated or synthesized. A course of action must then be followed to determine the composition of the synthesized product and, in many cases, of the intermediate products. Reasons for loss or change of reaction constituents can frequently be learned by the analysis of side-reaction products, wash solutions or other treatment media,

JoAnn M. Schmidt begins an X-ray diffraction crystal structure study on an experimental phosphor. The X-ray fluorescence unit on the extreme right is used primarily for rapid quantitative elemental analysis for concentrations above 1 per cent.



Donald W. Bartch utilizes RF flashing of getters to study variations in gas content and barium yield. The vacuum system on the left is used for measurement of evolved gases from various internal tube coating formulations.

TABLE 1 — METHODS OF CHEMICAL ANALYSIS

1. Chemical	**2. Chemophysical**	**3. Physicochemical**	**4. Physical**
A. Gravimetric	A. Colorimetric	A. Spectroscopic	A. X-ray diffraction
B. Volumetric	(1) Photometric	(1) Emission spectroscopy	B. X-ray fluoresence
(1) Visual	a. Spectrophotometric	a. Flame photometry	C. Mass spectroscopy
(2) Potentiometric	B. Turbidimetric	(2) Absorption spectroscopy	D. Electron microscopy and diffraction
(3) Conductometric	C. Fluorescence	(3) Raman spectroscopy	
(4) Amperometric	D. Radiochemical	(4) Microwave spectroscopy	
C. Gasometric	E. Chromatographic	B. Polarographic	
		C. Electroanalytic	
		D. Electrophoretic	

and environmental factors. The mechanisms and kinetics of reactions are also frequently studied.

In studies of chemical-processing techniques and phosphors analytical chemistry is employed to determine the efficiency of cleaning procedures, the nature of contaminations, and the presence of detrimental ingredients in new materials.

Although much of the development work in the electron tube industry lies in the realm of general physics it requires a considerable amount of supporting analytical effort, particularly in the case of emitters. Emission spectroscopy and x-ray diffraction, as well as chemical analysis are extensively employed in the study of emitter operation, in determining reasons for emitter malfunction, and in the development of new emitter materials.

Because very close relationship exists between certain physical properties of metals, such as grain size, and their chemical composition, metallurgical development is extremely dependent upon analytical chemistry. Such work may involve studies of gross composition and structure, surface composition and structure or the composition and structure of discrete areas as inclusions. In these investigations extensive use is made of emission spectroscopy, d-c or a-c arc excitation being used for gross-composition studies and high-voltage-spark excitation for surface-composition studies. Chemical analysis is also employed to a large extent in composition studies, and the potential advantages of x-ray fluorescence have only begun to be utilized. X-ray diffraction is frequently used to determine the molecular constitution and crystal structure of metals and alloys and to detect evidence of stress and strain. Atomic constitution, on the other hand, is usually determined by means of the emission spectrograph or x-ray fluorescence.

Many problems which can be solved

only by analytical chemistry still exist in the fields of glass and ceramics. Although emission spectroscopy (including flame photometry) and chemical analysis have been used primarily in the past for glass and ceramic investigations, a potent new weapon for these problems is x-ray fluorescence.

ELECTRON TUBE DEVELOPMENT

The development of any tube type involves considerable analytical-type work. The design and manufacture of a new tube, like the synthesis of a new chemical, frequently requires an initial determination of the composition of an existing tube which successfully performs a similar function. In some cases it may be necessary to determine the chemical composition of all component parts: grids, plates, cathodes, envelope, coatings, etc. Once the general types of materials to be used in the new tube have been decided upon, those available must be checked for constituents such as sulfur, low-melting-point metals, and elements of the halogen family, which might interfere with optimum tube operation or affect tube life. A vast amount of information can be garnered from initial operation of tube samples by the cooperative efforts of the tube design engineer, the analytical chemist, and other specialists. For example, difficulties caused by migration or evaporation of tube components within the tube envelope can frequently be solved by analysis of the resulting deposits or spots. Difficulties due to poisoning of cathode components and liberated gases can also be solved by analysis.

ELECTRON TUBE MANUFACTURE

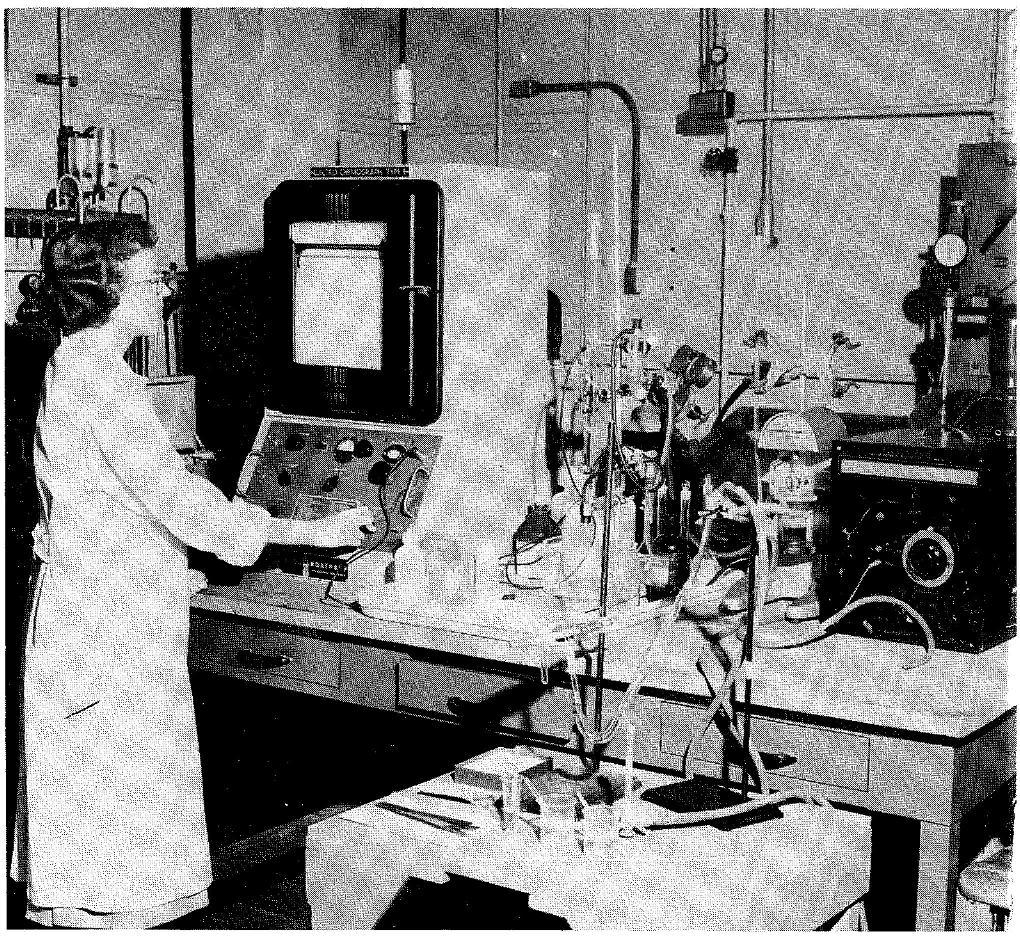
The applications of analytical chemistry to control of electron tube quality during manufacture include:

- Inspection and control of raw materials.
- Spot checking of materials on factory floor.
- Maintenance of in-plant atmospheres in a state of minimum contamination from gases, vapors, dust, and lint.
- Checking quality of finished components.
- Assistance in developing specifications for new materials.

One of the most important applications of analytical chemistry in production is control of raw materials. The term "production control" implies the testing of raw material for compliance with the specifications agreed upon by vendor and user. On the basis of these tests, the material is either approved or rejected for manufacturing use.

In many large industries analytical chemistry laboratories which handle production-control problems are independent of those which do research. In such industries, research and development of new methods and materials are carried out in a central research laboratory, while separate production-control laboratories are maintained at each plant. The production-control laboratories send their requests for new methods of analysis to the central research laboratory. This type of operation is feasible in the case of the steel, aluminum, petroleum, chemical, and other similar industries where only a limited number of products are produced at each plant and little development work is performed. In the electron tube industry, where many complicated products are produced at each plant and vast amounts of development work performed at many of them, separate production-control and analytical research laboratories are not feasible or desirable.

Production control, intelligently applied, is an economically sound investment. It is one of the best forms of quality insurance available. One analysis at a few dollars cost can prevent the loss of many thousands of dollars. The application of production control, however, must be reasonable. There can be over-control as well as under-control. The optimum approach is a middle course with a proportioning of effort based on cost of the end product.



View of electroanalytical and microchemical equipment. Charlotte G. Perry performs a polarographic analysis of a phosphor wash solution for zinc and cadmium content. An amperometric titration assembly for ascertaining very small traces of ions in solution is shown at the opposite end of the stone top table. A microchemical device for determination of thin surface sulfide layers on metals is depicted on the moveable table in the foreground.

The optimum course can best be determined through a knowledge of the relative hazards involved, the past performance of the vendors, and through a statistical approach.

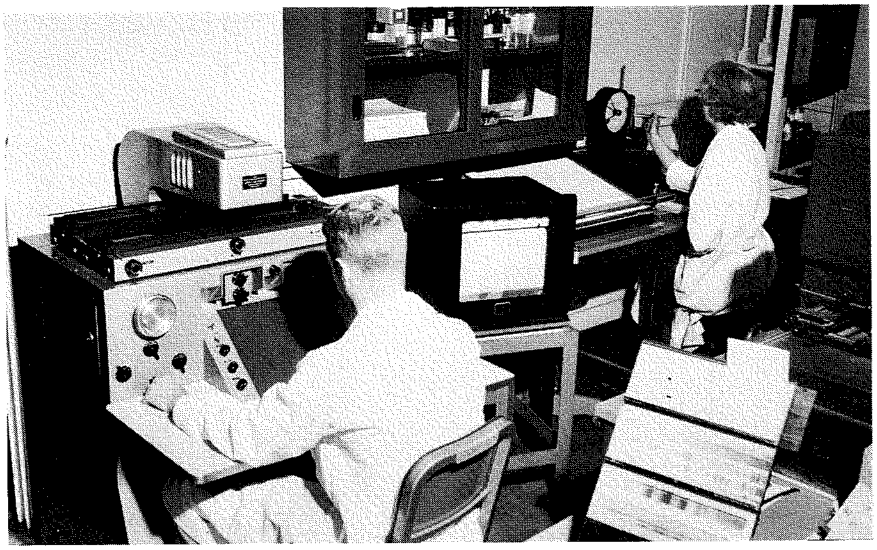
To provide maximum service in the electron tube industry, the analytical chemistry laboratory must cooperate fully with other laboratories and activities, make maximum use of instrumentation, and play an active role in the training of analytical chemists and technicians in the special requirements of the industry.

Cooperative effort is essential because, as in any analytical operation, a good job cannot be done without full understanding of the problem to which the effort is directed. Cooperation with manufacturing is particularly important because of the frequency with which this activity calls on analytical chemistry for detective-type assistance in locating the causes of production troubles. As the "Scotland Yard" of the electron tube industry, analytical chemistry cannot function at maximum efficiency without thorough discussion of each problem and study of all available evidence.

An extremely important factor in the success of any analytical operation is the maximum use of instrumentation. In the electron tube industry, particularly, the speed, accuracy, and sensitivity required are such that they cannot be achieved except by the proper and efficient use of instruments. Attempts to conduct such work by means of purely chemical procedures would either be so time-consuming or require the services of such a large staff of chemists as to render them valueless from the planning and economic standpoints. There are, in addition, certain types of analysis which cannot be performed chemically. These facts, however, by no means eliminate chemical work; on the contrary, they mean that the best possible chemical section is required to devise, set up, and check new methods of analysis using instruments, and to prepare and analyze standards for instrument calibration. Furthermore, there are still many chemical procedures which cannot be duplicated instrumentally.

In most industries, the analytical chemist need know only one or two narrow segments of a particular branch of analysis. In the electron tube industry, however, he must be capable and experienced in practically every segment of an extremely broad field. He must be able to attack a problem from any one of several directions. He must be able to make a clear and logical estimate of the situation, and based on this estimate, decide the objective to be attained and the mode of action. The ideal individual for work of this type must, therefore, combine the talents of the chemist, physicist, electrical engineer, statistician, and mechanical engineer. The importance of training, skill, and experience can be appreciated from the list of methods of analysis given in Table I which indicates the versatility required.

In-service training of analytical chemists and technicians in the electron tube industry requires a great expenditure of time and effort. In certain types of work, maximum proficiency can be achieved only by those who have had several years of specialized training.



View of a portion of Spectographic Laboratory. Robert H. Collins takes automatically recorded density measurements on spectral lines for a quantitative determination of lead and zinc in high purity copper. M. Catherine Clair weighs samples of cathode nickel for quantitative determination of minor elements. Emission spectroscopy is used primarily for qualitative elemental analysis and quantitative determination of minor and trace elements—below 1 per cent.

Emma D. Martin performs a spectrophotometric analysis for cyanide in plant processing water before stream disposal. This procedure is calibrated for cyanide concentrations of 0.01 to 0.1 parts per million. Instrumental attachments to the basic spectrophotometer unit include: flame photometer, photomultiplier unit, ultraviolet absorption accessory, and ultraviolet fluorescence equipment.

Patents Granted

TO RCA ENGINEERS

Based on Summaries Received over a period of about two months

DEFENSE ELECTRONIC PRODUCTS

Moorestown, N. J.

Single Action Timing Circuit
Pat. No. 2,818,532—granted Dec. 31, 1957 to M. L. Aitel.

Storage Tube
Pat. No. 2,818,523—granted Dec. 31, 1957 to M. C. Johnson and W. W. Weinstock.

Camden, N. J.

Optical Device for Providing a Light Defining Aperture
Pat. No. 2,782,685—granted Feb. 26, 1957 to G. L. Dimmick and M. E. Widdap, no longer employed at RCA.

Color Television Systems
Pat. No. 2,810,779—granted Oct. 22, 1957 to D. G. C. Luck.

Color Television System
Pat. No. 2,811,577—granted Oct. 29, 1957 to D. G. C. Luck.

Blocking Oscillator Circuit
Pat. No. 2,816,230—granted Dec. 10, 1957 to J. E. Lindsay.

Light Dividing Apparatus
Pat. No. 2,817,265—granted Dec. 24, 1957 to F. D. Covely, III.

Los Angeles, Calif.

Magnetic Switching Device
Pat. No. 2,816,278—granted Dec. 10, 1957 to R. L. Whitely.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

Raster Centering Control
Pat. No. 2,780,749—granted Feb. 5, 1957 to Leonard Dietch.

Two-Band Tuner with Stator Carried Coil Inductors and Rotor Carried Strip Inductor
Pat. No. 2,789,212—granted April 16, 1957 to John C. Achenback and P. C. Swierszak.

Beam Convergence Apparatus for Tri-Color Kinescopes
Pat. No. 2,806,164—granted Sept. 10, 1957 to B. R. Clay and J. H. DuBois.

Frequency Converter and Local Oscillator with Series Connected Space Current Paths
Pat. No. 2,811,636—granted Oct. 29, 1957 to John C. Achenbach.

Transistor Oscillator Circuit
Pat. No. 2,811,646—granted Oct. 29, 1957 to H. B. Yin.

Adjustable Voltage Supplies
Pat. No. 2,813,225—granted Nov. 12, 1957 to L. Dietch.

Electromagnetic Cathode Ray Beam Deflection System
Pat. No. 2,813,212—granted Nov. 12, 1957 to G. L. Grundmann.

Frequency Converter
Pat. No. 2,816,220—granted Dec. 10, 1957 to H. C. Goodrich.

Color Demodulation
Pat. No. 2,816,952—granted Dec. 17, 1957 to R. K. Lockhart.

Signal Coupling System
Pat. No. 2,817,064—granted Dec. 17, 1957 to D. J. Carlson.

Card Switching Device
Pat. No. 2,817,824—granted Dec. 24, 1957 to J. E. Albright.

Automatic Frequency Control Circuits
Pat. No. 2,817,755—granted Dec. 24, 1957 to W. R. Koch.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Methods of Making Metal Cones for Cathode Ray Tubes
Pat. No. 2,752,675—granted July 3, 1956 to A. Bauer.

Vibratory Motor for an Electric Watch
Pat. No. 2,791,732—granted May 7, 1957 to L. F. Jones.

Audio Recording Level Indicator
Pat. No. 2,816,281—granted Dec. 10, 1957 to A. I. Aronson.

Metering Circuit
Pat. No. 2,816,268—granted Dec. 10, 1957 to L. S. Lappin.

Sound Translating Systems
Pat. No. 2,816,165—granted Dec. 10, 1957 to R. M. Carrell.

COMPONENTS DIVISION

Camden, N. J.

High Voltage Supply
Pat. No. 2,783,412—granted Feb. 26, 1957 to B. V. Vonderschmitt.

Wavemeter
Pat. No. 2,790,150—granted April 23, 1957 to H. F. Hanthorn.

Raster Centering Circuit Arrangement
Pat. No. 2,814,758—granted Nov. 26, 1957 to B. V. Vonderschmitt and D. K. Guhn.

Raster Centering Circuit
Pat. No. 2,814,759—granted Nov. 26, 1957 to B. V. Vonderschmitt.

RCA VICTOR RADIO & "VICTROLA" DIVISION

Cherry Hill, N. J.

Electric Motor
Pat. No. 2,814,770—granted Nov. 26, 1957 to J. A. Tourtellot.

ELECTRON TUBE DIVISION

Harrison, N. J.

Electrode Arrangement for Gas Tubes
Pat. No. 2,813,217—granted Nov. 12, 1957 to H. J. Prager and R. A. Wissolik.

Disc Lead-in for Electron Tubes
Pat. No. 2,813,219—granted Nov. 12, 1957 to K. E. Hanft and N. E. Pryslak.

Basing Oven
Pat. No. 2,812,933—granted Nov. 12, 1957 to I. Harris.

Electron Beam Tube
Pat. No. 2,813,215—granted Nov. 12, 1957 to R. D. Reichert.

Lancaster, Pa.

Quick Heating Cathode for Electron Discharge Device
Pat. No. 2,813,227—granted Nov. 12, 1957 to A. P. Sweet, Jr.

Electron Beam Tube
Pat. No. 2,813,209—granted Nov. 12, 1957 to R. E. Byram and A. P. Sweet, Jr.

Electron Beam Controlling Apparatus
Pat. No. 2,816,244—granted Dec. 10, 1957 to H. N. Hillegass.

High Power Electron Tube
Pat. No. 2,817,031—granted Dec. 17, 1957 to W. P. Bennett.

Stud Welder
Pat. No. 2,817,746—granted Dec. 24, 1957 to W. G. Henderson.

Metal Cones for Cathode Ray Tubes
Pat. No. 2,817,456—granted Dec. 24, 1957 to H. R. Seelen.

Preparation of Selenide Phosphors
Pat. No. 2,818,391—granted Dec. 31, 1957 to G. E. Crosby.

Marion, Ind.

Triple Gun for Color Television
Pat. No. 2,806,163—granted Sept. 10, 1957 to R. E. Benway.

RECORD DIVISION

Indianapolis, Ind.

Magnetic Head Assemblies
Pat. No. 2,807,676—granted Sept. 24, 1957 to R. A. Lynn.

Safety Mechanism for Molding Apparatus
Pat. No. 2,807,049—granted Sept. 24, 1957 to J. J. Kimbro.

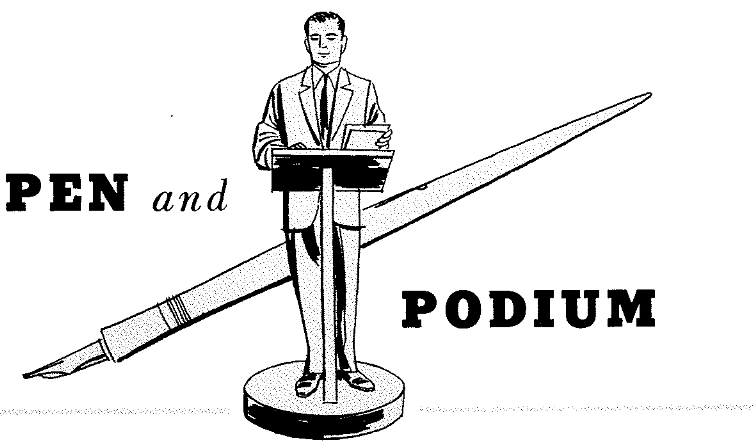
INTERNATIONAL DIVISION

Quebec, Canada

Variable-Selectivity Amplifier Circuits
Pat. No. 2,796,469—granted June 18, 1957 to F. Papouschek.

Tuning Device
Pat. No. 2,796,519—granted June 18, 1957 to F. Papouschek.

Switch
Pat. No. 2,811,594—granted Oct. 29, 1957 to F. Papouschek.



PEN *and* PODIUM

Based On Reports Received Over a Period of About Two Months

ELECTRON TUBE DIVISION

Lancaster, Pa.

Development of Round Glass Bulbs for RCA-21CYP22 Color Picture Tubes
By R. H. Zachariason, C. H. Mattson, and B. N. Becker: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D. C., Oct. 31, 1957. The development of a round all-glass envelope for use in the RCA-21CYP22 color picture tube is discussed.

Increased Light Output for Color Tubes Through Optical Analogy
By D. D. VanOrmer and F. VanHekken: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D.C., Nov. 1, 1957. This paper describes how the optical analogy between the electron system in the color picture tubes and the "lighthouse" exposure technique used in the manufacture of color screens was applied to achieve more efficient tolerances.

Two Backward-Wave Oscillators Covering the 30-75-KMc Frequency Range
By D. J. Blattner and F. Sterzer: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D.C., Nov. 1, 1957. Two developmental backward-wave oscillators which tune over the frequency range from 35 to 50 kilomegacycles and from 48 to 74 kilomegacycles, and deliver power of the order of milliwatts.

The Compositron, a Developmental Printing Tube for Computer Output
By R. J. Kistler: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D.C., Nov. 1, 1957. A developmental character-printing tube for use in non-mechanical high-speed printers for computers and data processing machines.

Extending Camera-Tube Performance to Lower Light Levels and Different Wavelengths
By R. G. Neuhauser: Presented at Section Meeting of IRE Professional Group on Medical Electronics, Wash., D.C., Nov. 6, 1957. Techniques are described for extending the performance of television camera tubes to make them useful at lower light levels and for the detection of information and images in the infra-red, ultra-violet, and X-ray.

Design and Development of the RCA-21CYP22 21" Glass Color Picture Tube
By C. P. Smith, A. M. Morrell, and R. C. Demmy: Presented at IRE/EIA Radio Fall Meeting, Toronto, Nov. 13, 1957. This paper describes the features of the new 21-inch round glass color picture tube, RCA-21CYP22, and evaluates the design.

Application of the RCA-21CYP22 Round Glass Color Picture Tube
By H. N. Hillegass, R. W. Hagmann, and D. J. Ransom: Presented at IRE/EIA Radio Fall Meeting, Toronto, Nov. 13, 1957. This paper describes the new RCA-21CYP22 directly viewed, round glass color picture tube.

Harrison, N. J.

Conversion of AM Transmitters to Double-Sideband—Suppressed-Carrier Operation
By C. A. West: Published in CQ, Nov. 1957. A simple method for converting an AM transmitter to provide the advantages of sideband operation is described.

The Reflex Magnetron, a UHF Oscillator Having Voltage-Controlled Frequency and Pushing Characteristics
By C. L. Cuccia: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D.C., Nov. 1, 1957. A new type magnetron in which reflex action of portions of the space-charge spokes controls the operating frequency as a function of the magnetron current is discussed.

A Packaged Medium-Power Traveling-Wave-Tube Amplifier for Airborne Service
By G. Novak and H. J. Wolkstein: Presented at East Coast Aeronautical and Navigational Electronics Conference, Balt., Md., Oct. 30, 1957. A developmental, pulsed, packaged, medium-power, traveling-wave tube for amplifier service operating in the 10-centimeter band is described.

High-Power, Wide-Tuning-Range, X-Band Magnetrons Extremely Stable At Rates of Rise Above 200 Kv/usec
By M. Ungar and J. Jacobs: Presented at East Coast Conference on Aeronautical and Navigational Electronics, Balt., Md., Oct. 30, 1957. The electrical performance and operating characteristics of a new tunable X-band magnetron is discussed.

A Grid-Controlled Medium-Power Traveling-Wave Tube Using Periodic Focusing
By G. Novak and H. J. Wolkstein: Presented at 3rd Annual Meeting of IRE Professional Group on Electron Devices, Wash., D. C., Oct. 31, 1957. A developmental pulsed medium-power traveling-wave tube for amplifier service in the frequency range from 2000 to 4000 megacycles is presented. The tube package weighs only 12.5 pounds.

Vacuum-Tube Requirements in Vertical-Deflection Circuits
By K. W. Angel: Presented at IRE/EIA Radio Fall Meeting, Toronto, Nov. 12, 1957. This paper discussed vertical-deflection-output circuits from the viewpoint of an idealized equivalent circuit.

An Image-Converter Tube for High-Speed Photographic Shutter Service
By R. G. Stoudenheimer and J. C. Moor: Published in RCA REVIEW, Sept. 1957. A developmental image-converter tube having electrostatic focus, a shutter grid, and electrostatic deflection is described.

Voltage Measurements with an Oscilloscope
By Rhys Samuel: Published in ELECTRONIC TECHNICIAN, Sept. 1957. The use of an oscilloscope in the measurement of peak-to-peak voltage of complex waveforms is covered.

SEMICONDUCTOR DIVISION

Somerville, N. J.

Design Considerations for Portable Transistor Reflex Receivers
By R. V. Fournier, Semiconductor Division: Presented at IRE/EIA Radio Fall Meeting, Toronto, Nov. 13, 1957. This paper describes the reflex amplifier principle, its merits and its limitations. Methods of overcoming these limitations in portable transistor reflex receivers are discussed.

High-Frequency Applications of Transistors
By R. M. Cohen: Lecture Series of IRE Section, Chicago, Nov. 11, 1957. The use of transistors in audio applications to 100 megacycles is covered. The design of I-F amplifiers is included, and drift transistors in short-wave receivers considered.

COMPONENTS DIVISION

Camden, N. J.

Ferrite-Cored Transducers for Electromechanical Filters
By G. S. Hipskind: Published in ELECTRONIC DESIGN, Sept., 1957. The suitability of ferrite rods having the proper temperature characteristics and a high degree of magnetostrictive activity for use as transducers in electromechanical filters is described.

DEFENSE ELECTRONIC PRODUCTS

Camden, N. J.

Television Pickup Tube Performance at Low Scanning Rates
By C. T. Shelton and H. W. Stewart: Presented at SMPTE convention, Phila., Pa. Oct. 7, 1957. The paper discusses operation of vidicons and image orthicons in television systems operating at low frame rates.

High-Power Transistor Audio Amplifiers
By M. B. Herscher: Presented at Audio Engineering Society Meeting, Oct. 12, 1957. Several types of high-power audio amplifiers developed are capable of 45 watts output.

Characteristics of Airborne Digital Computers
By A. Baker: Presented at IRE-PGEC Meeting at MIT, Dec. 3, 1957. Applications of airborne digital computers in present and possible future systems and features which distinguish this type of computer from its land-based counterpart are discussed.

An Airborne Digital Computer
By L. H. Bannister: Presented at IRE-PGEC Meeting at MIT, Dec. 3, 1957. A relatively high speed, general purpose digital computer, implemented with transistor logic and ferrite memories is described.

Precise Trackless Compensator
By M. R. Alexy: Published in ELECTRICAL MANUFACTURING, Sept. 1957. This paper describes the development of a particular type of compensator that eliminates the usually present flexible band and results in extremely high transmission accuracy.

Radiation Damage to Low-And-High-Frequency Transistors
By J. R. Parker and T. E. Lindsay: Presented Oct. 23, 1957 at Radiation Effects Symposium, Columbus, Ohio, and Nov. 1, 1957 at PGNS in New York. Paper describes the work of the DEP Special Systems and development and central services and Engineering group in identifying departures on radiation damage from predicted behavior.

An Experimental Realization of Spectrum Conservation
By H. E. Haynes, IEP, and D. T. Hoger, DEP: Presented at 3rd Aeronautical Communications Symposium, Utica, N. Y., Nov. 6, 1957. A system in which spectrum utilization in transmission of black-white images has been increased by factors of five or more.

Meet Mr. VIP
By R. H. Baker: Presented at Bureau of Ships, Wash., D.C. A description is given of the RCA Value Engineering Program, its objectives and how it increases the value per dollar for the customer.

Reliability Control Based on Multiple Sequential Feedback
By C. M. Ryerson: Presented at EIA Radio Fall Meeting, Nov. 11, Toronto. The classical approach to reliability improvement is based on a single feedback loop embracing design, development, production, and field service. A procedure of multiple sequential feedback is described.

Quality Control and Reliability
By C. M. Ryerson: Presented at Drexel Univ., Sept. 20, 1957. Differences and companion functions of Quality Control and Reliability are defined and described.

Moorestown, N. J.

Comments on 1952 Predictions
By R. M. Jacobs: Published in AMERICAN MACHINIST, Nov. 1957. Author comments on predictions made by Editors in 1952 on subject of "Statistical Technique to be used in Industry Ten Years from Now." Predictions were accurate with minor deviations.

Reliable Design is Not Expensive
By M. M. Tall: Published in ELECTRONIC EQUIPMENT Magazine, Jan. 1958. The article indicates that those reliability activities which make a direct improvement to a product, contribute to a reduction in cost.

Development of Talos Band-Based System
By D. B. Holmes: Presented Jan. 28, 1957 at 26th Annual Meeting of Inst. of Aeronautical Sciences, New York City. The outstanding features of Talos such as high fire-power, automaticity, and minimum manning requirement are described.

New Multiple-Sampling Plan for Quality Control
By Richard M. Jacobs: Presented Jan. 15, 1958 to New England Sections of American Society for Quality Control at MIT Faculty Club. Paper describes in detail an economical adoption of a popularly used sampling plan that protects the user.

An Area Moving Target Indicator System
By D. S. Weise: Presented at 4th Annual Radar Symposium, Univ. of Michigan, Feb. 4, 1958. Area MTI is a non-coherent system which accomplishes velocity discrimination by means of scan-to-scan comparison of search radar data. Storage tube techniques distinguish Area MTI from other types.

Specifications on Magnetron Applied Pulse Characteristics as Related to Operational Requirements
By D. C. Pruitt and W. I. Smith: Presented at Symposium on High Cost Electron Tubes, Gentile AFB, Dayton, Ohio, Sept. 5, 1957. Specification problems are outlined and examined in detail.

Waltham, Mass.

Management of RCA Boston Airborne Systems Lab
By R. C. Seamans, Jr.: Presented to New England Radio Electronics Meeting, Nov. 16, 1957 at Boston. History and Function of Labs, development process and management strategy are covered in this presentation.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

A Transistorized Preamplifier for Professional Turntables
By Harold J. Paz: Presented at 9th Annual Convention of Audio Engineering Society, N.Y. City, Oct. 10, 1957. A transistor preamplifier equalizer used with RCA postage stamp pickup is designed for mounting in RCA professional turntables.

Application of Negative Impedance Amplifiers to Loudspeaker Systems
By R. E. Werner and R. M. Carrell: Presented at Audio Engineering Society Convention, N. Y. City, Oct. 12, 1957. Improved loudspeaker performance is obtained by giving attention to equalization for low-frequency radiation, cancellation of voice-coil inductance and resistance.

Component Characteristics for an Active Ear Defender
By Willard F. Meeker: Presented to the Acoustical Society of America, Ann Arbor, Mich., Oct. 24, 1957. The microphone and earphone characteristics for effective noise reduction are discussed, and a negative feedback system described which provides 15 db of noise reduction from 100 to 200 cps.

A VHF Microminiature Receiver
By R. A. Beers, Jr.: Presented at IRE Convention, Wash., D.C., Oct. 7, 1957. A 17-cubic inch pocket size, 152-174 mc land-mobile communications receiver is described (18-transistor, double superhet.).

Medium Screen TV Projection
By S. L. Bendell and W. J. Neely: Presented at SMPTE Convention, Phila., Pa., Oct. 8, 1957. Basic engineering and economic factors influencing design and use of a small inexpensive TV Projector are discussed.

The BK-10A Bigradient Uniaxial Microphone
By J. W. O'Neill: Presented at the Audio Engineering Society Convention, N. Y. City, Oct. 11, 1957. The RCA Type BK-10A is the first broadcast quality second order gradient unidirectional microphone and doubles the effective operating distance.

Automatic Cueing of TV Film Projectors
By B. F. Melchionni: Presented at the SMPTE Convention, Phila., Pa., Oct. 8, 1957. Methods are described for automatically stopping a projector at predetermined frame. Suitable cueing information is added.

Developments in Electronic Data Processing at RCA
By A. H. Stillman: Presented at International Systems Meeting, Oct. 9, 1957. This paper points out recent developments in magnetic tape file units, high speed storage units, and output printers for Bizmac.

Component Characteristics for Active Ear Defender
By W. F. Meeker: Presented at Meeting of Acoustical Society of America, Ann Arbor, Mich., Oct. 24, 1957. The microphone and earphone characteristics required for effective noise reduction are discussed.

Digital Computer Fundamentals
By W. A. Gerhart: Presented at ASME-AIEE Meeting at Phila., Pa., Nov. 11, 1957. The "ABC's" of computers including History, What it is, what it does, and a description of a large scale data processing system.

Effects of Radiation on Vidicon Performance
By R. A. Davidson and B. H. Rosen: Presented at the IRE Symposium on Nuclear Science, New York City, Oct. 31, 1957. A commercial one inch vidicon was exposed to a total radiation dosage of approximately 10^{15} NVT in the Brookhaven National Laboratories Nuclear Pile Reactor. No measurable degradation of performance occurred.

Case History of the Application of Human Engineering
By J. L. Owings: Presented at AMA Meeting, Nov. 25, 1957, at New York City. Importance of human engineering in system design is emphasized and related to development of Bizmac productions.

A New Arm for Vehicular Communications
By J. R. Neuhauer: Presented Dec. 4, 1957, at IRE-PGVC, 8th National Conference, Wash., D.C. Land-mobile vehicular communications for pocket carrier receiver is described.

The Utilization of Domain Wall Viscosity in Data-Handling Devices
By V. L. Newhouse: Published in Nov. IRE Proceedings. Various digital circuit applications are described, including technique of continuously displaying the contents of magnetic shift registers and means of operating.

RCA VICTOR RECORD DIVISION

Indianapolis, Ind.

Discussion for Symposium on Test Records
By B. J. White: Presented at Audio Engineering Society Convention, Oct. 1957. The use of the square wave signals as a means of evaluating the performance of disc recorders, pickups and records was discussed.

RCA VICTOR TELEVISION DIVISION

Cherry Hill, N. J.

VHF Television Tuners
By Wen Yuan Pan: A Book Review published in ELECTRONICS, Sept., 1957 issue.

Technique for Increasing Engineering Efficiency
By C. M. Sinnett: Presented Oct. 24, Wash., D.C. This talk covered the general area of creativity, its aims and processes. After a discussion of some of the mental blocks which inhibit our creative thinking, the general area of creative problem statement was perused.

CORPORATE STAFF STANDARDIZING

Camden, N. J.

Standardization in the Electronics Industry
By S. H. Watson: Presented on Nov. 14, 1957, at 8th National Conference on Standards in San Francisco, Calif. The paper was sponsored jointly by the ASA and the Standards Engineers Society. Organization and activities of Corporate Standardizing are described.

Engineering NEWS *and* HIGHLIGHTS

RCA ENGINEER RECEIVES FULBRIGHT AWARD

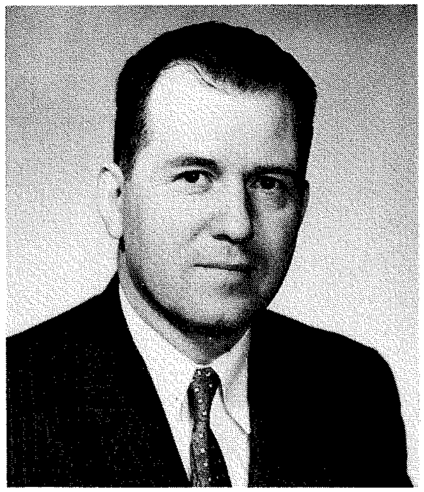
Everett R. Brown, DEP Missile & Surface Radar Engineering at Moorestown, recently received a Fulbright Award as a guest lecturer at Queensland University, Brisbane, Australia.

Mr. Brown was chosen from a number of applicants by the State Department to lecture and conduct seminars in the field of industrial management at the University. The award selection is based on teaching and professional experience.

The lecture tour begins at the opening of the Australian school year March 1958, and terminates November 1958.

The award includes all expenses for the winner and partial expenses for his family, all of whom will be traveling with him.

The Program authorized by the Fulbright Act is part of the international Educational Exchange Program conducted by the Department of State. Its basic purpose is to further good will and understanding between the United States and other countries through the exchange of students, teachers, university lecturers and research scholars. Enabling legislation is provided by Public Law 584, 79th Congress, the Fulbright Act, which specifies that certain foreign credits acquired by the United States may be used to finance a) studies, research, instruction and other educational activities of or for American citizens in schools and institutions of higher learning in the participating countries, and b) transportation to the United States for citizens of participating countries wishing to study, do research, or teach in American schools and institutions of higher learning.



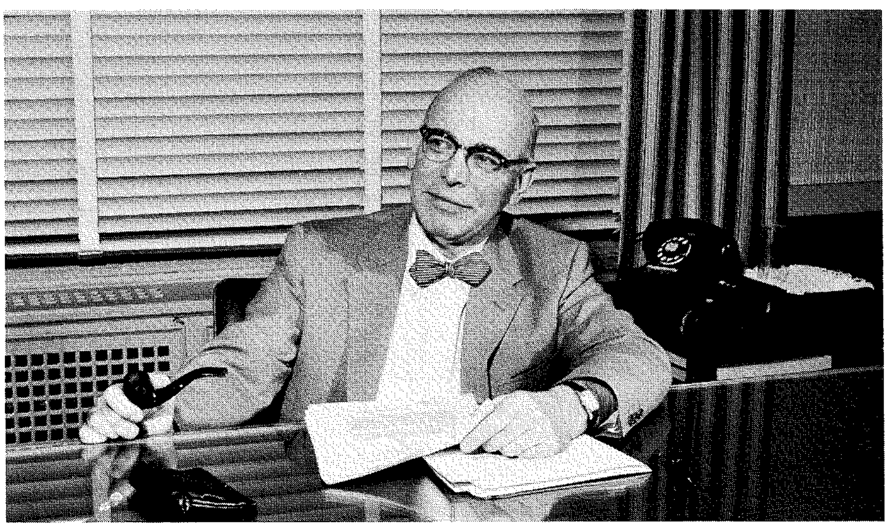
Everett R. Brown

Mr. Brown graduated from Stevens Institute of Technology with BSME. He holds a MS degree in Industrial Management and is studying for a Doctor's degree in the same field.

Mr. Brown had a 3½ year tour in the Navy serving as Engineering Officer and Field Service Officer.

He worked with Rheem Manufacturing Company, Fischer and Porter and Automatic Temperature Control Company prior to coming to RCA.—*G. W. K. King*

JOHN B. COLEMAN TO HEAD NEW RADAR PROGRAM



With the announcement of RCA's new Ballistics Missile Early Warning System (BMEWS) contract came the glad news that John B. Coleman has been appointed Manager, BMEWS, at Moorestown. A recognized authority in the field of communications transmitters (both Government and Commercial), Mr. Coleman's leadership in transmitter engineering started with his becoming Chief Engineer at station WBZ, Boston, in 1924. The Editors are thankful for Mr. Coleman's guidance and suggestions concerning the RCA ENGINEER during his association with Product Engineering, RCA Staff, and look forward to his continued participation.

ENGINEERS IN NEW POSTS

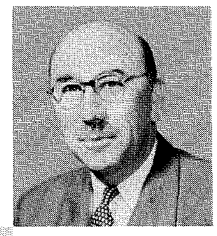
A new division has been formed in IEP. Called the Electronic Data Processing Division, it will be headed by **E. D. Foster** as V. P. and Gen'l. Mgr. The former BIZMAC Engineering becomes the Engineering Dept. of the new Division, with **J. W. Leas** as Chief Engr. **A. R. Hopkins** is Mgr. of Sales Dept. and **L. F. Jones** becomes Mgr. of Product Planning.

The former Theatre and Industrial Products Dep't. of IEP has been changed to Industrial and Audio Products Dep't., **H. M. Emlein** as Mgr.

Also in IEP, the Telecommunications Division (under **T. H. Mitchell**) has a new Chief Engineer, **W. C. Morrison,** formerly of the Technical Staff at Princeton.

Big news in DEP is the BMEWS Program (Ballistics Missile Early Warning System), to be administered by **W. L. Richardson,** responsible for overall policy direction. **John B. Coleman** leaves Product Engineering, RCA Staff, to become Manager BMEWS at Moorestown.

H. R. Wege ▶



◀ J. T. Cimorelli

In line with the BMEWS Program, **Harry R. Wege** announces his staff of Missile and Surface Radar Dep't at Moorestown: **G. F. Breitwieser** is Chief Product Engineer; **J. B. Coleman,** Mgr., BMEWS; **A. G. deSherbinin,** Financial Operations; **F. J. Drakeman,** Plant Mgr.; **N. I. Korman,** Chief Systems Engr.; **C. B. McGinley,** Personnel; **H. J. Morley,** Purchasing; **R. E. Posthauer,** Marketing; and **R. C. Willman,** Mgr. Engineering Administration.

E. A. Speakman named Mgr. DEP Planning; he was formerly V. P. and Gen'l. Mgr. of Fairchild Corp's. Guided Missile Div. . . . **C. A. Gunther** announces **I. K. Munson** as Mgr. of Central Services and Engineering, DEP.

In the Electron Tube Division, **H. A. DeMooy** becomes Mgr. Receiving Tube Operations . . . engineers on his staff include **K. G. Bucklin,** Engineering Mgr. and **J. T. Cimorelli,** Mgr. Manufacturing . . . on Bucklin's staff are **R. A. Wissolik,** Engineering Processes; **N. S. Freedman,** C&P Lab.; **S. Umbreit,** Materials Admin.; **R. F. Dunn,** Entertainment Tube Dev.; **G. M. Rose,** Advanced Dev.; and **R. L. Klem,** Engineering Admin.

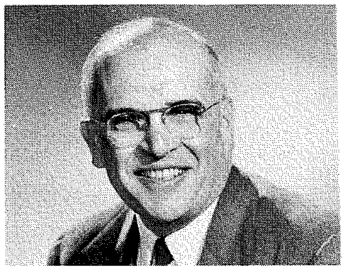
In the TV Division, **C. N. Reifsteck** is appointed General Quality Control Mgr.

RCA SCHOLARSHIPS AND FELLOWSHIPS ANNOUNCED

RCA GRANTS $3,500 FELLOWSHIPS TO NINE UNIVERSITY GRADUATE STUDENTS

RCA has awarded RCA Fellowships to nine university graduate students for advanced studies in engineering, physics and dramatic arts, Dr. C. B. Jolliffe, RCA Vice President and Chairman of the RCA Education Committee recently announced.

"These fellowships have the double purpose of assisting students to obtain advanced degrees in arts and sciences related to the electronics industry and of increasing the number and quality of trained scientific personnel in this country," Dr. Jolliffe said.



Dr. C. B. Jolliffe

More than 120 students have received the awards since the RCA Fellowships were inaugurated in 1947. Each Fellowship is valued at approximately $3,500. It includes full tuition costs, $2,100 toward the student's living expenses and $750 as an unrestricted gift to the university attended by the RCA Fellow.

An additional fellowship, in medical electronics, is maintained at Columbia University but no recipient has been named as yet.

RCA Fellows named for the current school year include residents of New York, New Jersey, California and Illinois.

They are:

John J. Metzner, Rego Park, N. Y., who will study toward a Doctor's degree in Electrical Engineering (Communications) at New York University.

Leon J. Schkolnick, Jamaica, N. Y., who will study toward his Doctor's degree in Physics at Columbia University.

Robert A. Moog, Flushing, N. Y., who is working toward a Master of Engineering Physics degree at Cornell University.

Algirdas A. Avizienis, Chicago, Ill., will work toward his Doctor of Electrical Engineering (Digital Computers) degree at the University of Illinois.

Jack K. Wolf, Newark, N. J., will pursue studies toward a Master of Electrical Engineering degree at Princeton University.

Gerald Chanin, Bronx, N. Y., who will study toward a Master's Degree in Physics at Rutgers University.

Victor Evtuhov, Pasadena, California, will continue work toward a Doctor of Electrical Engineering degree at the California Institute of Technology.

The two RCA-NBC Fellowships in dramatic arts have been awarded to:

David Z. Goodman, Richmond Hill, N. Y., and Dominick L. Cascio, Forest Hills, N. Y.

THIRTY-ONE COLLEGE STUDENTS AWARDED TO ENCOURAGE PREPARATION FOR SCIENCE TEACHING CAREERS

RCA has awarded thirty undergraduate scholarships and one graduate fellowship in a new program to encourage students to prepare for science teaching careers, Dr. C. B. Jolliffe, RCA Vice President and Chairman of the RCA Education Committee, announced recently.

The first Science Teacher Scholarships have been established at twenty colleges and universities in sixteen states where a survey by the RCA Education Committee showed the shortage of such teachers to be most critical. The first Science Teacher Fellowship, valued at $3,000, has been established at Purdue University, West Lafayette, Indiana. The awards are part of RCA's Scholarship and Fellowship Program which was inaugurated in 1945.

Scholarships of $800 each were awarded to a junior or senior student at the following schools:

Berea College, Berea, Ky.; Adelphi College, Garden City, N. Y.; Clark College, Atlanta, Ga.; Goucher College, Baltimore, Md.; West Virginia Wesleyan College, Buckhannon, W. Va.; University of Wyoming, Laramie, Wyo.; Trinity College, Hartford, Conn.; St. Louis University, St. Louis, Mo.; the University of Rhode Island, Kingston, R I.; and the University of Delaware, Newark, Del.

RCA also has made an unrestricted contribution of $500 to each of the seven independent colleges in the above group.

Ten scholarships of $800 each were awarded to a junior or senior student, and ten scholarships of $250 were awarded to a freshman or sophomore student at the following schools:

New Jersey State Teachers Colleges at Trenton and Montclair, N. J.; Eastern Kentucky State College, Richmond, Ky.; New York State College for Teachers, Albany, N. Y.; Georgia State College for Women, Milledgeville, Ga.; Henderson State Teachers College, Arkadelphia, Ark.; Western Illinois State College, Macomb, Ill.; New Mexico Highlands University, Las Vegas, N. M.; Arizona State College, Flagstaff, Ariz.; and Western Washington College of Education, Bellingham, Wash.

COLLEGE SCHOLARSHIPS AWARDED THREE GRADUATES OF RCA INSTITUTES

RCA has awarded scholarships with annual grants of $800 each to three graduates of the RCA Institutes, George F. Maedel, President of the Institutes, announced recently.

"The scholarships in engineering and physics are awarded for four years unless the students complete requirements for their baccalaureate degrees in less time," Mr. Maedel said. "In addition, a contribution of $500 is given each privately-endowed school attended by an RCA scholar."

The awards are part of the Radio Corporation of America's Scholarship and Fellowship Program which this year is helping eighty-three students further their education.

Recipients of the RCA awards for the 1957-58 academic year are:

Frederick B. Smith, Jr., Oceanside, New York, who is continuing studies in physics at Hofstra College.

Floyd W. Garrett, Austin, Texas, who is majoring in electrical engineering at the University of Texas.

Charles Atzenbeck, Bronx, N. Y., who is majoring in electrical engineering at City College of New York.

J. A. WADE REPRESENTS RCA ENGINEER AT TUCSON

J. A. Wade

Mr. Wade graduated from the University of Iowa in 1953, obtaining a BS degree in EE. Upon graduation he joined DEP Surface Communications as an Electrical Engineer. During his time with RCA he has been associated with the Walkie Talkie (AN/PRC Series), SSB Receiver Development, Micro-Miniature Receiver Development, and Navy Receiver (SRR Series) conversion to SSB operation.

Mr. Wade is presently with the Surface Communications Field Systems group and engaged in Area Communications Systems Studies being conducted for the Signal Corps at the Army Electronic Proving Grounds, Fort Huachuca, and at Tucson, Arizona.

Mr. Wade is also engaged in graduate studies at the University of Arizona. He is an associate member of the IRE.

ASSISTANT EDITORIAL REPRESENTATIVES AT MOORESTOWN ANNOUNCED BY I. N. BROWN

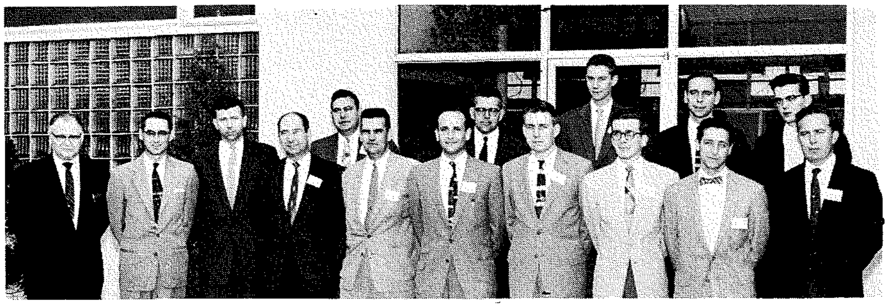
I. N. Brown

Missile and Surface Radar Engineering at Moorestown has been operating for over a year with a group of Assistant Editorial Representatives assisting the Editorial Board Member in securing and processing papers from this activity. Several new appointments have been recently made to fill vacancies that have developed. The revised list of Assistant Editorial Representatives for the Engineering Department follows.

Activity	*Assistant Editor*
Projects Engrg.—Talos	R. D. Black
Projects Engrg.—Missile R&D	M. Nachman
Projects Engrg.—Radar	E. F. Poole
Dev. & Design—Radar	G. R. Field
Dev. & Design—Information Handling	J. Cornell
Dev. & Design—Mechanical	H. A. Brelsford
	G. W. K. King

Irmel N. Brown will continue to represent the Systems Engineering activity.

MEETINGS, COURSES & SEMINARS



The BIZMAC Maintenance Engineer Training School at the RCA Service Co. laboratory in Pennsauken, N. J. has continued throughout the winter. The present class will complete training in April, when the next BIZMAC System will be installed at the Travelers Insurance Company of Hartford, Conn. Left to right in the photo are E. Stanko, Manager of Engineering, J. Stoeger and J. Lawler, Home Office Managers, G. Kropp and J. Anderson, Instructors, and the following are students:

R. Woodbury, W. Davids, J. McKinney, D. Phelps, D. denBoef, J. Wentz, R. Bernetich, H. Srolovitz, R. Heacock, and I. Bengtson.

Electron Microscope

An extensive training course on electron microscope installation, service, and application techniques was recently conducted for four Technical Products Field Engineers of RCA Service Company.

Messrs. B. F. Feranski (Chicago), H. L. Phillips (Detroit), W. B. Attmore (Richmond, Va.), and C. J. Faulstich (Atlanta) were tutored by Harry W. Taylor, Electron Microscope Specialist in the Technical Products Home Office. These activities were augmented by seminars and lectures conducted by IEP Engineers, Dr. John Reisner, and Messrs. H. C. Gillespie and Louis Shapiro. Commercial activities, customer relationship, and specimen preparation techniques were discussed by Dr. F. J. Herrmann and Mr. J. J. Kelsch of Scientific Instrument Sales. Time was also spent on the production floor observing instrument assembly and test procedures. Practical service problems were introduced to, then solved through demonstration on two electron microscopes located in the IEP Engineering Laboratory.

This is the fourth such training session conducted during the past year for field engineers. Another is scheduled for early in March of this year.—*E. Stanko*

Reliability

Mr. T. C. Reeves, Administrator of Value Engineering and Reliability in DEP Surface Communications recently announced a series of reliability seminars which are being held weekly on Friday mornings for design personnel who are serving as reliability engineers in the Surface Communications Engineering activity. The series began on November 29. The topics planned are:

(a) Basic Failure Models, Measures and Mathematics of Reliability, by T. C. Reeves.
(b) Use of Stress Analysis and Failure Rate Data in Evaluating Design and Predicting Reliability, by D. I. Troxel.
(c) Work Shop Session in the Use of TR-1100 to Predict Failure Rates for Simple Circuits by F. A. Hartshorne.
(d) Developmental Procedure Required to Comply with the Recommendations of AGREE Task Group 4, M. C. Batsel.
(e) Reliability Organizations and Operations Elsewhere in Defense Electronic Products, by C. M. Ryerson.
(f) Common Violations of Reliable Circuit Part Applications, by Staff of the DEP Reliability Analysis Group.
(g) What we can learn from Moorestown's experience with the design review as a reliability tool, by H. C. Bryson, Jr.

The series has been attended by about fourteen engineers and has been very well received within the department.

—*T. T. N. Bucher*

Air Traffic Control

Mr. I. Maron of the Special Systems and Development Department, DEP, addressed the Lancaster Sub-section of the IRE on November 26, 1957 on the topic of "A Systems Approach to Air Traffic Control." Mr. Maron, Project Engineer of RCA's ATC Systems team, outlined the definition of the general problem and elaborated in some detail the specific sub-system of automatic air-to-ground communication.

TELEVISION SYSTEM INSTALLED AT STRATEGIC AIR COMMAND HEADQUARTERS

The design and installation of a closed-circuit color television system at Strategic Air Command Headquarters, Omaha, Nebraska, has been completed by Broadcast Systems Engineering. The acceptance of the system completed a 15 month cycle of design and installation. Most of the assembly and wiring was completed in Camden prior to shipment to the site. This permtted completion of installation and test on the site in only 5 months.

The system is used to provide coordinated presentation of current information required to monitor and plan the operation of the SAC force. This information is displayed on receivers strategically located through the Headquarters upon request from any location.

Broadcast quality audio and video equipment has been used throughout the system. A total of 26 racks together with a separate control room and film projection room are required to house a major portion of the equipment. Three remote controlled TK-41 (3 image orthicon) color cameras and one studio type TK-41 are used to program information from the Intelligence and Operations area. Continuous weather information is provided by a TK-45 (3 vidicon) color camera located in the weather briefing area. Provision for showing 16 mm film 35 mm slides and opaque art work is incorporated through the use of a TK-26 (3 vidicon) color film camera with its accessory equipment.

The programming from the primary briefing areas is combined with other outside sources of information to provide "on call" service to each receiver location. Combined audio-video relay switching is provided to furnish efficient program selection, complete talk-back circuits as well as switch tally lights necessary for proper control monitoring of the system.—*J. H. Roe*

DR. BEAM HONORED BY ETA KAPPA NU

Dr. W. R. Beam

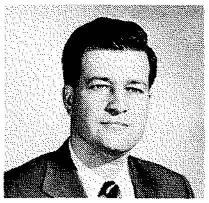
Dr. Walter R. Beam, Manager, Microwave Advanced Development for the Electron Tube Division at Princeton, has been named one of three recipients of awards in the annual nationwide talent search for Outstanding Young Electrical Engineer conducted by Eta Kappa Nu, national electrical engineering honor society. Dr. Beam, who was selected from 95 nominees, received an Honorable Mention award.

Eligibility for the awards is restricted to men who have been graduated within the preceding ten years from a regular course in electrical engineering from an American college or university, and who are not more than 35 years of age. Selection is made on the basis of the candidate's record of achievement in his work; in his service to community, state or nation; in his cultural or aesthetic development; and for his professional activities.

Dr. Beam, at the age of 29, is an established authority in the field of microwave electron tubes. He has made particularly significant contributions in connection with the reduction of fluctuation noise in traveling wave tubes. Educated at the University of Maryland, Dr. Beam received his BSEE degree in 1947, MS in 1950 and Ph.D. in 1953, and joined RCA Laboratories in July, 1952.

ENGINEERING DEGREES

D. J. Carlson



W. N. Moule

The following RCA engineers, through an oversight, were omitted from our list of engineers receiving degrees published two issues ago. The Editors apologize for this, and feel that announcement of this late date will not detract from the honor bestowed upon them.

W. N. Moule, IEP Broadcast Transmitter Engineering received the MS degree in EE from the University of Pennsylvania, June 1957.

D. J. Carlson and Harold M. Wasson, both of Advanced Development Engineering, Television Division at Cherry Hill, received the MS degree in EE from the University of Pennsylvania in June 1957

55 SESSIONS SCHEDULED FOR IRE NATIONAL CONVENTION

A comprehensive 55 session program, involving some 280 papers ranging over 27 fields of radio-electronics, has been set for the 1958 IRE National Convention on March 24-27 in New York City. Thirty-three sessions will be held at the Waldorf-Astoria Hotel and 22 at the New York Coliseum.

The Coliseum will also house the Radio Engineering Show, at which approximately 20,000 items of the most advanced electronic apparatus wil be displayed by 850 exhibitors, much of it for the first time.

The high point of the technical program will be two special sessions on Tuesday evening, March 25, at which panels of the nation's leading experts will discuss "Electronics in Space" and "Electronics Systems in Industry."

This year's program presents for the first time sessions on Education, Engineering Writing and Speech, and Radio Frequency Interference, due to the establishment of new IRE Professional Groups in these fields within the past year.

NEW 'RADIOMARINE' GEAR INTRODUCED AT NATIONAL MOTOR BOAT SHOW

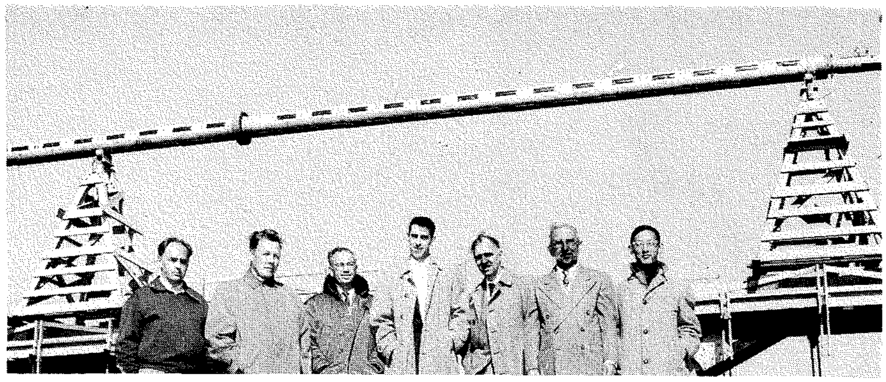
New space-saving electronic navigation, communications, and fish-finding gear for pleasure craft and small commercial vessels was introduced by RCA at the 48th Annual National Motor Boat Show, January 1958, in the New York Coliseum.

Shown for the first time were: a small-craft "Lodar" system which provides both horizontal and vertical scan of ocean depths for fish-finding and depth-sounding; a navigation radar which "sees" accurately to within 20 yards of the vessel; a 20-channel, 150-watt radiotelephone, and a four-range, cathode-ray type fish-finder specially adapted for combing shallow waters.

COMMITTEE APPOINTMENTS

Dr. J. H. Reisner, IEP Theater and Industrial Products, has been elected President of the Electron Microscope Society of America.

S. D. Ransburg, Record Engineering, Indianapolis, was elected President for 1958 of the Central Indiana Section of the Society of Plastics Engineers.



TRAVELING WAVE ANTENNA DELIVERED TO KGHL-TV

Shown with the KGHL-TV Channel 8 traveling wave antenna at the Gibbsboro Test Site are, left to right, engineers A. Turecki, Dr. M. S. O. Siukola, M. R. Johns, H. H. Westcott (VHF Antenna Engineering Leader), H. E. Gihring (Manager, Antenna Engineering), G. A. Kumpf, and Y. M. Chen. The antenna is 114 ft. long and weighs 23,000 lbs.

REGISTERED PROFESSIONAL ENGINEERS

The following names have been added to the RCA ENGINEER list of registered professional engineers:

Name	*State*	*Licensed as*	*License No.*
Tube Division, Harrison			
C. L. Christian, Jr.	N. Y.	Elec. Eng.	33839
L. J. Schnobeck	N. J.	Prof. Eng.	9943
Television Division, Findlay			
K. D. Lawson	Ohio	Mech. Eng.	23182
IEP BIZMAC, Camden			
Ralph Herman	N. J.	Prof. Eng.	9841

ENGINEERING MEETINGS AND CONVENTIONS

February-March 1958

FEBRUARY 18:
Fourteenth Annual Quality Control Clinic, Rochester Society for Quality Control, War Memorial, Rochester, N. Y.

FEBRUARY 20-21:
Conf. on Transistor and Solid State Circuits, PGCT, AIEE, Univ. of Penn., Phila., Pa.

MARCH 16-21:
Nuclear Eng. and Science Congress, PGNS, EJC, ANS, Palmer House, Chicago, Ill.

MARCH 24-27:
IRE National Convention, All Prof. Groups, New York City

MARCH 24-29:
Fourth International Instrument Show, Caxton Hall, Westminster, London, S. W. I.

MARCH 31-APRIL 2:
Instruments and Regulators Conf., PGAC, ASME, AICHE, ISA, Univ. of Delaware, Newark, Del.

CLIP OUT AND MAIL TO:

EDITOR, RCA ENGINEER
Radio Corporation of America
Bldg. 2-8, Camden 2, N. J.

RCA ENGINEER

HAVE WE YOUR CORRECT ADDRESS?

If not indicate the change below.

PLEASE INDICATE THE CODE LETTER(S) THAT APPEAR NEXT TO YOUR NAME ON THE ENVELOPE.

Name ____________________ Code __________

Street or Bldg. ____________________

City and State or Plant ____________________

RCA ENGINEER EDITORIAL REPRESENTATIVES

The Editorial Representative in your group is the one you should contact in scheduling technical papers and arranging for the announcement of your professional activities. He will be glad to tell you how you can participate.

DEFENSE & INDUSTRIAL ELECTRONIC PRODUCTS

Editorial Representatives, Defense Electronic Products

I. N. BROWN, *Missile and Surface Radar Engineering, Moorestown, N. J.*

T. T. N. BUCHER, *Surface Communications Engineering, Camden, N. J.*

T. P. CANAVAN, *Airborne Fire Control Engineering, Camden, N. J.*

H. R. DYSON, *Technical Administration, Camden, N. J.*

M. HOLLANDER, *Airborne Systems, Moorestown, N. J.*

R. W. JEVON, *Airborne Systems Laboratory, Waltham, Mass.*

DR. D. G. C. LUCK, *Airborne Systems Equipment Engineering, Camden, N. J.*

C. MCMORROW, *Aviation Communications and Navigation Engineering, Camden, N. J.*

J. H. PRATT, *West Coast Engineering, Los Angeles, Calif.*

L. M. SEEBERGER, *Special Systems and Development, Camden, N. J.*

W. W. WAGNER, *Camden Engineering Personnel, Camden, N. J.*

H. L. WUERFFEL, *Engineering Standards and Services, Camden, N. J.*

Editorial Representatives, Industrial Electronic Products

I. F. BYRNES, *Radiomarine Engineering, New York, N. Y.*

H. E. HAYNES, *Advanced Development Engineering, Camden, N. J.*

C. E. HITTLE, *Hollywood Engineering, Hollywood, Calif.*

C. D. KENTNER, *Broadcast Transmitter and Antenna Engineering, Camden, N. J.*

T. T. PATTERSON, *BIZMAC Engineering, Camden, N. J.*

J. H. ROE, *Broadcast Studio Engineering, Camden, N. J.*

J. E. VOLKMANN, *Theater and Sound Products Engineering, Camden, N. J.*

B. F. WHEELER, *Communications Engineering, Camden, N. J.*

RCA VICTOR RECORD DIVISION

Editorial Representative

S. D. RANSBURG, *Record Engineering, Indianapolis, Ind.*

RCA LABORATORIES

Editorial Representative

E. T. DICKEY, *Research, Princeton, N. J.*

RCA ELECTRON TUBE, COMPONENTS & SEMICONDUCTOR DIVISIONS

J. F. HIRLINGER, *Chairman, Editorial Board*

Editorial Representatives, RCA Electron Tube Division

W. G. FAHNESTOCK, *Cathode Ray & Power Tubes, Lancaster, Pa.*

J. DEGRAAD, *Black & White Kinescopes, Marion, Ind.*

D. G. GARVIN, *Color Kinescopes, Lancaster, Pa.*

A. E. HOGGETT, *Receiving Tubes, Cincinnati, Ohio*

R. L. KLEM, *Receiving Tubes, Harrison, N. J.*

J. KOFF, *Receiving Tubes, Woodbridge, N. J.*

F. H. RICKS, *Receiving Tubes, Indianapolis, Ind.*

Editorial Representatives, RCA Components Division

E. E. MOORE, *Electronic Components, Camden, N. J.*

T. A. RICHARD, *Materials Advanced Development, Needham, Mass.*

Editorial Representative, RCA Semiconductor Division

R. E. RIST, *Semiconductors, Somerville, N. J.*

RCA VICTOR TELEVISION DIVISION

C. M. SINNETT, *Chairman, Editorial Board*

Editorial Representatives

E. J. EVANS, *Resident Engineering, Bloomington, Ind.*

R. D. FLOOD, *Color TV Engineering, Cherry Hill, N. J.*

F. T. KSIAZEK, *Black & White TV Engineering, Cherry Hill, N. J.*

J. OSMAN, *Resident Engineering, Indianapolis, Ind.*

R. W. SONNENFELDT, *Advanced Development Engineering, Cherry Hill, N. J.*

H. P. J. WARD, *Electronic Components, Findlay, Ohio*

K. G. WEABER, *Engineering Services, Cherry Hill, N. J.*

RCA VICTOR RADIO & "VICTROLA" DIVISION

Editorial Representative

W. S. SKIDMORE, *Engineering Department, Cherry Hill, N. J.*

RCA SERVICE COMPANY, INC.

Editorial Representatives

W. H. BOHLKE, *Consumer Products Service Department, Cherry Hill, N. J.*

L. J. REARDON, *Government Service Department, Cherry Hill, N. J.*

E. STANKO, *Technical Products Service Department, Cherry Hill, N. J.*