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RCA ENGINEER

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Send all inquiries to Bldg. 2-8, Camden, N. J.

OBJECTIVES

To disseminate to the RCA engineer technical information of professional value.

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To publish in an appropriate manner the important technical developments at RCA, and the part played by contributing engineers.

•

To serve as a medium of interchange of technical information between various engineering groups and locations.

•

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.

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

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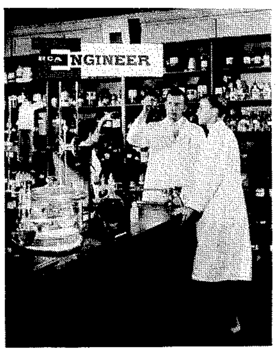
To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.



OUR COVER

The Chemical and Physical Laboratory at Lancaster, Penna. is the subject for our Oct-Nov cover. Dr. Joseph D. Donahue (right) and Samuel B. Deal, chemists, are shown at the bench in the Chemical Laboratory. Miss Dorothy J. Neal, an engineer specializing in metallurgy, is shown at left. Work in progress involves the separation and examination of the components of a phosphor mixture for color kinescopes. In this issue see Dr. Donahue's technical paper and story by Dr. A. L. Smith.

THE INTERCHANGE OF TECHNICAL INFORMATION

An acute problem faces today's electronics engineer! As electronic product complexity increases and engineering tasks also become more complex, so do the engineer's needs for technical information increase. To keep pace with the demands of his job, he must select from voluminous material the specific information which satisfies his needs. Unlike his predecessor, who could satisfy most all his needs with letters, phone calls, or business meetings, plus the usual technical reports, the intercommunication requirements of the modern engineer have increased many fold.

Every engineer is aware of the importance of "keeping informed" to assist him in generating his own ideas. He also knows that these ideas are seldom wholly original and that even the most unusual or revolutionary ones require some stimulation from associates. The cascading benefits which result from the regular interchange of information by means of technical articles provide solutions to problems of the writer as well as the reader. Consequently, the interchange or "pooling" of information is essential to every engineer in coping with the many technical problems facing him.

Certainly, one of the vitally important objectives of the RCA ENGINEER is to provide a convenient medium for the interchange of technical information relating to RCA products. The magazine serves as a systematic source from which the engineer can draw, both to help satisfy his technical needs and to further broaden his professional viewpoint. In order to achieve the best possible result, nearly fifty RCA engineers throughout the company have been appointed for the purpose of providing editorial assistance in selecting material which will be most helpful to the reader—the RCA engineer.

D. F. Schmit

Vice President
Product Engineering
Radio Corporation of America

THE ENGINEER IN CIVIC AFFAIRS

by

JULIUS HABER,

Director, Community Relations and Exhibits

Corporate Staff, Camden, N. J.

As I LOOKED through recent engineering publications, I was impressed with the number of articles which discuss the engineer and his social environment. Many appear to be devoted to aspects of the engineer's relationships to his own community. Assuming that articles are selected for publication on the basis of editorial responsiveness to the reader's interests, it follows that there must be an increasing sensitivity and awareness among members of the engineering profession to their social responsibilities as individuals.

To me, whose job involves the planning, coordination and administration of our Company's programs and activities in connection with community relationships, this is a welcome development. For the corporate program and activities by themselves can achieve only part of our overall objective. To establish RCA as a good citizen and a good community neighbor in all of its plant locations, the corporate program must be complemented by individual participation. And in our entire corporate structure, there is no single group better fitted for active participation in community affairs than our engineers.

APTITUDE, ANALYSIS AND ACTION

As a group, engineers have probably the highest average level of formal education. Engineers are inclined to have a logical approach to problems. They are trained to separate the wheat of truth from the chaff of propaganda or speculation. They are disciplined to think in terms of cause and effect. Therefore they should be able to recognize and evaluate community problems and to pursue constructive courses of action on behalf of their families and their neighbors.

It seems to me that we have passed a crossroad—that increasingly among engineers there is a growing sense of awareness to the world around the world of technological specialization. As an old campaigner in the field of public relations, I can recall countless civic, charitable and other types of meetings and organizational activities in years gone by, where almost every profession in the community would be encountered. There would be doctors, teachers, businessmen, lawyers, merchants, bankers, ministers, labor and civic officials, and others, but rarely any engineers.

TREND TO BROADER OUTLOOK

If this is a trend, it's in keeping with the broadening curricula of engineering colleges and universities, directed to the "education for living" of well-rounded individuals, rather than *over-specialized* technologists. Old timers and leaders in engineering helped bring about this change. They saw the paradox—and the danger—of technological sectarianism and "ivory tower" isolation from life. Here is a profession responsible for the fantastic complexity of modern science and industry, which have had such a profound influence on our civilization. Yet, its activities in the areas of human relations were hardly apparent. No wonder, there has been so much inner questioning among the profession as to whether invention was an end in itself, or whether invention also imposed an obligation of service to society upon the inventor.

My own feeling is that all of these factors had a contributing influence to the changing attitudes. But coupled with them are a number of other factors. Engineers realized that they couldn't just stand aloof from civic affairs. They know that they have the responsibility to participate—to pursue the positive course of action in response to their own and their families' status in the community.

AWARENESS IN ACTION

Looking around in our plant communities we see this awareness in action. Our Community Chest, local Red Cross and hospital fund drive solicitors. Our leaders in Junior Achievement and Boy Scouts. Our active participants in civic affairs and public offices. Let's look at just a random sampling! (For a random sampling, see list on opposite page.)

We can find many similar civic and community activities, multiplied many fold, in these and other major engineering locations. Good, but we should have more, much more!

BENEFICIAL TO OURSELVES

As an expression of management policy, RCA's corporate community programs and activities are based on the recognition that what helps the community is beneficial to the company and its people. They help keep our community neighbors informed about RCA and its people, so that they think well of us and share our pride in our work. But a corporation is people, and it is in terms of people that community relationships are realized.

The same community consciousness is evident in the support by the company and by its people—in terms of time, effort, experience and money—to the Community Chest and Red Cross Fund drives, hospitals, YMCA's, community centers, and numerous other projects benefiting the community as a whole. Corporate contributions are made by RCA in each of its plant communities in accordance with a formula based to a large extent on the number of employees at each location.

PARTICIPATION AND SUPPORT

It is important to RCA people that their home communities should have the most desirable facilities and environment for their families' living and welfare. Participation by RCA engineers in school, church, organizational and civic affairs is one way in which to help assure this goal. Financial contributions to support worthwhile charities and community projects, augmenting corporate contributions, are another way.

Community recognition that its corporate neighbor, RCA, is a good citizen and a good company is important to us as individuals. It is also important to us because it helps to make loyal customers for our products, which in turn, makes for greater opportunities for us all.

The point I am trying to make is that a good community and good community relationships are created by activity, rather than passivity. Engineers are the vanguard of the creativity which helps identify RCA as a good company. In their communities, they must also take their rightful creative place in those activities which contribute to dynamic good citizenship.

JULIUS HABER has devoted his business career to the art of winning public recognition for RCA's achievements in its many and varied fields of activity. The word *public* is used here in its broadest sense—meaning not only the general public, but such specialized "publics" as employees, customers, vendors and the industry.

Mr. Haber joined RCA in New York in 1922, and became a pioneer member of the Company's publicity group shortly afterwards. In 1930, he was "loaned" to Lord and Thomas, then RCA's advertising agency, to organize and direct a publicity department for the company. In this capacity, he handled publicity activities for the Victor Talking Machine Company as well as RCA.

Following the consolidation of RCA and Victor Talking Machine Co., Mr. Haber returned to Camden as publicity director in 1931. In 1937, he had a special assignment under the manufacturing company's president, to organize the company's internal education program. During this period, he established and edited employee house organs and other employee communications media, and instituted foreman and executive educational programs. During World War II, Mr. Haber played a major role in instituting and managing RCA's prominent "Beat The Promise" campaign.

In 1946, he transferred to the RCA Tube Department as advertising and sales promotion manager, and in 1951, was appointed director of advertising and sales promotion activities for all the division's technical products. He became director of public relations of the RCA Victor Division in 1952. Early in 1954, when activities of Victor Division were integrated with those of the Radio Corporation of America, Mr. Haber was appointed Director of Community Relations and Exhibits, Corporate Staff.

Mr. Haber has served as publicity chairman for such organizations as the Institute of Radio Engineers, and the Society of Motion Picture and Television Engineers.

Typical Examples of Engineers' Civic Activities

A. D. BURT,
manager of Radio and "Victrola" Division, Record Changer Engineering, RCA-Cherry Hill, has been a member of the Haddon Heights, N. J. School Board for the past 14 years, and its president for the last three.

•

H. O. BARRACLOUGH,
mechanical engineer of EPD Aviation Communications Engineering, Camden, is vice president of the Delaware Township, N. J. School Board, of which he, too, has been a member for many years.

•

MEL STRUBHAR,
metallurgist in the Chemical and Physical Laboratory, Lancaster Plant, is chairman of the Manor-Millersville joint High School Authority.

•

RALPH W. ENGSTROM,
physicist at Lancaster, is technical advisor of Lancaster County Civilian Defense.

•

IRVING G. PITMAN,
an electrical engineer in Product Development, Receiving Tube Engineering, at the Harrison Plant, is a member of the Borough Planning Board in Roseland, N. J., and the Essex County Civil Defense radio net.

LOW-NOISE TRAVELING-WAVE TUBES*

By **A. J. BIANCULLI**
R. M. COLLINS
E. W. KINAMAN
G. NOVAK
RCA Tube Division
Microwave Tube Engineering
Harrison, N. J.

The rapid and continuing expansion of activity in the microwave region has created a need for low-noise microwave amplifier tubes capable of providing good gain over wide frequency bands. Of various tube types so far developed for microwave amplifier service those which best meet these requirements are traveling-wave tubes.

Traveling-wave tubes permit direct amplification of electromagnetic waves by the addition to the waves of energy from directed electron beams. The possibilities obtainable by interaction between waves and electron beams were recognized as early as 1935 during experiments with multi-anode magnetrons. Analysis indicated that the "traveling" oscillations produced by these tubes were initiated and sustained by energy drawn from rotating electron beams. Intense effort devoted to the application of the traveling-wave principle, both before and during World War II, led to the development of the cavity-resonator magnetron.

In the light of these disclosures and other developments it became apparent that the traveling-wave principle could be applied to amplifiers as well as to oscillators, and during 1943-1944 Dr. R. Kompfner, working in England, designed a tube employing a linear electron beam which can be considered the prototype of the modern traveling-wave amplifier.

Subsequent research conducted by several laboratories has resulted in improved understanding of traveling-wave theory and in the development of practical traveling-wave tubes for several applications. These tubes include types designed for use as broadband amplifiers, electronically tuned oscillators, and microwave oscilloscopes. Special effort has also been devoted to the development of the low-noise amplifier types which are the principal subject of this article.

BASIC COMPONENTS

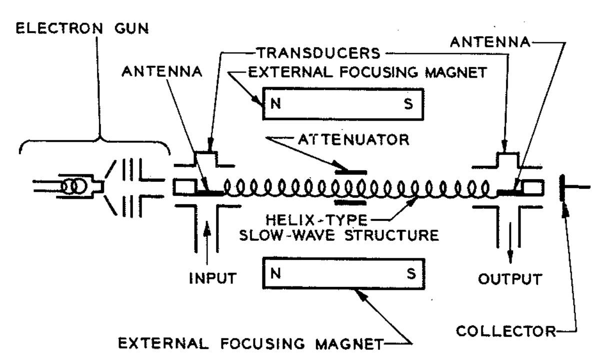
Although traveling-wave tubes may differ considerably in internal construction, size, and appearance, they all operate on the same principle, and employ the basic components shown in Fig. 2.

* The research in this document was supported jointly by the Army, Navy, and Air Force under contract with the Massachusetts Institute of Technology under Subcontract No. 31 of Prime Contract AF19 (122)-458.

The electron gun at the left produces a beam of electrons which is directed along the axis of the tube and absorbed by the collector. The gun consists of a cathode, several focusing and accelerating electrodes which form and direct the beam, and auxiliary parts necessary for alignment and support of the gun structure. The slow-wave structure provides a low-velocity propagation path for the electromagnetic wave to be amplified. This structure, which is usually of the helix type shown, surrounds the beam and permits interaction between the wave and the beam. The field of the external magnet is used to focus the electron beam properly with respect to the electron gun and the slow-wave structure. The input and output transducers are coupling devices used to introduce driving signals to the tube and to remove the amplified signals. The design of these transducers is determined by the operating frequency and bandwidth requirements of the tube. Low-noise tubes may use helix, coaxial-cavity, or plunger-tunable waveguide transducers. Transfer of the signals between the transducers and the helix is effected by the antennae at the ends of the helix. The attenuator is a section of lossy material placed in the

Fig. 1—The traveling Wave Tube. Bottom to top: Developmental type A-1038 TWT; tube with input and output transducers in place; packaged TWT; packaged TWT with solenoid.

Fig. 2—Basic components of a traveling-wave amplifier tube.



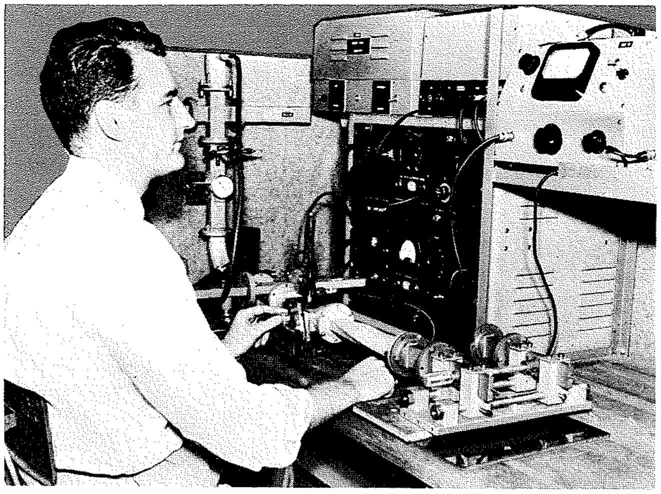


Fig. 3—R. M. Collins measuring impedance and voltage standing-wave ratio of completed low-noise traveling-wave tube. Tube is mounted between the waveguide terminations at lower right.

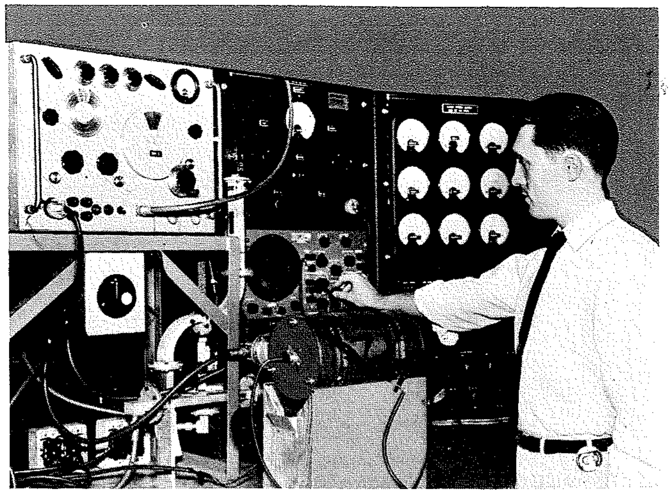


Fig. 4—G. Novak making gain and noise measurements on a completed low-noise traveling-wave tube. The large perforated-metal housing surrounds the tube and the solenoid focusing magnet.

tube to absorb reflections which might cause instability or oscillation.

Helix-type slow-wave structures are easily constructed and are operable over very wide frequency bands. Their wideband properties are attributable to the fact that the velocity of propagation in a helix is substantially independent of frequency. Thus all the frequency components of a wideband signal, or several independent signals on widely different frequencies can be synchronized with a single electron beam and amplified simultaneously.

TRAVELING-WAVE TUBE OPERATION

The method by which interaction between a traveling wave and an electron beam is used to obtain amplification of the wave is shown in Fig. 5.

The stream of electrons emanating from the gun enters the helix from the left at a velocity determined by the d-c potential difference between helix and cathode. These electrons are maintained in a cylindrical beam by the magnetic field applied parallel to the tube axis, and will travel through the helix at uniform mean velocity unless other forces are introduced.

The signal to be amplified is applied to the helix through the input transducer and antenna. This signal initiates an electromagnetic wave which is propagated along the helix in much the same manner as such a wave is propagated along a two-wire transmission line. The velocity with which this wave travels around the circumference of the helix V_1 is approximately equal to the velocity of light. The velocity of the wave in the direction of the electron beam V_2 is smaller than V_1 by a factor approximately proportional to the ratio between helix pitch and helix circumference.

The r-f electric field of this wave interacts with the fields of the beam electrons and affects their kinetic energies and velocities. At any instant electrons in regions where the field acts in one direction acquire kinetic energy from the field and are accelerated; electrons in regions where the field acts in the opposite direction relinquish kinetic energy to the field and are decelerated. Since the accelerated electrons tend to overtake those which have been decelerated, a bunching action takes place. If the velocity of the beam and the axial velocity of the electromagnetic wave are equal, the interchanges of energy over a finite number of wavelengths will balance out and the wave amplitude will remain constant. If, however, the beam electrons enter the helix at a velocity slightly greater than the velocity of the electromagnetic wave, the decelerating action becomes predominant, the wave acquires more energy from the electron beam than it loses, and its amplitude increases as it travels down the helix.

If the velocity of the decelerated electron bunches is sufficiently reduced the interchange of energy will reverse and the wave amplitude will decrease. Consequently, the helix must be terminated and the wave removed at the point of maximum amplitude. The power output of the tube at this point is proportional to the beam power and therefore increases with the beam current. In order to obtain maximum in-beam current ,the beam must be fo-beam current, the beam must be focused so that its surface is as close as possible to the inner circumference of the helix. Losses due to interception of electrons by the helix can be held by proper focusing to less than 1 per cent of the beam current.

Impedance mismatches at helix terminations and slight nonuniformities in helix pitch produce reflections which travel backwards in the tube and may result in instability or oscillation unless attenuated. The necessary attenuation is obtained by the use of lossy material in proximity to the helix at a point between input and output. Proper positioning of the attenuator permits almost complete absorption of the backward wave and negligible absorption of the forward wave.

NOISE CONSIDERATIONS

The ability of any amplifier tube to respond to weak signals is determined by the amount of noise generated in the tube. Since noise tends to override weaker signals, the lower the noise the more sensitive the tube.

Tube sensitivity is usually expressed by a "Noise Figure" indicating the difference (in decibels) between the signal-to-noise ratios at the input and output of the tube. For maximum sensitivity it is desirable, therefore, that the noise figure of a tube be as small as possible.

The noise figure of a traveling-wave tube is proportional to the beam noise at the input to the helix. In a well-focused tube most of this beam

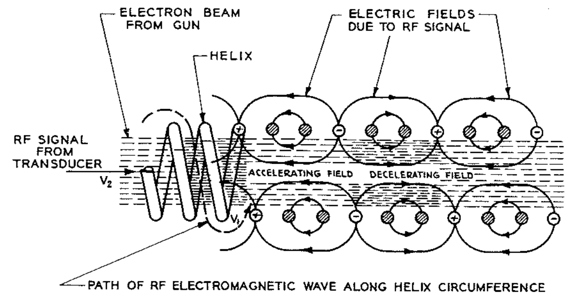


Fig. 5—Instantaneous electric fields and relative beam velocities in traveling-wave tube helix.

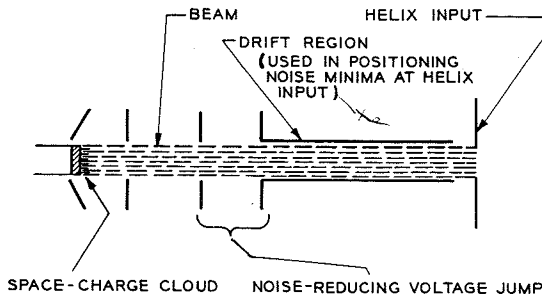


Fig. 6—Noise-reducing techniques used on RCA low-noise gun.

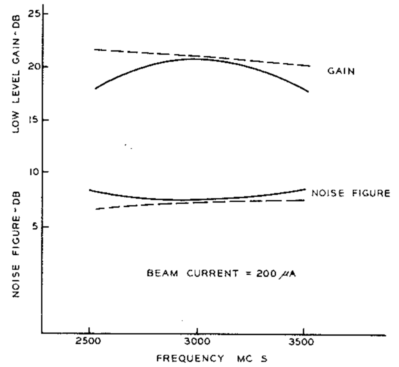


Fig. 7—Gain and noise figure vs. frequency for RCA Developmental Type A-1038 Low-Noise Traveling-Wave Tube.

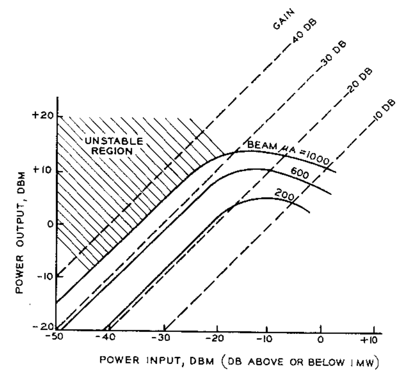


Fig. 8—Transfer characteristics of RCA Developmental Type A-1038 Traveling-Wave Tube.

noise originates in the cathode, and is contributed by two components. One, called "shot noise" is associated with thermionic emission phenomena. It consists of random variations in beam density, caused by the fact that the individual electrons composing a thermionic emission current leave the cathode at random times. Shot noise is a function of cathode temperature and can be partly cushioned by operating the cathode at a temperature higher than that necessary to supply the current needs of the anode electric field. Under these conditions, called "space-charge-limited" operation, most of the emitted electrons return to the cathode and tend to minimize the random fluctuations in the density of the emission current. The other component, called "velocity-fluctuation noise," arises from the shot noise fluctuations but is otherwise independent. This component consists of random fluctuations in electron velocity which have a Maxwellian distribution in the beam and are not reduced by space-charge-limited operation.

The resultant of these two noise components appears in the beam as a standing wave and thus has points of maximum and minimum amplitude. The periodic character of this resultant can be explained by the "elastic" action of electrons composing a beam, which causes a disturbance to any electron to reappear farther along the beam at a distance determined by the beam density, the average beam velocity, and the configuration of the surrounding structure. A substantial reduction in the amount of noise coupled to the helix circuit can be obtained by proper positioning of the helix with respect to the minimum points.

In addition to space-charge cushioning and helix positioning, another method of reducing noise, called the "velocity-jump" technique, is also used. In this method an accelerating voltage is applied to the beam at the point where the velocity-fluctuation noise is a maximum. The sudden acceleration compresses the range of the random velocity fluctuations with respect to the mean beam velocity and thus reduces their contribution to the total beam noise.

The application of these noise-reduction techniques in the RCA low-noise electron gun is shown in Fig. 6.

Other noise-contributing factors in traveling-wave tubes are initial beam divergence at the cathode, helix size, helix operating potential, helix lossiness, and accuracy of beam focus. Space limitations, however, do not permit discussion of these factors in this article.

TRAVELING-WAVE TUBE CHARACTERISTICS

Bandwidth: Low-noise traveling-wave tubes developed by RCA include types designed for operation in the L, S, and C bands. The bandwidth over which any of these tubes can be properly operated is determined primarily by the bandwidth limitations of its input and output transducers and by the characteristics of its helix circuit. In practice, these factors limit the bandwidth to about 30 to 40 per cent of the mid-band frequency for which the tube is designed.

Gain and Noise Figure: Fig. 7 shows typical operating characteristics of an S-band tube, RCA Developmental Type A-1038. The dashed curves indicate gain and noise values obtained by optimizing all tube voltages at the various frequencies; the solid curves indicate the gain and noise values obtained when transducers and voltages are adjusted for maximum bandwidth. Best tube noise figures are obtained at the synchronous helix voltage, which is the voltage that produces maximum signal gain. Noise figures below 6 db, with gains of 20 db or greater, have been attained in S-band tubes.

Power Characteristics: Low-noise traveling-wave tubes when operated under optimum noise conditions, have power outputs in the order of a few milliwatts. For requirements where higher gain and high output power are the principal considerations tubes have been developed which have power outputs ranging from 25 to 40 milliwatts and noise figures of 15 to 20 db.

Fig. 8 shows the transfer characteristics of an RCA low-noise traveling-wave tube (developmental type RCA A-1038.) The solid curves indicate that the gain of the tube is proportional to the 1/3 power of the beam current. The dashed lines provide a convenient reference to tube gain.

The stability limit of the tube is reached when a further increase in beam current causes such high gain that the backward wave is amplified sufficiently to cause self-sustained oscillations. By reducing reflections caused by mismatches and helix discontinuities, it has been possible to produce tubes having a stable gain of 40 db. with only a slight degradation in noise figure.

Fig. 8 also shows that at low input-signal levels the amplification characteristic of the tube is linear. For example, at these levels a change of 10 db in the input signal produces a 10 db change in output power.

When very strong signals are fed onto the helix, however, the relation between input and output power is no longer linear. At high signal levels the tube overloads and saturates in the manner shown by the right hand portion of the curves. As still stronger signals are introduced, the gain of the tube decreases steadily. Under these conditions, the tube becomes an attenuator or limiting device, and so protects the following circuit from becoming overloaded.

CONCLUSIONS

The traveling-wave tube, by virtue of its unique and desirable characteristics, fulfills the requirements of a low-noise microwave amplifier. At this time, several developmental-type low-noise tubes are being made and undoubtedly many improvements will be forthcoming. These improvements are expected to lead to the use of these tubes in new applications, as well as for improvement of existing commercial and military equipment.

ACKNOWLEDGEMENTS

The authors particularly wish to acknowledge the significant and valuable contributions and suggestions made by R. Peter, H. Jenny, P. Wakefield, A. Hogg, E. Stefanowicz, and W. Johnson.

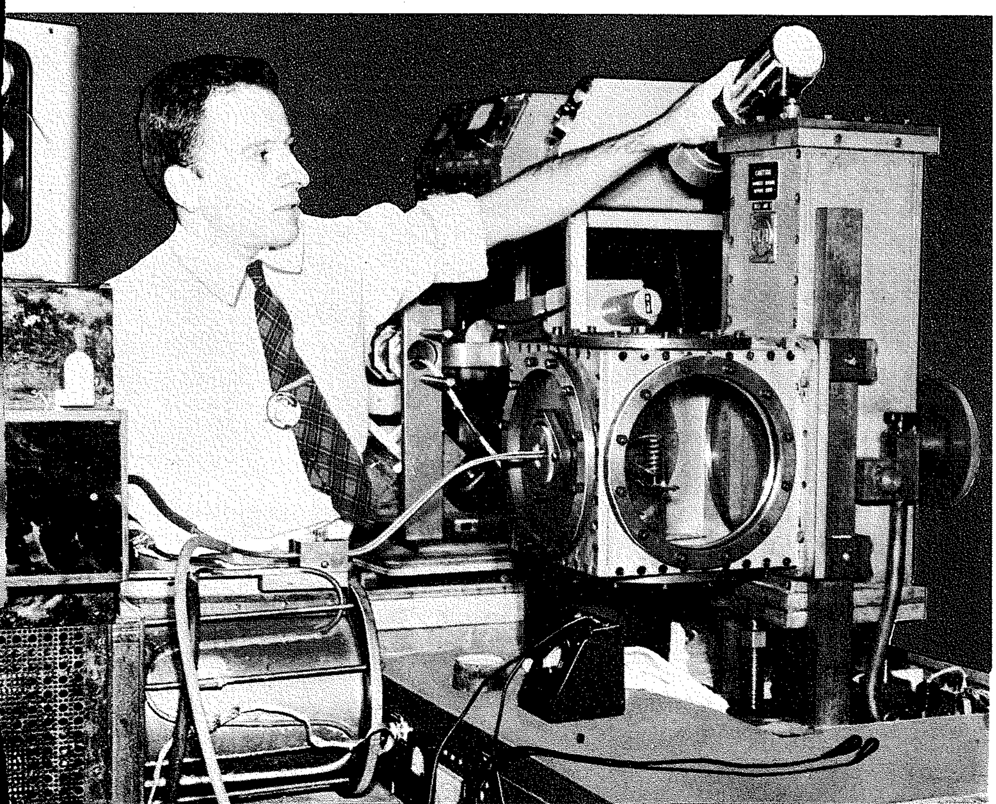
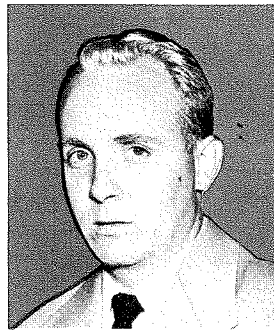


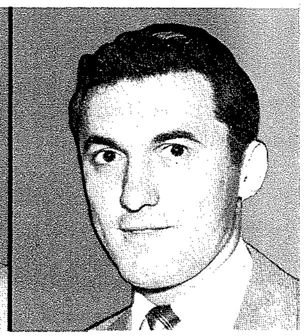
Fig. 9—A. J. Bianculli conducting "bell-jar" test of traveling-wave tube structure. Portholes in evacuated chamber permit continuous observation of changes occurring during tube processing.

A. J. BIANCULLI

R. M. COLLINS



E. W. KINAMAN



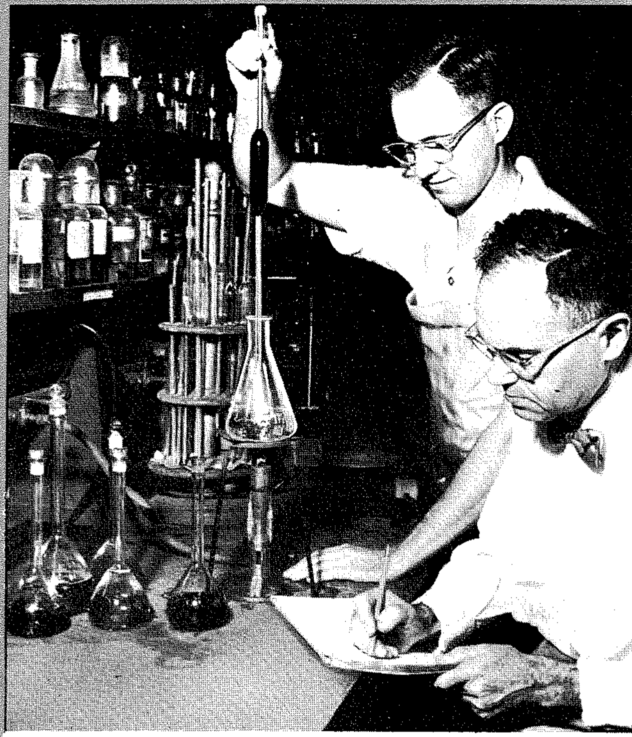
G. NOVAK

ANTHONY J. BIANCULLI received a B.S. degree in Mechanical Engineering from the Polytechnic Institute of Brooklyn in 1949, and is presently studying at the same school for an M.S. degree in Mechanical Engineering. From 1949 to 1952 he was engaged in mechanical design work for the U. S. Army in Brooklyn, N. Y. and for the Ceco Steel Products Corporation in Hillside, N. J. He joined the Microwave Tube Engineering activity of the RCA Tube Division in Harrison, N. J. in 1952, and is presently a project engineer on low-noise and medium-power traveling-wave tubes.
Mr. Bianculli is a member of the American Society of Mechanical Engineers and Pi Tau Sigma.

ROBERT M. COLLINS received the B.S. degree in Physics from Boston College in 1950. He did graduate work in Physics at the same school during 1951, and joined the Microwave Tube Engineering activity of the RCA Tube Division at Harrison, N. J. in 1952. He worked on cold-test measurements until January, 1954, and has since been engaged in the development of traveling-wave tubes.
Mr. Collins is an associate member of the Institute of Radio Engineers.

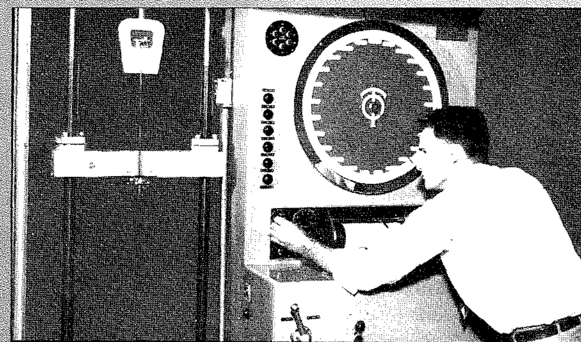
EUGENE W. KINAMAN received the B.S. degree in Electrical Engineering from Rensselaer Polytechnic Institute in 1949, and the M.S. degree in Electrical Engineering from New York University in 1953. From 1949 to 1951 he was engaged in design work on the A. B. Du Mont 5-kilowatt aural and visual television transmitter. From 1951 to 1953 he worked at New York University as a research assistant on classified Government contracts. He joined the Microwave Tube Engineering activity of the RCA Tube Division at Harrison, N. J. in 1953, and is presently a project engineer on low-noise traveling-wave tubes.
Mr. Kinaman is a member of the Institute of Radio Engineers and Eta Kappa Nu.

GEORGE NOVAK received the B.S. degree in Electrical Engineering from the University of Pittsburgh in 1952. After graduation, he joined the Radio Corporation of America as a specialized trainee, and was later assigned to the Microwave Tube Engineering activity of the Tube Division at Harrison, N. J. His work concerns the design and development of traveling-wave tubes.
Mr. Novak is a member of the American Institute of Electrical Engineers, Eta Kappa Nu, and Sigma Tau.



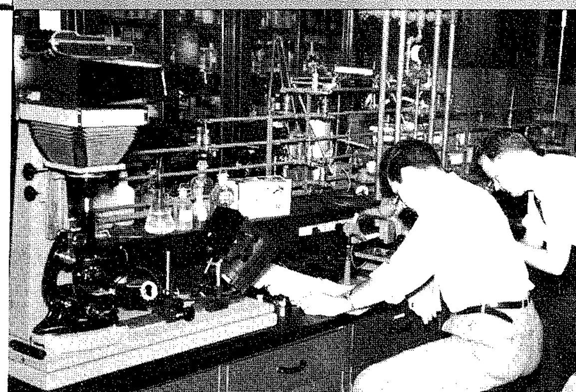
This is a picture of Analytical Chemists, Wand and Bryans. They are analyzing a ferrite mixture used in the manufacture of RCA made ferrites. This type of work enables our organization to keep track of composition while similar analyses made on the completed product are useful in helping identify composition of the completed ferrite with its electrical properties.

This is Laboratory Technician, Robert Forster, measuring the tensile strength and elongation of a sample of fine magnet wire on the Electromatic Tensile Machine. Wire in many forms is one of the basic materials of our organization and the Laboratory has devoted considerable time to furtherance of its technology in order to provide wire material for specific jobs.

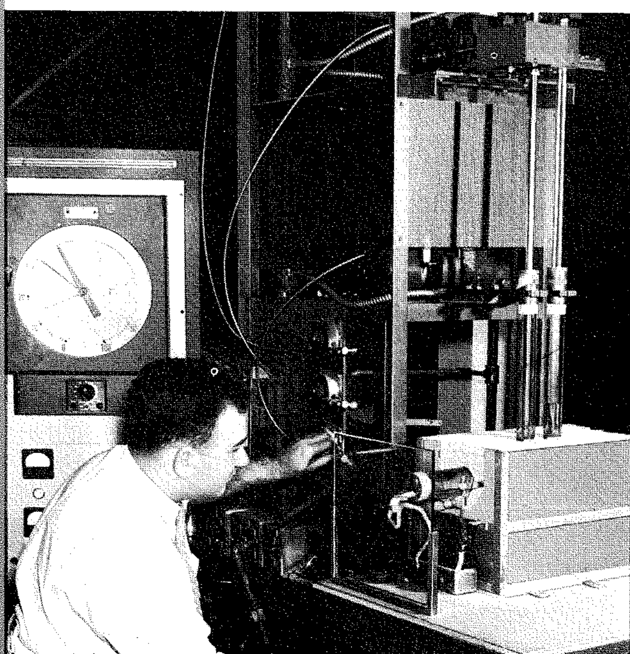


CHEMISTRY AT RCA

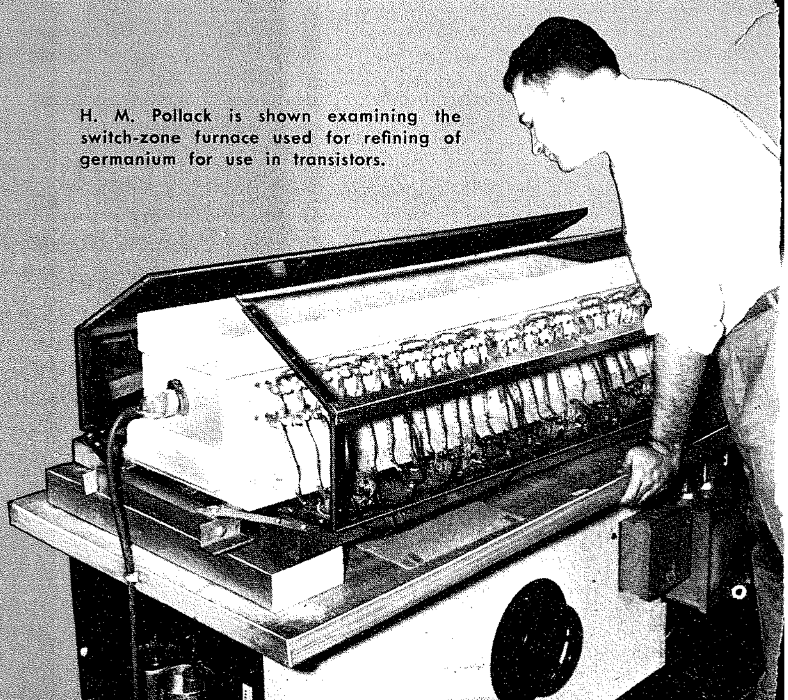
By **DR. A. L. SMITH, Mgr.**
Chemical and Physical Laboratory
Tube Division
Lancaster, Pa.



A. G. Zourides and E. L. Jordan are shown making a microscopic examination of transistors.



H. M. Pollack is shown making an adjustment on the vertical furnace in which germanium crystals are "grown."



H. M. Pollack is shown examining the switch-zone furnace used for refining of germanium for use in transistors.

THE CONTRIBUTIONS made by chemists and chemical engineers to our national health and prosperity are well recognized. Publicity and educational advertising by professional groups and by the chemical industry continuously remind the public of these contributions and emphasize the importance and value of new technical advances. Plastics, synthetic fibers, antibiotics and other medicinals, improved petroleum products and jet fuels, detergents and even the H-bomb, are a few of the products made possible by modern chemistry.

Less widely known and publicized is the extent of the contribution made by chemistry to electronics and to its related industries. RCA management, however, has long been aware of chemistry's importance, and has organized and maintained vigorous chemistry programs in all its research, development, and manufacturing activities.

RCA'S CHEMICAL ACTIVITIES

An article by H. I. Reiskind in the RCA ENGINEER, Vol. I, No. 1, has pointed out how chemistry and chemical engineering are integrated into record manufacturing. In this issue, an article by Dr. D. J. Donahue of the Lancaster engineering staff shows the contributions of these professions in tube manufacturing operations with particular emphasis on color tube development.

It is doubtful, however, that many RCA engineers realize the full scope and magnitude of the company's chemical activities. Few of us regard RCA as a chemical manufacturer, yet our production of just a few items—for example, phosphors at Lancaster, ferrites at Camden, and emission carbonates, ceramics, and insulating materials at Harrison, is very substantial both in terms of tonnage and as an economic factor in the company's business. And yet these products represent only a fraction of the chemical activity within one division —the Tube Division. The ramifications of chemistry and chemical engineering are very extensive in this Division. Its chemists are working to develop improved carbonates for use as cathode coating materials, better phosphors for black-and-white as well as for color kinescopes, and ferrites for many applications. In addition, they are engaged in continuous study and development on photo-sensitive materials, getters, electroplated and carbonized metals for tube parts, glass- or ceramic-to-metal seals, solvents, plastics for tube bases, and contamination problems, to mention only a few.

Semiconductor Devices Operations, which is also a Tube Division function, is almost totally dependent on chemical processing, since the quality of any semiconductor device depends entirely on the purification and treatment of its constituents.

RCA's chemical activities, however, extend to every item we manufacture, for every material we use has at some time been developed or improved by chemists working either for RCA or for one of its many suppliers. Much of the basic chemical work for its products must be undertaken by the company itself, for in many cases the quantities we require are so small that it is not economically feasible for the larger chemical manufacturers to undertake production.

Another factor which chills the interest of outside suppliers is our inability in many cases to specify the degree of chemical purity we require, for many of our problems are caused by impurities too minute to be readily measured or controlled. In such cases, the only proof of acceptability is the performance of the material or of the end product: if it works, it is satisfactory; if it does not, it is useless.

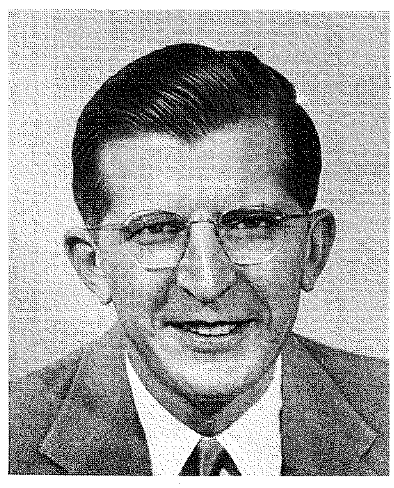
PERSONNEL

Almost all our major plant locations are serviced by groups whose prime function is the investigation of materials and their processing. In the engineering activities of a plant, the greater part of this work is performed in the Chemical & Physical Laboratory; in the manufacturing activities chemists and chemical engineers are generally integrated into the engineering staffs.

Chemists in RCA are men and women with training in physical, organic, or inorganic chemistry. Those with Masters' degrees and Ph.D.'s have usually had training in more than one of these fields. An RCA chemist's work is rarely if ever, routine. In fact, the scope of his activities is frequently across several of the subdivisions of chemistry and thus requires a correspondingly broad background. A factory consultant on chemical processes, for example, is often required to answer in a single day questions on plastics, paints, waxes, metal plating, and parts cleaning. A laboratory worker may find that a single assignment involves inorganic synthesis, surface chemistry, dielectrics, and crystallography.

Numerically, chemists and chemical engineers are a relatively few. Their responsibility is, therefore great, for they must influence RCA operations not by force of number but by scientific logic and fact. Their ability to be helpful and important members of the team is attested by the company's success.

ARTHUR L. SMITH graduated from Fordham University in 1941 with a B.S. in Chemistry. An M.S. degree in Chemistry was obtained from Brooklyn Polytechnic Institute in 1943, during which time he held a Teaching Fellowship. He spent the next two and one-half years at the Institute as a Research Fellow and Research Associate working on government contracts. As an outgrowth of this work, a Ph.D. in Chemistry was awarded by BPI in 1946. In November, 1945, he joined RCA as a chemist in the Luminescent Materials Section at Lancaster, and in 1951 became Group Leader of the Section. In 1953 he became manager of the Lancaster Chemical & Physical Laboratory. He is a member of the American Chemical Society, Phi Lambda Upsilon, Sigma Xi, and is a past chairman of the Electronics Division of the Electrochemical Society.



THE CHEMISTRY OF COLOR TELEVISION

by **D. J. DONAHUE**
Color Kinescope Engineering
Tube Division, Lancaster, Pa.

Fig. 1—A laboratory view showing the author demonstrating the application of phosphor to the color "cap" of a color kinescope.

WHAT DOES a chemist do in an electronics industry such as color television? A brief review shows that the color television process is fundamentally electronic in nature. However, a more detailed examination of the manufacture and operation of various components used in a color television system reveals that chemistry plays a very important role in this industry. This article discusses the chemical aspects of a few of the more important components. Because of its recent development and important part in the color television system, the color kinescope is covered more completely than other items.

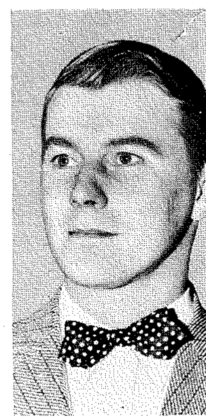
IMAGE ORTHICON

Image-orthicon pickup tubes are used in color television cameras to convert color images into electrical signals. The lens of the color camera causes the image of the color scene to pass through a set of dichroic mirrors which separate the image into its respective color components. Each of the three separated images — blue, green, and red — comes to focus on an image-orthicon pickup tube. A schematic diagram of an image orthicon is shown in Fig. 2. The image is absorbed within the image orthicon by a photoemissive surface which emits electrons in proportion to the intensity of the incident light. The photoemissive surface is prepared by the evaporation of a silver-bismuth alloy in the evacuated tube. The evaporated surface is then partially oxidized by a trace of oxygen obtained from a heated sample of silver oxide. The photoemissive surface is completed by the evaporation of cesium metal upon the partially oxidized silver-bismuth layer.

The electron image from the photoemissive surface is focused upon a storage target having a diameter of 1.5 inches and a thickness of 0.0002 inch. These electrons cause the emission of secondary electrons from the target, and thus produce a net positive charge. The glass used in the target must have a resistivity which permits the positive charge pattern to pass through the target readily but not to travel laterally to any great degree. The optical properties and mechanical strength of the glass must also be very good.

If the secondary electrons emitted from the target are not collected, they return to the target and produce a spurious signal, or instability. The secondary electrons are collected by a fine mesh screen located about 0.001 inch from the glass target. This 500-mesh screen, which has 250,000 holes per square inch, is electroformed from a glass master. In the preparation of the glass master, a piece of ground and polished glass is coated with acid-resistant wax. Crosslines are ruled into the wax, and are subsequently etched into the glass with hydrofluoric acid. After the wax coating is removed, the glass master is sputtered with a thin layer of palladium. The palladium is mechanically rubbed from the unetched surface of the glass so that only the etched lines are conductive. The glass master is then placed in a plating bath, and the fine mesh is electroformed to a thickness of approximately 0.0002 inch. A single glass master is used to prepare hundreds of pieces of mesh, although the sputtering, rubbing, and plating operations must be repeated for each piece.

The positive charge patterns on the glass target are neutralized from the back by a scanning electron beam. The difference in the current of the scanning electron beam before and after the neutralization of the charge constitutes the electrical television signal.



DR. D. J. DONAHUE is a graduate of the University of Michigan from which he received a BS in Chemistry in 1947, an MS in chemistry in 1948, and a PhD in Physical Chemistry in 1951. He was employed as a Teaching Fellow in General Chemistry from 1948 to 1950 and as an Instructor of Physical Chemistry in the 1950-51 year.

In 1951, he joined the Engineering Section of the RCA Tube Division at Lancaster where he spent one year on the mesh master program which included development of improved techniques of making fine mesh screens. He then transferred to the development of new tricolor screening techniques. This work has included decalcomanias, printed screens, sprayed screens, and several types of photographically applied screens.

Dr. Donahue is a member of Sigma Xi, Phi Lambda Upsilon, Alpha Chi Sigma, the American Chemical Society, and the Electrochemical Society.

VIDICON

The vidicon pickup tube, which is frequently used for color-film pickup, operates on a photoconductive principle. A schematic diagram of a vidicon is shown in Fig. 3. The internal side of its front surface contains a very thin layer of a transparent conductive coating of stannic oxide. A very fine mist of a stannic chloride solution is slowly sprayed onto the glass surface, which is held at a temperature of 550°C. When the stannic chloride strikes the hot glass surface, is hydrolyzes to form a very hard coating of transparent conductive stannic oxide. Upon this surface is then evaporated a photoconductive layer of amorphous antimony trisulfide which is specially prepared for good photoconductive properties. A short distance behind the photoconductive surface is a fine mesh screen similar in nature to that used in the image orthicon.

The photoconductive layer, which is an insulator in the dark, becomes slightly conductive when it is illuminated. When the light image is focused on the photoconductive layer, each illuminated element conducts slightly, depending on the amount of illumination on the element, and thus causes an increased positive potential on its opposite surface. A positive-potential pattern results, therefore, on the gun side of the photoconductive layer. Low-velocity electrons from the scanning electron beam are then deposited on the photoconductive layer until the positive potential produced by the light image is neutralized. The deposition of electrons from the scanning electron beam causes an equal number of electrons to flow to the transparent conductive coating and out of the tube as the video signal. The remaining electrons from the scanning beam are collected by the fine mesh screen.

POWER TUBES

Although the majority of power tubes used to transmit color television signals are basically simple triodes or tetrodes, many complex structures are used to achieve various effects. Some of these tubes contain ceramic sections between the external plate, screen, grid, and cathode leads. Because these ceramic sections constitute part of the tube envelope, vacuum-grade ceramic must be manufactured, and vacuum-tight ceramic-to-metal seals must be made. In the preparation of ceramic-to-metal seals, the ceramic is coated with a mixture of powdered molybdenum and manganese, and the part is fired to form a metalized surface on the ceramic. The metalized surface is nickel plated, and copper tube parts are then brazed to the plated surfaces. Ceramic is superior to glass in power loss, mechanical strength, and permissible exhaust and operating temperatures.

Chemistry is also used in the preparation of etched grids and screens for power tubes. Cylindrical sections of copper are mechanically rolled on a form which produces alternating thin and thick sections in the wall of the cylinder. The rolled parts are then etched with nitric acid or ferric chloride until the thin sections are completely removed and only the thicker sections remain as thin wires.

COLOR KINESCOPE

The present RCA color kinescope is a 21-inch, round, formed-mask tube. Structurally, the tube contains three electron guns, as shown in Fig. 4, which are spaced at distances of 120 degrees with respect to each other. A tricolor phosphor-dot screen is located on the internal surface of the glass faceplate. About one-half inch behind the screen is a thin piece of perforated metal called the formed shadow mask. In operation, the three electron beams converge at the location of the shadow mask. The converging beams cross over as they pass through the holes in the shadow mask, as shown in Fig. 5, and then proceed on to the respective phosphor dots on the screen. Because of the geometry of the tube, each beam can strike phosphor dots of only a single color, no matter which part of the phosphor screen is being scanned.

GLASS PARTS

In the manufacture of color kinescopes, nearly all of the processing and assembly steps involve the use of some chemistry. For the envelope, the glass must have a thermal coefficient of expansion which matches that of the metal. The metal used in metal kinescopes is usually 17-percent chrome-iron alloy or cold-rolled steel. In addition, the annealing point of the glass must be above the temperatures used in baking cycles and the resistivity must be high enough to prevent electrical break-

Fig. 2—Sketch showing the structure of the Image Orthicon Tube.

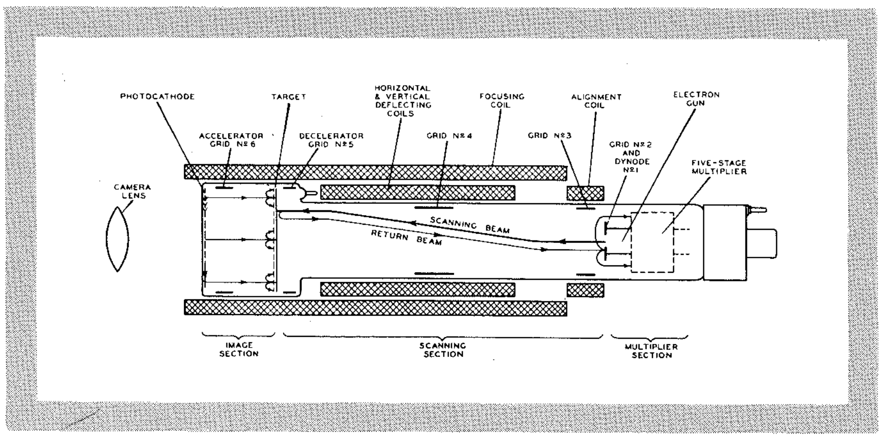
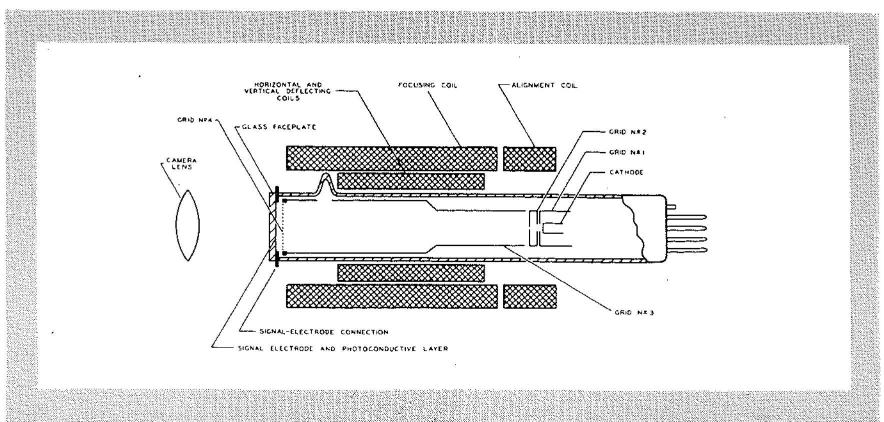


Fig. 3—Sketch showing the structure of the Vidicon Tube.



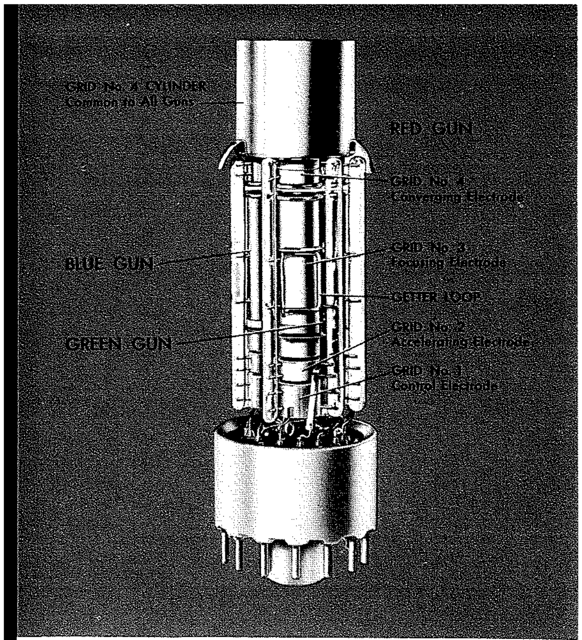


Fig. 4—Photo showing three electron guns in color kinescope.

down at the high voltages used in tube operation. It is also highly desirable that the glass be a neutral-filter type to improve picture contrast, that it be non-browning under electron bombardment, and that it be x-ray absorbent.

The metal surfaces to which the glass is sealed are spray coated with an enameling frit. A thixotropic clay is used to suspend the frit in the spray solution. In the sealing operation, the glass and metal parts are brought together, and heat is applied by means of gas-fired burners. The frit melts first, thus presenting a surface which is easily wetted by the main body of the glass. After the seal is completed, the part is annealed.

The lower end of the funnel and the neck of the tube are glass. For proper tube operation, however, most of this surface must be electrically conductive. The desired portion of the surface is painted with a graphite suspension which contains an organic binder as well as a soluble silicate. After application, the graphite coating is baked to remove the organic binder, and the remaining silicate forms the bond between the graphite and the glass. The organic binder is used to produce a better graphite suspension and permit easier application.

SHADOW MASK

The shadow or aperture mask of the color kinescope is made of 0.008-inch stock of a 95-per-cent copper, 5-per-cent nickel alloy selected for etchability and mechanical strength. A completed mask contains approximately 350,000 holes having a diameter of 0.010 inch. The holes are located in a hexagonal pattern on 0.028-inch centers. The manufacture of the masks begins with the cleaning and degreasing of the metal with an alkaline cleaner. A photosensitive coating of dichromated fish glue is then flowed over both sides of the clean metal and allowed to dry. Photographic negatives of the mask are placed on both sides of the coated metal, registered together, and pulled into close contact under vacuum. Strong arc lamps are used to print the mask patterns on the photosensitive coatings. The exposed areas of the coating are tanned, or insolubilized, but the areas protected from the light by the negatives remain water-soluble. The printed pattern is developed with a light water spray which dissolves the coating in the unexposed areas. The remaining fish-glue pattern is burned to a chocolate-brown color by baking for a few minutes at a temperature of 300°C to increase its resistance to the solution of ferric-chloride mordant. A 40-per-cent aqueous solution of warm ferric chloride is simultaneously sprayed on both sides of the printed metal until the holes are etched to their desired size. The ferric-chloride-metal reaction consists of the oxidation of the metal and the reduction of the ferric chloride to the ferrous state. After completion of the etching, the fish-glue pattern is stripped from the mask with caustic. The mask is then mechanically formed into a spherical section. For superior heat dissipation during the operation of the tube, the masks are blackened. Although very good black surfaces of copper oxide can be formed on the copper-nickel alloy, copper oxide is not sufficiently stable to withstand the exhaust bake cycle. It has been necessary, therefore, to iron-plate the masks and subsequently form a stable iron-oxide black surface.

PHOSPHORS

The phosphors in the screen of the color kinescope convert the energy of the electron beams into visible light. Phosphors are crystalline inorganic salts or oxides, the majority of which are activated by a small quantity of foreign metal ions. The phosphors currently used in color kinescopes are silver-activated zinc sulfide (blue), manganese-activated zinc orthosilicate (green), and manganese-activated zinc orthophosphate (red). A typical phosphor preparation is that used for the silver-activated zinc sulfide. The zinc sulfide is precipitated from a zinc-sulfate solution by means of hydrogen sulfide. The precipitate is washed, 2 per cent of sodium-chloride flux and 0.01 per cent of silver nitrate activator are added, and the mixture is then dried. The dried mixture is fired at a temperature of 900°C for one hour. The sodium-chloride flux promotes crystal growth and activator diffusion during the firing. After the firing process, the sodium chloride is washed out and the phosphor is coated lightly with silicate.

In the selection of a phosphor for use in color kinescopes, several factors must be considered. The color of the emission must match one of the color primaries of the color television rather closely, and the persistence of the emission must be short. The efficiency with which the phosphor converts the energy of the electron beam into visible light is very important. The phosphors must also be sufficiently stable to withstand the processing and baking steps encountered in their application.

PHOSPHOR-DOT SCREEN

The phosphor screen of the color kinescope contains slightly more than 1,000,000 phosphor dots having a diameter of 0.017 inch. A trio containing a blue, green, and red dot exists for each hole in the shadow mask. In the preparation of the screen, each phosphor is dispersed in a water soluble colloid such as polyvinyl alcohol, and the mixture is then rendered photosensitive by the addition of ammonium dichromate. A solid coating of a photosensitized phosphor slurry is then applied to the faceplate of the color "cap" by means of a mechanical spinner which flows and spins the slurry over the faceplate. When the drying of this coating is complete, the formed shadow mask is inserted into the color "cap" and the unit is placed on a lighthouse. The lighthouse contains an intense point source of light which can be located in the virtual source of each electron beam in the plane of deflection. The point source of light projects through the holes in the shadow mask and exposes dots on the screen. After exposure, the mask is removed, and the screen is developed with a light spray of water. The tanned colloid in the exposed areas holds the phosphor, thus forming phosphor dots, while the unexposed areas are washed clean. The second photosensitized phosphor slurry is then coated over the first dot pattern. For exposure of the second screen, the point source of light is rotated 120 degrees to the virtual source of the second electron beam. The third screen is applied, exposed, and developed in a similar manner. After the screen is completed, the tanned

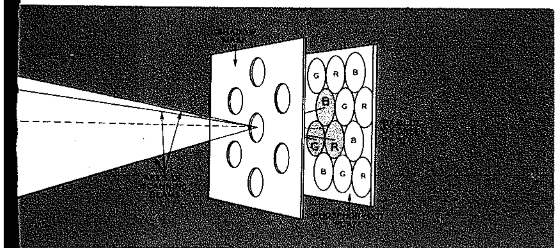


Fig. 5—Portion of shadow mask and phosphor-dot screen showing path of electron beams.

colloid forming the bond between the phosphor and the glass is burned out by baking of the screen at a temperature of 425°C for one hour. A phosphor-to-glass bond is then formed by a light silicate coating applied to the screen by spraying.

Many interesting problems are encountered during the application of the phosphor screens. One such problem results from the fact that zinc sulfide can be activated by copper as well as silver. The silver-activated material emits blue light, while copper activation produces a green-emitting phosphor. As little as 0.1 part per million of copper causes the emission of the silver-activated zinc sulfide to shift a perceptible amount toward green. Not only is this quantity of copper found in many chemicals, but an even more troublesome source is present in airborne copper. Although no complete solution to the problem of airborne copper has been found, measures such as replacement of air drying with infra-red drying, removal of airborne-copper sources such as brush motors from the screening area, and the use of enclosed areas containing good air-filtration systems have helped to reduce the incidence of airborne-copper sulfide contamination.

ALUMINIZED SCREEN

During electron bombardment, the phosphors emit light in all directions. The light which is emitted back into the tube is utilized by means of an electron-permeable aluminum mirror deposited on the back of the screen. Because the phosphor dots in the screen are rather porous, the direct application of aluminum results in severe aluminum penetration and little, if any, mirror effect. The screen is prepared for aluminizing by the spraying of water on the screen while it is spinning in an inverted position. The water wets the screen and fills the interstices between the particles of phosphor. As soon as the excess water has spun off, a filming lacquer is sprayed on the screen. The lacquer spreads over the screen, forming a continuous lacquer film which rests on the backs of the phosphor dots. After the water and lacquer solvents have evaporated, the color "cap" is placed into a vacuum system, and about 1500 Angstroms of aluminum are evaporated over the lacquer film. When the aluminized screen is again baked at a temperature of 425°C for one hour, the silicate is dehydrated and the lacquer film is burned out.

OTHER PARTS AND PROCESSES

The cathodes, or electron-emitting portions of the electron guns, are made of alkaline earth oxides. In the preparation of a cathode, a mixture of calcium, barium, and strontium carbonates is dispersed in a nitrocellulose lacquer and sprayed on a special nickel base. During the exhaust of the tube, the nitrocellulose is burned off and the carbonates are calcined to oxides. The aging or activation of the cathode in the completed tubes causes some of the barium oxide to react with the silicon in the nickel support to form barium silicate and free barium. This free barium is responsible for the thermionic emission of electrons in the oxide cathode. Even the small heater for the cathode is coated with a chemical; it contains a thin coating of aluminum oxide which serves as an electrical insulator.

During the exhaust of a tube, the parts are outgassed by the 400°C baking cycle, and the tube is evacuated with mechanical and oil-diffusion pumps. The final outgassing of the completed tubes, however, is accomplished by chemical getters. On the electron guns are mounted pieces of an aluminum-barium alloy which can be evaporated in the evacuated tube by rf heating. The free barium, a very active chemical, reacts with the remaining gases in the tube. The excess unreacted barium is deposited on the side of the tube neck where it remains to react with the gases that are liberated throughout the life of the tube.

After the exhaust process, a plastic base is attached to the tube. The base is composed of a phenolic compound having good mechanical strength, as well as excellent electrical properties. When the base is tested after soaking in water for 48 hours, the resistance between two pins must be several thousand megohms. The plastic base must be cemented to the glass neck of the tube with an adhesive that will withstand extreme temperature and humidity conditions as well as considerable mechanical shock throughout the life of the tube. The adhesive used for this application consists of a combination of phenolic resin, shellac, rosin, and silicone resin. The last operation on a finished tube is the application of a black decorative lacquer on the outside of the tube.

In addition to the processing steps discussed, many cleaning operations are involved in the manufacture of color kinescopes because the life of the tube is largely dependent on the cleanliness of the completed assembly. Such materials as hydrofluoric acid, sodium hydroxide, detergents, trichloroethylene, and water are used to clean different parts.

CONCLUSION

It is apparent, therefore, that the color television industry relies to a large extent upon the chemist for the development and manufacture of a satisfactory system. The development and manufacture of the present high-quality color television system is actually the result of the close cooperation of many chemists, physicists, electrical engineers, metallurgists, mechanical engineers, and glass technologists.

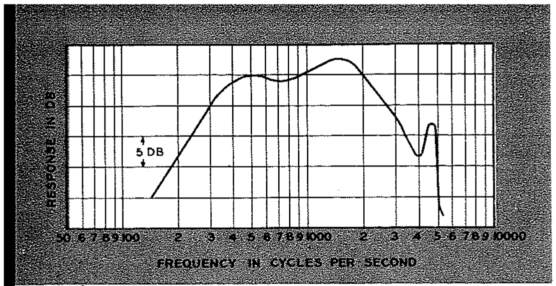


Fig. 1—Curve representing artificial voice calibration of a single-button carbon microphone.

ROSS. M. CARRELL graduated with a BS in E. E. degree from Iowa State College in 1949 and joined RCA as a trainee the same year. He is presently engaged in the development of military and commercial microphones, and specialized acoustical test equipment. Mr. Carrell is a member of the IRE Professional Group on Audio and the Acoustical Society of America.

APPLICATION OF CARBON MICROPHONES TO NARROW-BAND SPEECH TRANSMISSION

by **R. M. CARRELL**

Theatre and Industrial Engineering

Engineering Products Division

Camden, N. J.

THERE ARE many speech transmission systems in which the total bandwidth must be severely limited in order to conserve spectrum space. Such systems would include narrow-band FM mobile transmitters, military communications and the like, where economic considerations often dictate the use of a carbon microphone.

LIMITED FREQUENCY RESPONSE REQUIREMENT

The designer of narrow-band systems often looks to the microphone to limit the frequency range of the incoming speech signal, relying on the published response curves of inexpensive carbon microphones which usually look somewhat like Fig. 1. One might assume that such a microphone would have little speech-energy content beyond 1,500 cps present in the output. Also, it is customary to expect the microphone to reduce the low-frequency energy in the voice, which wastes transmitter power in AM systems and contributes little to intelligibility.

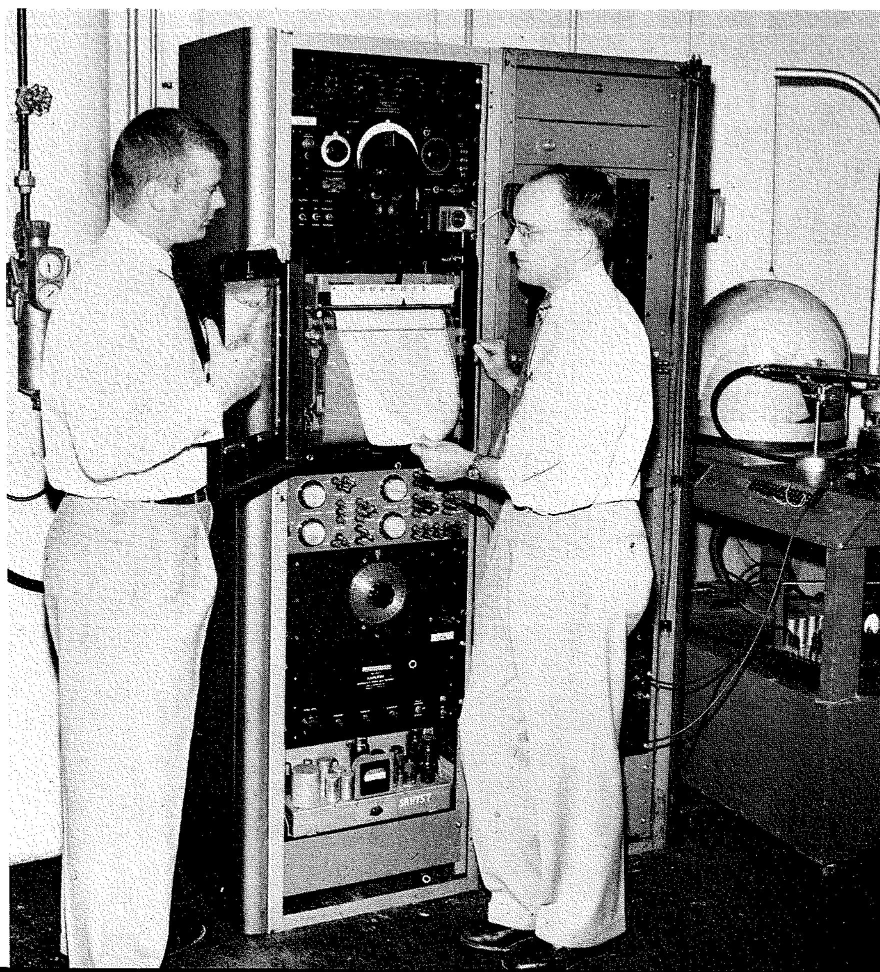


Fig. 2—W. D. Johnson (engineer at left) and R. M. Carrell discussing calibration of the artificial voice shown at extreme right. Also visible is a vacuum chamber for measurements of frequency response and electrical impedance of microphones at low air pressures. The two racks are used for frequency response measurements.

The artificial voice response is indicative of the overall speech bandwidth in a microphone which generates little distortion, such as the variable-reluctance, moving-coil (dynamic), ribbon and condenser types. The artificial voice response can be distinctly misleading in a carbon microphone.

LOUD TALKING PRODUCES "SPLATTER"

It has long been known that the carbon microphone produces distortion, and that there is some spurious, high-frequency output from a carbon unit. It may not be generally realized that the intermodulation distortion with speech input may be so great as to extend the effective range of the microphone by more than an octave toward each end of the spectrum. This extra range is spurious and consists of distortion rather than useful information. This "splatter" may spill over to adjacent channels. In addition, it tends to waste transmitter power. A single-button carbon microphone will generate as much as 30% harmonic distortion when it is exposed to sound pressures of 100/dynes/cm². This is about the pressure experienced by the microphone when held close to the mouth of a person speaking loudly.

ARTIFICIAL VOICE CURVES NOT REPRESENTATIVE

The usual response curves shown on microphones in sales literature are obtained with an artificial voice or

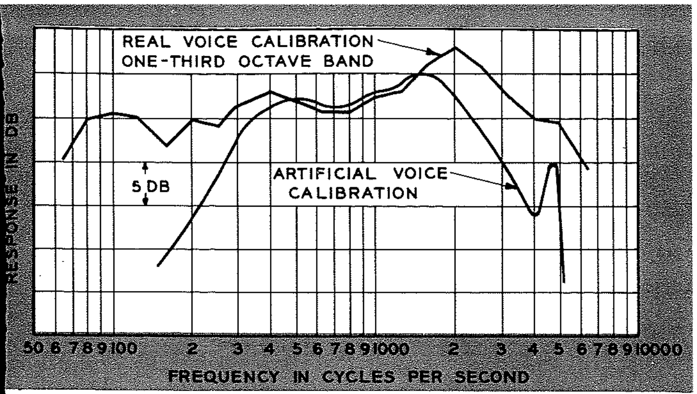


Fig. 3—Curves illustrating "Real Voice" and "Artificial Voice" calibration of a carbon microphone.

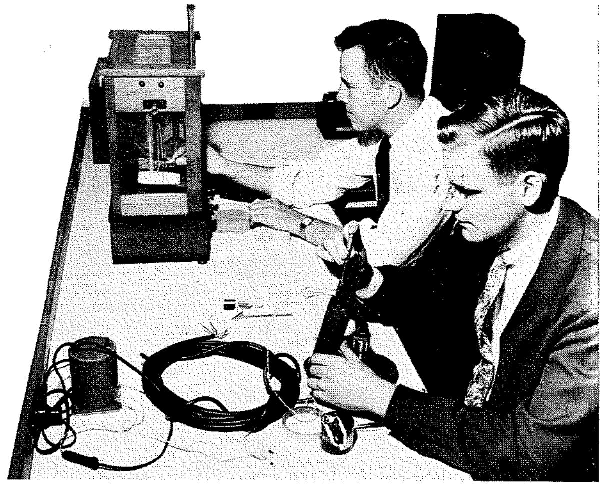


Fig. 5 — E. R. Ware (technician in background) and J. W. O'Neill, acoustical engineer shown in the dust-free, transducer design laboratory. Mr. O'Neill is assembling a BK-5A microphone and Mr. Ware is weighing a sample of headphone earcushion material.

loudspeaker. An audio oscillator is used to drive the speaker. The frequency is slowly swept through the audio range and the microphone output registered on an automatic graphic recorder. Two curves are usually obtained; one with a calibrated standard microphone such as the Western Electric 640AA, and another with the test microphone. A comparison of these curves will yield an artificial voice calibration of the microphone. A harmonic distortion content of as much as 30% will not cause important errors in this type of measurement.

The artificial voice single-frequency response curve does not represent the microphone performance when it is excited by a complex speech signal. The intermodulation distortion so generated is not easily calculated, but its effect on overall bandwidth is easily measured by real voice audiospectrometry.

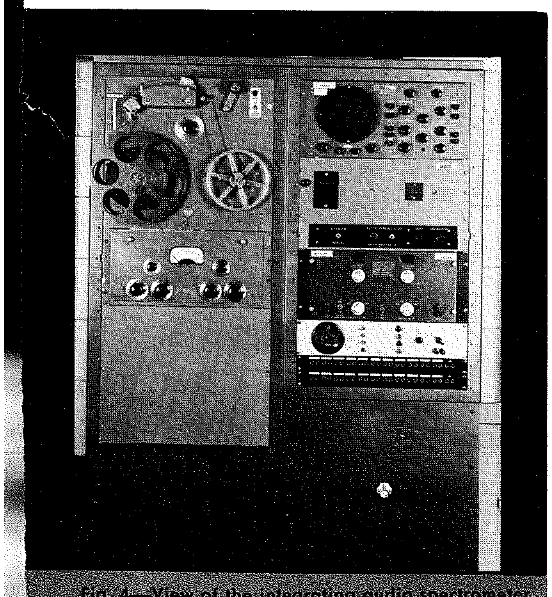


Fig. 4—View of the integrating audio spectrometer used in making "Real Voice" engineering measurements. This equipment was designed and built by members of the Audio Communications Group, Specialties and Shoran Section.

TRUE CALIBRATION EMPLOYS "TEST SENTENCE"

A *real voice* calibration of a microphone is done in a manner which parallels that used with an artificial voice except that a real talker speaking a standard test sentence is used as the signal source instead of an audio oscillator. The technique consists of using a standard microphone to make a tape recording of the talker speaking a standard test sentence, and then to compare this recording with one made by the same talker speaking the same sentence into the microphone under test. The standard microphone is a Western Electric 640AA laboratory standard condenser microphone.

The talker practices the speech sample until he can speak it in the same manner twice in succession. Then he makes the test recordings, switching rapidly from the standard to the test microphone for two successive sentences. The usual test sentence is, "Joe took father's shoe bench out, she was waiting at my lawn." This sentence is constructed so as to have a distribution of speech sounds similar to that found in ordinary English text.

ENDLESS TAPE LOOP AIDS SPECTROANALYSIS

After the two sentences are recorded, the portion of the tape containing each sentence is cut out and formed into a loop which can be played endlessly by the recorder as the speech sample is analyzed. The output of the recorder is fed to a bandpass filter, then to an amplifier and rectifier. The fluctuating d-c output of the rectifier is fed through a timer to an electro-mechanical integrator. The integrator sums the energy of the speech sample in each band over a fixed period determined by the timer, and so determines the energy content of the talker's voice, as modified by the microphone, in that particular band. The timer is set to permit several passages of the speech sample through the integrator.

A very rough spectroanalysis can be made if the filter is set for octave pass bands; a very detailed, though lengthy analysis is possible if a harmonic wave analyzer is used as the filter. A photograph of the spectrometer is shown in Fig. 4. The filter used in this analysis was a Bruel & Kjaer third-octave filter.

"REAL VOICE" CALIBRATION

By comparing the spectrum obtained using the standard condenser microphone with the spectrum obtained using the test microphone, a real voice calibration can be made. This is shown in Fig. 3. The second curve is one obtained by the standard artificial-voice technique.

A comparison of these two response curves will show that the artificial voice response does not represent the performance of the microphone under conditions of actual use. This is peculiar to a carbon microphone; this discrepancy is not found in other types.

FREQUENCY RESPONSE RELATED TO MECHANO-ACOUSTICAL SYSTEM

This may be further explained as follows: The frequency response curve has primarily to do with the mechano-acoustical system which drives the electro-mechanical conversion element; the actual conversion of mechanical motion to electrical output is a process which is essentially independent of frequency. Most of the distortion present in a microphone's output originates in the electro-me-

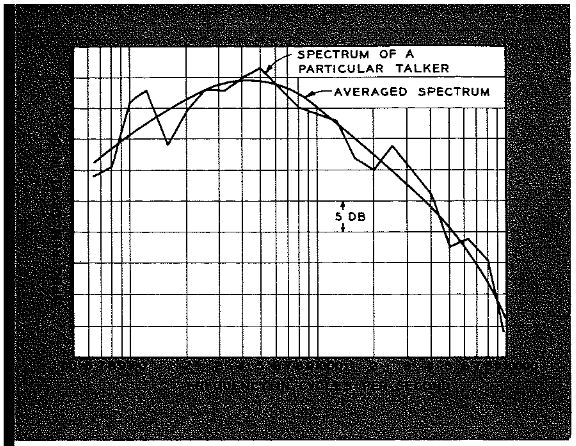


Fig. 6—Curves showing one-third octave band spectrum levels for a male voice speaking the test sentence, "Joe took father's shoe bench out, she was waiting at my lawn."

chanical conversion process. This is especially true of the carbon microphone. The conversion is here accomplished by agitating a flexible cup containing loosely packed carbon granules.

The mass of the diaphragm, and its stiffness, plus the stiffness of any cavities coupled to the diaphragm, and the mechanical constants of the carbon element, basically determine the artificial voice response curve of the microphone. These elements exercise no control over the bandwidth of the intermodulation distortion generated by the carbon element.

Thus if the system considerations in fact require the speech bandwidth to be limited to, say, 3,000 cps, then some filtering external to the carbon microphone will be required.

ADJACENT CHANNEL INTERFERENCE MEASUREMENTS

We have seen so far that a carbon microphone produces a speech bandwidth in excess of its nominal response limits. It remains to assess this information in practical terms in actual systems. The high-frequency response of the microphone is of interest because of its relation to bandwidth and adjacent channel interference. A practical test of the importance of the intermodulation distortion would be to measure the adjacent channel interference using a microphone which produced considerable distortion and using one which is comparatively distortion free.

A test was arranged with the cooperation of C. A. Rammer and R. A. Beers of the Mobile Communications Group. An F-M signal generator was connected to a receiver and tuned to the channel above the receiver channel. The signal generator was modulated by a carbon microphone through a simulated transmitter input circuit. The adjacent channel interference was judged by the signal generator output level which just caused the speech to be lost in the receiver noise.

The test was made with an acoustical filter over the microphone as one condition. The second condition was with an electrical filter in the output of the microphone. The overall artificial voice response curves with the two filters were similar to each other and to Fig. 1.

The threshold level using the acoustical filter was 75 microvolts. With the electrical filter, the threshold was 300 microvolts. The electrical filter eliminates the high-frequency intermodulation components which are unaffected by the acoustical filter.

PRACTICAL CONSIDERATIONS

This reduction in adjacent channel interference amounts to some 6 decibels; in some systems this could be an important gain. The importance of such a gain would have to be balanced against the increased cost of a non-carbon system.

There are two more considerations which are pertinent here. One is the reason why the reduction in adjacent channel interference, using an electrical filter, is not greater than would be suggested by Fig. 3. The second item is the effect of differentiation, clipping, and integration on the speech bandwidth.

To answer the first item, consider the actual speech spectrum as shown in Fig. 6. The spectrum is for one talker; the trend, however, is typical for male speech. It will be seen that there is relatively little energy, on the average, above 2,000 cps. Therefore, although the carbon microphone may produce spurious high-frequency response, the spurious energy is small compared to that in the region of 500 cps. The effect of differentiation, clipping, and integration on the speech spectrum is small. Considerable intermodulation distortion is produced by the clipping process; however, the subsequent integration reduces the high-frequency components below the point where they cause any major extension of the speech bandwidth.

The carbon microphone is becoming passé in many military communications systems. Paramount among the non-carbon systems is the AN/AIC-10 aircraft interphone developed by RCA for the Air Force. This is a high-gain system using dynamic noise-cancelling microphones. In three years of service there has not been a single field failure of one of these microphones. This is well beyond the life expectancy of a carbon unit in similar service.

CONCLUSIONS

Several conclusions could be drawn from the data presented here. The first is that carbon microphones produce sufficient intermodulation distortion to extend the electrical output bandwidth an octave beyond the high- and low-cutoff frequencies as determined from an artificial-voice response curve. Second, this spurious response can be eliminated by suitable electrical filtering. Third, such filtering will effect an appreciable reduction adjacent channel interference which may be an important performance gain in some systems. Fourth, this intermodulation distortion problem can also be eliminated by the use of dynamic, or variable reluctance microphones.

As spectrum space becomes even more crowded in the future, successful design will become more dependent upon consideration of such things as intermodulation distortion which presently may be of secondary importance.

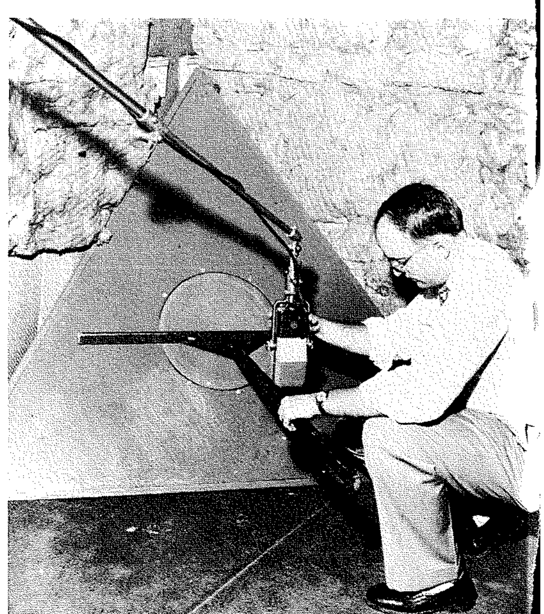


Fig. 7—The author setting up a microphone for calibration in the Transducer Design Anechoic Chamber.

BROADER TRAINING OF ENGINEERS REQUIRED TO MEET CHALLENGE OF SYSTEMS CONCEPT

by
M. C. BATSEL
Chief Engineer
Engineering Products Division
Camden, N. J.

THE NEW services that it is possible to provide the Government and industry through the use of electronic devices are supplied by systems of increased complexity. The scope of engineering skills required to design and produce these devices demands specialists capable of handling the many phases of these complex developments. There are so many potential applications of electronic systems that there is a further need for engineers who can visualize possible applications and who can appraise the economics and timing of developments, both in military and commercial applications. An understanding of automatic control, as a factor in business, and its effect on present and future industry operation must be developed by analysis and interpretation. This can be done only by those who understand the significance of new concepts of techniques and systems. There is a need for engineers trained in the disciplines of operations research and of systems engineering where probability and statistical analysis, and other mathematical techniques, are employed in making decisions in areas of advanced planning.

For these new functions, engineers should have a thorough knowledge of Physics and Mathematics so that they can quickly adapt themselves to the problems arising from the use of new techniques and materials, for example, transistors and magnetics. Specialized knowledge, without a thorough grounding in Physics and Mathematics, is not sufficient to permit an engineer to become effective in systems engineering.

New developments come so rapidly that industry has found it expedient to provide post graduate training courses. The universities have also responded to this need. One of the fields that must be covered by special educational courses is, for example, user needs, both commercial and military. This involves studies in human engineering, market research, applied psychology, economic studies, and even politics. Other fields which are more technical, but which require specialized training because of their special interest at present, are miniaturization, transistorization, and reliability.

These rapid advances in the electronic industry have confronted Engineering Management with several problems. One is how to organize project teams so as to combine effectively the work of physicists and engineers broadly trained in scientific concepts with the work of circuit development and mechanical design engineers. The second problem is how to find a sufficient number of men with broad scientific training. Some of the engineering schools have recognized this need, and have reorganized their courses in engineering accordingly. Engineering Management can and should do something to augment the supply of men capable of undertaking analytical studies and planning required in systems concepts, by making available to qualified individuals opportunities to take graduate work in appropriate subjects. To carry out this objective, RCA has arranged to have a number of qualified men take a special course in Systems Engineering offered by the Moore School of the University of Pennsylvania. It is expected that these men will augment a Systems Management team so essential to carrying out successfully systems development projects.

MAX C. BATSEL brought 30 years of engineering experience to his present post. After his graduation with a BME degree from the University of Kentucky in 1915, Mr. Batsel worked with Western Electric Company and Westinghouse. He came to RCA's Photophone Division as Chief Engineer in 1929. In 1932, Mr. Batsel became Manager of Sound for RCA's Engineering Division. From 1941 until his appointment in 1945 as Chief Engineer of Engineering Products, he served as Chief Engineer on Special Equipment of RCA's Indianapolis plant. Mr. Batsel is a member of Tau Beta Pi, a Fellow of IRE, A Fellow of SMPTE, a member of the American Society of Naval Engineers and of Radio Pioneers. He has received the Modern Pioneers Award of the National Association of Manufacturers.

SOME PROBLEMS ASSOCIATED WITH TELEVISION AGC CIRCUITS

By **L. P. THOMAS**
Black and White Television Engineering
RCA Victor Television Division
Cherry Hill, N. J.

To the average television viewer it may not be immediately apparent that the television receiver must be capable of presenting a clear picture over a rather extreme range of signal strength. Signal strengths may vary from channel to channel, especially in areas where there are both local stations with transmitters nearby and fringe area stations with transmitters many miles distant.

Television signals may also fade in or out from time to time, being better at night or perhaps during the winter season. Passing airplanes may also cause a rapid change in signal level which must be controlled in order to present a picture of uniform intensity. This constantly changing signal level, whether rapid or "long-term", must be held constant by some electrical circuit if television viewing is to be enjoyed without having the viewer constantly compensating or adjusting for the differences in signal strength. Automatic Gain Control ("AGC") is a circuit that performs this function automatically, and is generally used in receivers throughout the United States. For the benefit of those engineers who have not followed television circuits closely, we shall look back a few years when the gain control in a television receiver was manual, or at least not automatic.

EARLY PROBLEMS WITH MANUAL CONTROL

The most dramatic impression of what AGC accomplishes can be gained by looking at a receiver that has manual gain control. Remember the famous 630 chassis? The contrast control changed the bias on i-f and r-f stages manually. Everything was fine until an airplane flew overhead or the user changed stations. The reflections from an airplane alternately increased and decreased the signal level at the receiver. The scene then wavered from side to side, with the background level alternately going white and black.

Switching from one television station to another with manual gain control also posed a problem. If channel 6 happens to be a considerably stronger r-f signal than channel 3, the kinescope probably will be black with possible sound buzz and drifting white bars when tuning in channel 6. The situation required a bias change in the receiver to accommodate the stronger signal. The bias was adjusted by the contrast control as mentioned previously. Tuning back to the weaker signal level on channel 3 resulted in a picture so low in contrast that the television program was barely perceptible. Decreasing the bias on the receiver solved this problem.

The early AGC circuits required the use of a negative power supply in the receiver and were costly, although they solved the problem of switching from weak to strong signals fairly well. These circuits worked so long as the signal level didn't change too rapidly. Rapid variations in signal level such as those caused by airplanes were still a problem. Some of today's low-cost AGC circuits still may have annoying characteristics in modern television receivers. For example, interference from an electric mixer, or electric shaver in the vicinity or on the same power line may cause the kinescope to become white. The AGC circuit in this case has just "set up" on noise pulses and since the receiver is biased off, the video information is lost.

A BRIEF REVIEW OF TELEVISION SYSTEM

Fig. 1A shows a transmitted television signal waveform in which the tips of sync represent the peak power of the transmitter, and are held constant in amplitude at the transmitter. It is these tips of sync that the AGC system (except the "average" type) maintains constant with varying signal levels in the television receiver, since the AGC voltage should not change with amplitude modulation. Fig. 1B shows conventional modulation as used in commercial broadcasting. The differences should be carefully noted.

The transmitted signal is amplified by the r-f stage, Fig. 2, and then converted to the i-f by the oscillator and mixer. Most present-day receivers use three i-f stages, with the first two controlled by AGC bias. The r-f stage, which largely determines the signal-to-noise ratio of the receiver, is also controlled by AGC bias.

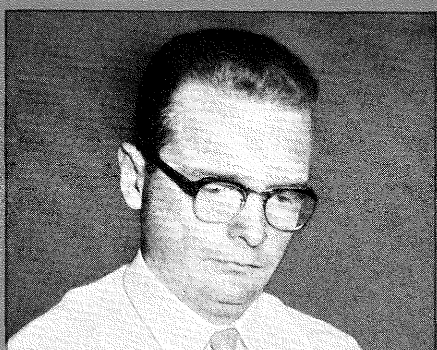
The second detector recovers the video information from the picture i-f carrier. The video signal is amplified by the video amplifier section and applied to the kinescope. The sound and sync signals are also taken from the video amplifier. In Fig. 2, the AGC amplifier is fed from the video section.

In the design of a television receiver, the AGC, video amplifier, and sync circuits must be designed as a unit in conjunction with r-f and i-f characteristics. Many other problems enter into the design of AGC circuits, including such factors as high-voltage regulation and B+ variations with signal level or fine tuning. This article will concentrate only on the design requirements of the AGC as such and not discuss at length, or at all, many of the other related factors that must be taken into account in the design of a practical AGC circuit.

"END-RESULT" REQUIREMENTS FOR AGC

First of all, an AGC circuit should keep the output of the second detector essentially constant with wide variations in signal levels. For example, a good system maintains an essentially constant second-detector output for approximately 50 microvolts to 100,000 microvolts of receiver r-f signal input. In this respect, the AGC circuit can be considered a d-c amplifier, with adequate gain to accomplish the above purpose. The AGC circuit should not limit the maximum gain of the receiver. The lower limit to which a good AGC system can hold the second detector output constant is largely determined by the overall gain of the receiver. The strongest signal the receiver can handle is limited by the overload or cross modulation that can occur in the r-f or i-f sections of the receiver.

In addition to being able to handle



LUCIUS P. THOMAS graduated from Clemson College in 1947 with a degree in Electrical Engineering, and joined RCA in the same year as a Student Engineer. Shortly after completing the Student Engineering Program, he joined the Television Receiver Design Section. At present, he is concentrating on the design of video, sync and agc circuits for television receivers. Mr. Thomas is a Member of the IRE.

wide variations in signal level, rapid variations in signal level must also be considered, such as those caused by reflections from airplanes. This requires consideration of the time constant of the AGC system. If the time constant is too long, the receiver cannot follow rapid variations in signal level due to airplane interference, and the picture flutters in amplitude. If the time constant is too short, noise immunity will be poor and some components of vertical sync may introduce a ripple voltage in the received picture.

If some types of gated AGC are used, ripple voltage will appear in AGC due to scene changes because the gating pulse changes with scene. If a picture is half black, the high voltage and the gating pulse (which is derived from the receivers' horizontal deflection circuits) are high during the black portion of the picture since the kinescope is not drawing beam current. The gating pulse will be lower during a white portion of a picture. This variation in gating pulse causes an unwanted ripple in the AGC. A form of feedback circuitry may be used to cancel this ripple voltage.

Feedback circuitry may also be used to cancel the vertical sync component in pulsed AGC circuits. Such circuits can be made to function so well that no AGC filtering would be required at all except for noise immunity considerations. There is a certain minimum capacity required on i-f bias source points to prevent impulse noise pulses (which can cause grid current in i-f tubes) from "setting up" the i-f bias and causing white flashing in the picture. In addition to the time constant effects, the d-c grid impedance of tubes in AGC must be kept low to prevent grid current transients (such as caused by switching from weak to strong signals) from blocking the receiver.

The AGC threshold control changes the bias on the AGC amplifier grid, which affects the overall gain of the receiver on strong signals. The ratio of r-f to i-f AGC bias is determined by circuit constants. The ratio of r-f to i-f bias, and the AGC threshold control are two distinct circuit functions. This will become clear as each of the circuits is discussed.

When a strong signal is imposed on the receiver (for example, 50,000 microvolts) and when the r-f bias is too low, there may be i-f overload or cross modulation. Overload can cause a washed out picture, sound buzz, or picture bending. Cross modulation can cause interference between the sound and picture carrier of a given station or even cause a "wind-shield wiper" effect from another television station. When a color signal is received, the cross modulation problem is more noticeable due to the presence of the color sub-carrier.

Too high an r-f bias under some conditions may also cause cross modulation, depending on the distribution of signal on the grids of the r-f amplifier. Too high an r-f bias in medium signal strengths, (1,000 microvolts, for example) will cause a picture to have excessive snow at the medium signal level. The above discussion indicates that the r-f bias can neither be too high or too low for any given input signal imposed on the antenna.

The r-f bias at any signal level is largely determined by resistor divider circuits, delay voltage applied to the r-f tube and the characteristics of the tubes controlled by AGC bias voltage, assuming a correctly aligned receiver with normal parts. The largest production variable that affects r-f gain is variation in tube cutoff.

R-f bias versus microvolt input is plotted in Fig. 3. If the developed r-f bias exceeds curve A in Fig. 3, there will be excessive snow in the picture at the input signal level where the curve is exceeded. If the developed r-f bias is less than curve B, Fig. 3, the set will be in overload or cross modulate.

Curve A is strictly a function of the tuner. It is in a sense a plot of the signal-to-noise ratio for high levels versus bias. A sharp cutoff r-f stage, for example, would lower curve A for all strong signal values of input. (Fig. 4)

Curve B, Fig. 3, is largely a function of the i-f section of the receiver. In general, the last i-f stage on AGC bias overloads first. If the second i-f stage were sharp cutoff its acceptance would be lower, therefore curve B, Fig. 3, would rise, or shift toward lower signal levels. On the other hand, if the r-f stage were remote cutoff, allowing still more signal than normal to be applied to the i-f section, curve B would rise still further. This condition is illustrated graphically in Fig. 4.

The effect of sharp-cutoff i-f tubes, in conjunction with a remote-cutoff r-f tube is illustrated in Fig. 5. The same lettering applies to Figs. 3, 4, 5 and 6. Fig. 6 is Figs. 4 and 5 superimposed to illustrate how the limits change with tubes.

The tubes in AGC not only determine the limit curves A and B but they also effect the developed r-f bias with all other factors remaining fixed. Assume the limit curves A and B as well as the developed r-f bias curve as shown in Fig. 3. If the nominal-cutoff i-f tubes of Fig. 3 were replaced with remote-cutoff i-f tubes, the bias required at each signal level would be greater. This means the negative voltage on the plate of the AGC tube is greater at all signal levels. Therefore, the r-f bias is greater at each signal level.

These figures illustrate that comparing two receivers or similar AGC systems (without knowing the tube characteristics) is futile.

Fig. 3 will be called the design center curve. Now let us look at the factors other than tubes that affect the developed r-f bias curve. Tubes determine the limit curves A and B as illustrated in Figs. 3, 4, 5 and 6. Resistors and a delay voltage are used to center the developed r-f bias (Fig. 3) with nominal tubes between curves A and B. The circuit is shown in Fig. 7. The delay voltage is

$$E_d = \frac{E_1 (R_2 + R_3 + R_4)}{R_1 + R_2 + R_3 + R_4}$$

The AGC tube must develop sufficient negative voltage to overcome this positive voltage before any bias is applied to the r-f stage. V_1 is a diode clamp used to prevent positive voltage from being applied to the r-f stage. Any variation in E_1, R_1, R_2, R_3 or R_4 will shift the developed r-f bias curve in Fig. 3. The resistors meet 5% tolerances, and the variations due to these components or E_1 are generally not as serious as tube variations.

AGC SYSTEMS

AGC systems can be divided into three rather broad categories: average, pulsed and gated. The latter two are generally referred to as amplified AGC and may use either a triode or pentode.

AVERAGE AGC

The average AGC system is simply a filter with a long time constant utilizing a voltage from the second detector (see Fig. 8). The average system tends to keep constant the d-c output of the second detector. Consequently, scene variations that affect the d-c component of the video signal cause the level of sync tips to vary at the second detector output. In addition, the second detector output varies with signal level, which means it is desirable to control the acceptance of the first video stage with the contrast control.

This system generally uses a pentode r-f stage with the i-f and r-f bias tied together. The cutoff of the r-f stage must accordingly be adjusted to go along with the i-f bias requirements. When a "totem" type of r-f stage (two triodes in series across the B supply) is used with an average AGC, normally an r-f bias control is provided in the form of a local-distance switch or potentiometer. There are other versions of this circuit which use an "assist voltage" from the sync separator grid.

PULSED AGC

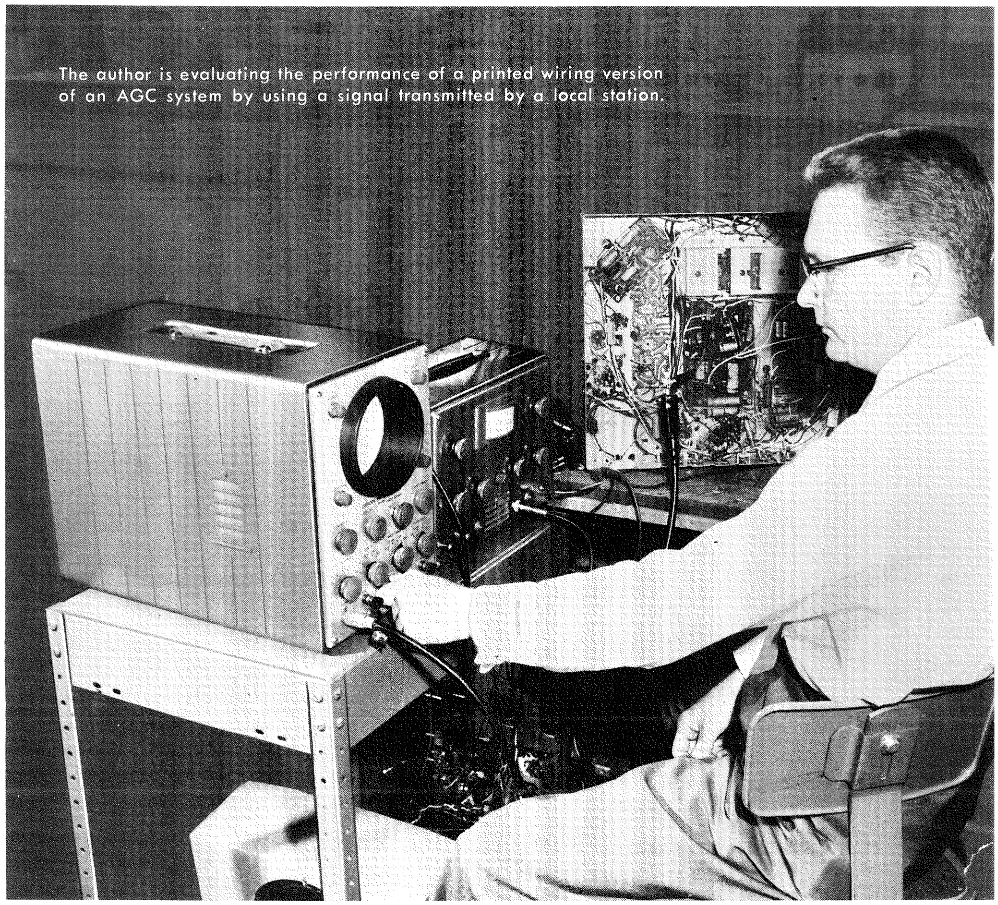
This system uses a tube to develop a d-c voltage proportional to the height of the tips of sync, which is applied to the grid of a tube whose plate is pulsed at the horizontal scanning rate. See Fig. 9.

R_1C_1 is tailored to give a voltage proportional to the tips of horizontal sync; thus, the cathode of V_1 (Fig. 9) acts as a peak detector. V_1 conducts only on sync tips and horizontal sync can also be taken from the plate of V_1. The d-c voltage developed on the cathode by R_1C_1 is applied to the grid of V_2 to give amplified AGC on the plate of V_2.

The high positive pulse on the plate of V_2, Fig. 9, causes a great number of electrons to collect on the plate, and thus as the tube current increases, so does the negative voltage on the plate. If the signal level tries to increase (represented by tips of sync as shown in Fig. 1), the voltage across R_1C_1 becomes more positive, decreasing the bias on the grid of V_2, thus increasing the plate current and the negative voltage on the plate of V_2, which increases r-f/i-f bias to hold video signal level constant.

The divider circuit shown in Fig. 7 would be connected to the plate of V_2 (Fig. 9) to control the r-f bias as already illustrated.

The pulse system is not dependent



The author is evaluating the performance of a printed wiring version of an AGC system by using a signal transmitted by a local station.

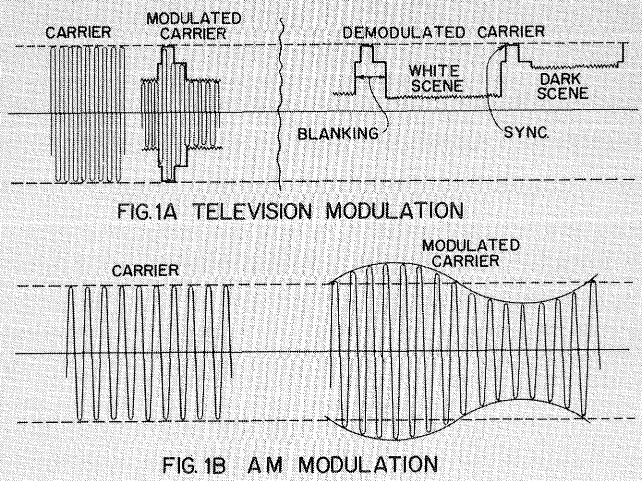


Fig. 1—Television and AM Broadcast modulation envelopes

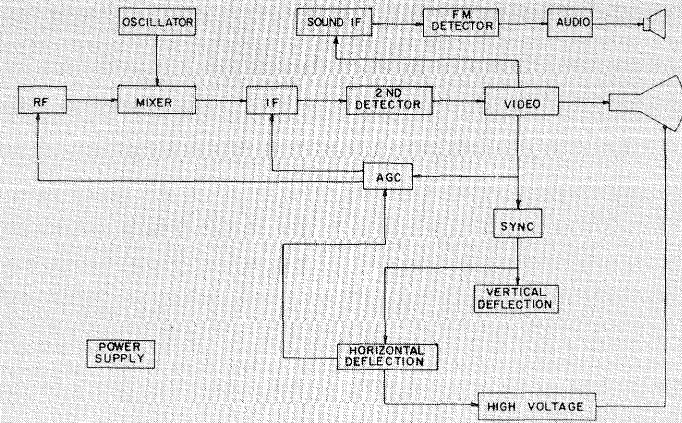


Fig. 2—Television receiver block diagram

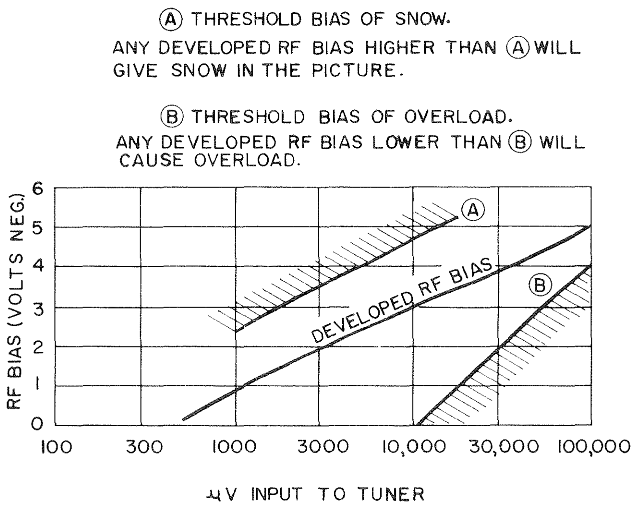


Fig. 3—R.F. bias limits vs. signal level with nominal cut off I.F. and R.F. tubes

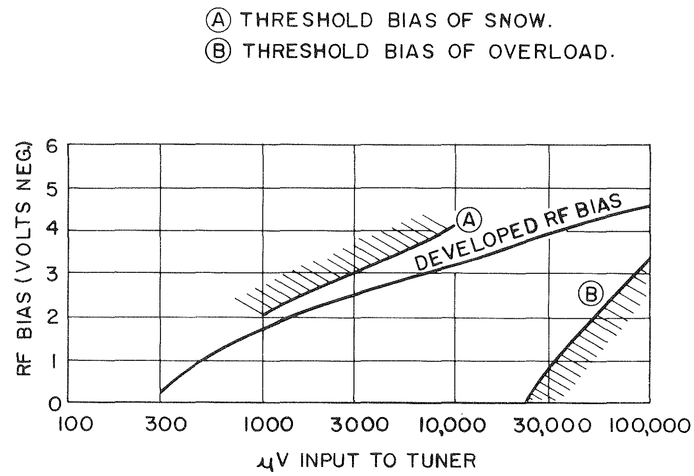


Fig. 4—Effect of sharp cut off R.F. tube and remote cut off I.F. tubes on (1) R.F. bias limits and on (2) developed R.F. bias curve

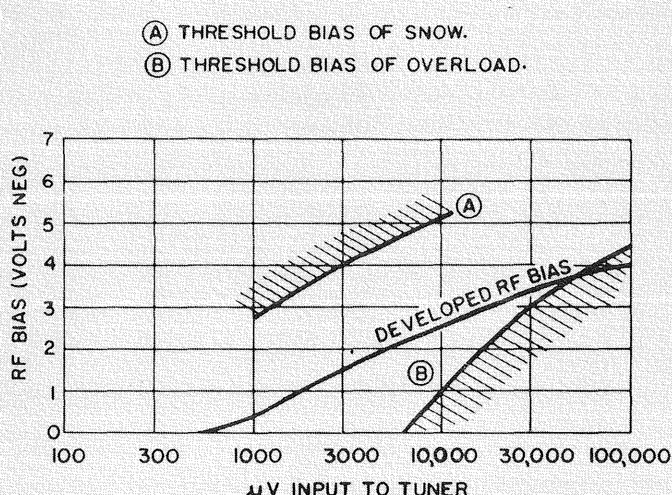


Fig. 5—Effect of remote cut off R.F. tube and sharp cut off I.F. tubes on (1) R.F. bias limits and on (2) developed R.F. bias curve

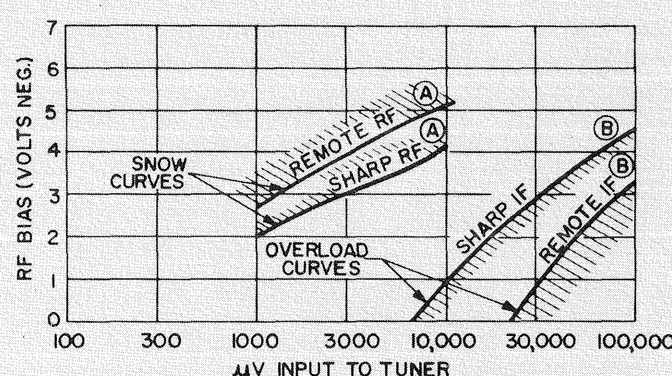


Fig. 6—Overall effect of tubes on R.F. bias limits

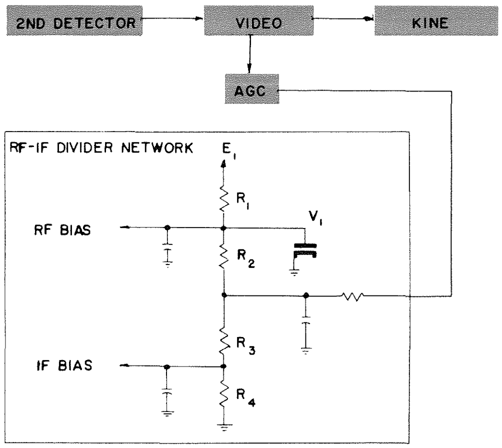


Fig. 7—Circuit that determines R.F.-I.F. bias ratio

on the horizontal circuit of a receiver being synchronized with the transmitted sync pulses. If the time constant R_1C_1, Fig. 9, is too long, noise immunity of the AGC system will be poor. If the time constant is too short, the cathode circuit of V_1, Fig. 9, will not function as a peak detector.

GATED AGC

This system is called a gated system because the AGC tube conducts normally when the plate gating pulse, derived from the horizontal deflection system of the receiver, and the transmitted horizontal sync pulses are coincident. See Fig. 10. Thus, the tube does not conduct on noise pulses that occur at any time between horizontal gating pulses. There are ways to prevent the AGC system from "blocking out" when the set is out of sync horizontally with either a triode or pentode gated AGC. The AGC tube normally conducts only on sync pulses, thus developing a voltage proportional to sync tips. The tips of sync represent the peak carrier output of the TV transmitter. It should be obvious then, that when the receiver is out of sync horizontally, the gating pulse (derived from the receiver's horizontal scanning system) and the transmitted sync pulses are no longer coincident. This requires some special design techniques to prevent the AGC bias from decreasing to such a level as to cause the set to overload and block when the receiver is out of sync horizontally.

Gated AGC provides amplified AGC voltage at a reasonable cost as well as having excellent noise immunity and airplane flutter characteristics.

In order to eliminate scene components, both gated and pulse systems must be d-c coupled to the second detector.

One example of an unusual problem that arose during the design of a triode-gated AGC circuit for one of our television receivers occurred when the writer was observing a western movie on the developmental receiver, and indicates how AGC circuits get involved with other portions of the TV receiver.

The triode-gated AGC circuit was carefully designed for adequate gain, airplane flutter, noise immunity, and r-f bias tracking (see Fig. 3). The circuit was given the usual checks with a signal generator modulated with the familiar Indian Head test pattern. Additional checks were made with on-the-air daytime programming on the local television stations. The circuit appeared to have excellent performance. During a casual observation, however, the hero of the 6:00 PM western movie rode across the kinescope on his white horse in the dead of night. With this circuit he also rode through the AGC!

The reason for this phenomena may be explained in the following manner: the triode AGC circuit was gated by a pulse from the horizontal scanning circuit. The amplitude of the gating pulse is a function of kinescope beam current, since beam current represents a load on the horizontal scanning system. The western movie scene was a sharply contrasting one; the cowboy's horse drew appreciable beam current, while the black background drew none. The scene therefore caused a fluctuation of the gating pulse as the horse galloped across the screen. It is generally known that the output of a triode varies as a function of plate voltage. The triode AGC tube hence produced a fluctuating AGC bias to the r-f/i-f stages.

The average televised scene or test pattern has a fairly constant average video level, which explains why this condition did not present itself earlier.

The solution to this problem was found, fortunately, without increasing the cost of the receiver: it is known that a ripple voltage, which is a function of scene variations, is present in the "B-boost" supply originating in the horizontal circuit. By returning one of the filter capacitors in the plate of the AGC tube to "B-boost", the ripple in AGC caused by the cowboy scene was cancelled.

AGC THRESHOLD CONTROL

In either the pulsed or gated system, the AGC threshold control is adjusted to operate the second detector output level just under the point (threshold) at which sync would be clipped in the first video stage.

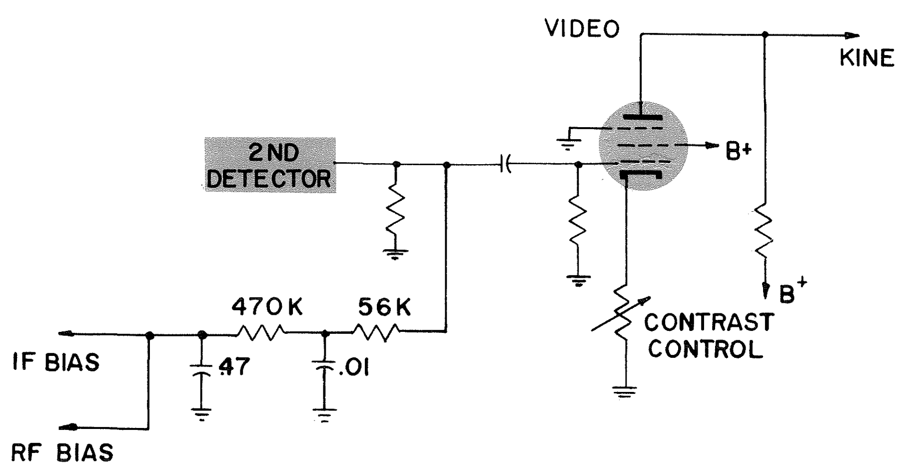


Fig. 8—Average AGC

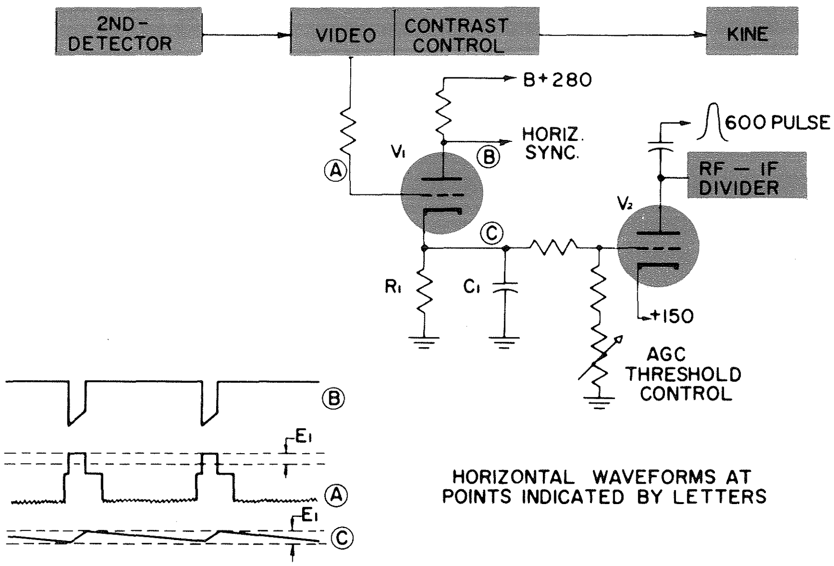


Fig. 9—Pulsed AGC

Fig. 11A shows the second detector output in the presence of electrical interference. Fig. 11B shows the acceptance of the first video. Fig. 11C shows the result of correct AGC bias, too little AGC bias and too much AGC bias.

Too little AGC bias causes the second detector output to exceed the acceptance of the first video, and consequently clip sync. This may cause buzzing in the sound and bending in the picture.

Excessive AGC bias will cause the second detector output to be low. This will result in weak contrast, and poor noise immunity. The poor noise immunity results because the impulse noise voltage far exceeds the sync signal, which tends to bias the sync separator too high. Fig. 11 illustrated the importance of the correct setting of the AGC threshold adjustment.

CONCLUSION

We have discussed several of the problems affecting AGC circuits as well as the necessity for properly adjusting the AGC threshold control. Working with the design of practical AGC circuits requires a thorough knowledge of most all of the circuits found in a television receiver.

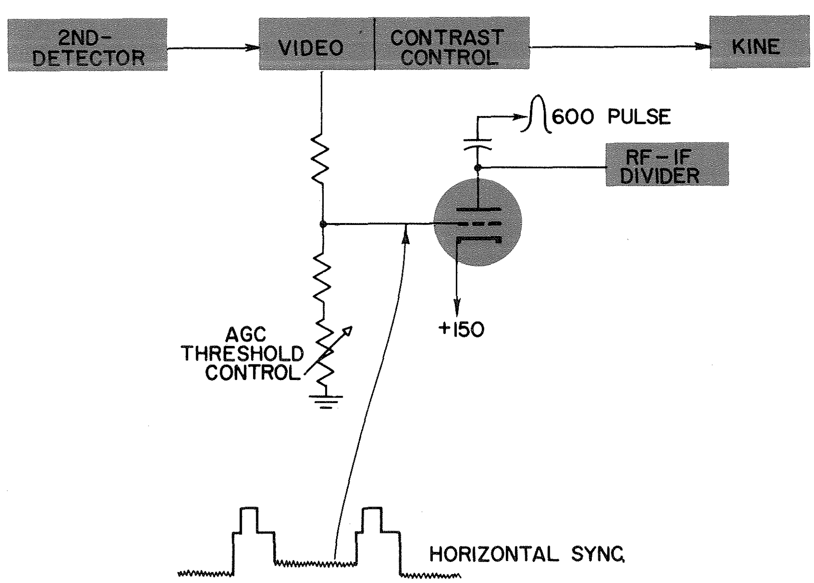


Fig. 10—Gated AGC

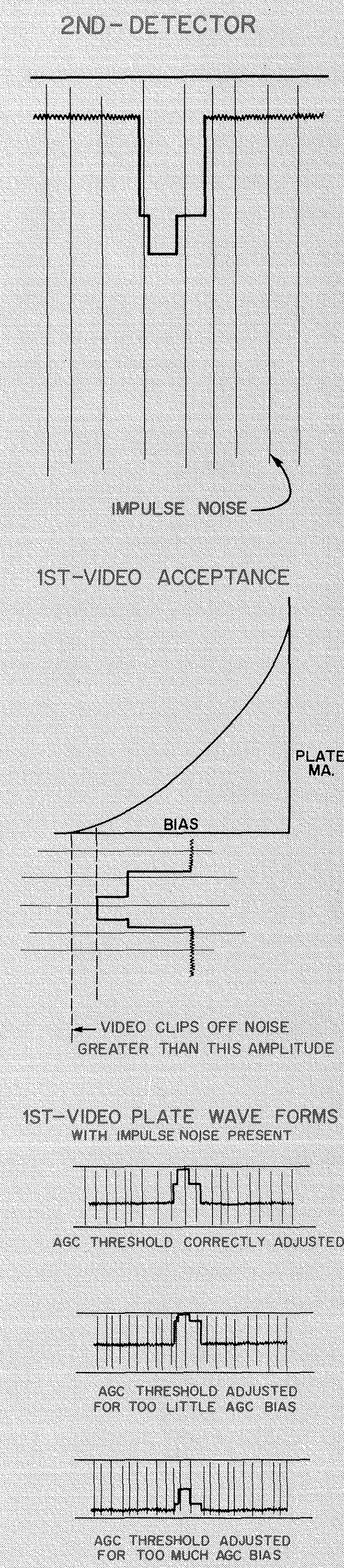


Fig. 11—Effect of AGC threshold adjustment (see text)

SOME PROBLEMS ASSOCIATED WITH TELEVISION AGC CIRCUITS

By **L. P. THOMAS**
Black and White Television Engineering
RCA Victor Television Division
Cherry Hill, N. J.

To the average television viewer it may not be immediately apparent that the television receiver must be capable of presenting a clear picture over a rather extreme range of signal strength. Signal strengths may vary from channel to channel, especially in areas where there are both local stations with transmitters nearby and fringe area stations with transmitters many miles distant.

Television signals may also fade in or out from time to time, being better at night or perhaps during the winter season. Passing airplanes may also cause a rapid change in signal level which must be controlled in order to present a picture of uniform intensity. This constantly changing signal level, whether rapid or "long-term", must be held constant by some electrical circuit if television viewing is to be enjoyed without having the viewer constantly compensating or adjusting for the differences in signal strength. Automatic Gain Control ("AGC") is a circuit that performs this function automatically, and is generally used in receivers throughout the United States. For the benefit of those engineers who have not followed television circuits closely, we shall look back a few years when the gain control in a television receiver was manual, or at least not automatic.

EARLY PROBLEMS WITH MANUAL CONTROL

The most dramatic impression of what AGC accomplishes can be gained by looking at a receiver that has manual gain control. Remember the famous 630 chassis? The contrast control changed the bias on i-f and r-f stages manually. Everything was fine until an airplane flew overhead or the user changed stations. The reflections from an airplane alternately increased and decreased the signal level at the receiver. The scene then wavered from side to side, with the background level alternately going white and black.

Switching from one television station to another with manual gain control also posed a problem. If channel 6 happens to be a considerably stronger r-f signal than channel 3, the kinescope probably will be black with possible sound buzz and drifting white bars when tuning in channel 6. The situation required a bias change in the receiver to accommodate the stronger signal. The bias was adjusted by the contrast control as mentioned previously. Tuning back to the weaker signal level on channel 3 resulted in a picture so low in contrast that the television program was barely perceptible. Decreasing the bias on the receiver solved this problem.

The early AGC circuits required the use of a negative power supply in the receiver and were costly, although they solved the problem of switching from weak to strong signals fairly well. These circuits worked so long as the signal level didn't change too rapidly. Rapid variations in signal level such as those caused by airplanes were still a problem. Some of today's low-cost AGC circuits still may have annoying characteristics in modern television receivers. For example, interference from an electric mixer, or electric shaver in the vicinity or on the same power line may cause the kinescope to become white. The AGC circuit in this case has just "set up" on noise pulses and since the receiver is biased off, the video information is lost.

A BRIEF REVIEW OF TELEVISION SYSTEM

Fig. 1A shows a transmitted television signal waveform in which the tips of sync represent the peak power of the transmitter, and are held constant in amplitude at the transmitter. It is these tips of sync that the AGC system (except the "average" type) maintains constant with varying signal levels in the television receiver, since the AGC voltage should not change with amplitude modulation. Fig. 1B shows conventional modulation as used in commercial broadcasting. The differences should be carefully noted.

The transmitted signal is amplified by the r-f stage, Fig. 2, and then converted to the i-f by the oscillator and mixer. Most present-day receivers use three i-f stages, with the first two controlled by AGC bias. The r-f stage, which largely determines the signal-to-noise ratio of the receiver, is also controlled by AGC bias.

The second detector recovers the video information from the picture i-f carrier. The video signal is amplified by the video amplifier section and applied to the kinescope. The sound and sync signals are also taken from the video amplifier. In Fig. 2, the AGC amplifier is fed from the video section.

In the design of a television receiver, the AGC, video amplifier, and sync circuits must be designed as a unit in conjunction with r-f and i-f characteristics. Many other problems enter into the design of AGC circuits, including such factors as high-voltage regulation and B+ variations with signal level or fine tuning. This article will concentrate only on the design requirements of the AGC as such and not discuss at length, or at all, many of the other related factors that must be taken into account in the design of a practical AGC circuit.

"END-RESULT" REQUIREMENTS FOR AGC

First of all, an AGC circuit should keep the output of the second detector essentially constant with wide variations in signal levels. For example, a good system maintains an essentially constant second-detector output for approximately 50 microvolts to 100, 000 microvolts of receiver r-f signal input. In this respect, the AGC circuit can be considered a d-c amplifier, with adequate gain to accomplish the above purpose. The AGC circuit should not limit the maximum gain of the receiver. The lower limit to which a good AGC system can hold the second detector output constant is largely determined by the overall gain of the receiver. The strongest signal the receiver can handle is limited by the overload or cross modulation that can occur in the r-f or i-f sections of the receiver.

In addition to being able to handle

LUCIUS P. THOMAS graduated from Clemson College in 1947 with a degree in Electrical Engineering, and joined RCA in the same year as a Student Engineer. Shortly after completing the Student Engineering Program, he joined the Television Receiver Design Section. At present, he is concentrating on the design of video, sync and agc circuits for television receivers. Mr. Thomas is a Member of the IRE.

wide variations in signal level, rapid variations in signal level must also be considered, such as those caused by reflections from airplanes. This requires consideration of the time constant of the AGC system. If the time constant is too long, the receiver cannot follow rapid variations in signal level due to airplane interference, and the picture flutters in amplitude. If the time constant is too short, noise immunity will be poor and some components of vertical sync may introduce a ripple voltage in the received picture.

If some types of gated AGC are used, ripple voltage will appear in AGC due to scene changes because the gating pulse changes with scene. If a picture is half black, the high voltage and the gating pulse (which is derived from the receivers' horizontal deflection circuits) are high during the black portion of the picture since the kinescope is not drawing beam current. The gating pulse will be lower during a white portion of a picture. This variation in gating pulse causes an unwanted ripple in the AGC. A form of feedback circuitry may be used to cancel this ripple voltage.

Feedback circuitry may also be used to cancel the vertical sync component in pulsed AGC circuits. Such circuits can be made to function so well that no AGC filtering would be required at all except for noise immunity considerations. There is a certain minimum capacity required on i-f bias source points to prevent impulse noise pulses (which can cause grid current in i-f tubes) from "setting up" the i-f bias and causing white flashing in the picture. In addition to the time constant effects, the d-c grid impedance of tubes in AGC must be kept low to prevent grid current transients (such as caused by switching from weak to strong signals) from blocking the receiver.

The AGC threshold control changes the bias on the AGC amplifier grid, which affects the overall gain of the receiver on strong signals. The ratio of r-f to i-f AGC bias is determined by circuit constants. The ratio of r-f to i-f bias, and the AGC threshold control are two distinct circuit functions. This will become clear as each of the circuits is discussed.

When a strong signal is imposed on the receiver (for example, 50,000 microvolts) and when the r-f bias is too low, there may be i-f overload or cross modulation. Overload can cause a washed out picture, sound buzz, or picture bending. Cross modulation can cause interference between the sound and picture carrier of a given station or even cause a "wind-shield wiper" effect from another television station. When a color signal is received, the cross modulation problem is more noticeable due to the presence of the color sub-carrier.

Too high an r-f bias under some conditions may also cause cross modulation, depending on the distribution of signal on the grids of the r-f amplifier. Too high an r-f bias in medium signal strengths, (1,000 microvolts, for example) will cause a picture to have excessive snow at the medium signal level. The above discussion indicates that the r-f bias can neither be too high or too low for any given input signal imposed on the antenna.

The r-f bias at any signal level is largely determined by resistor divider circuits, delay voltage applied to the r-f tube and the characteristics of the tubes controlled by AGC bias voltage, assuming a correctly aligned receiver with normal parts. The largest production variable that affects r-f gain is variation in tube cutoff.

R-f bias versus microvolt input is plotted in Fig. 3. If the developed r-f bias exceeds curve A in Fig. 3, there will be excessive snow in the picture at the input signal level where the curve is exceeded. If the developed r-f bias is less than curve B, Fig. 3, the set will be in overload or cross modulate.

Curve A is strictly a function of the tuner. It is in a sense a plot of the signal-to-noise ratio for high levels versus bias. A sharp cutoff r-f stage, for example, would lower curve A for all strong signal values of input. (Fig. 4)

Curve B, Fig. 3, is largely a function of the i-f section of the receiver. In general, the last i-f stage on AGC bias overloads first. If the second i-f stage were sharp cutoff its acceptance would be lower, therefore curve B, Fig. 3, would rise, or shift toward lower signal levels. On the other hand, if the r-f stage were remote cutoff, allowing still more signal than normal to be applied to the i-f section, curve B would rise still further. This condition is illustrated graphically in Fig. 4.

The effect of sharp-cutoff i-f tubes, in conjunction with a remote-cutoff r-f tube is illustrated in Fig. 5. The same lettering applies to Figs. 3, 4, 5 and 6. Fig. 6 is Figs. 4 and 5 superimposed to illustrate how the limits change with tubes.

The tubes in AGC not only determine the limit curves A and B but they also effect the developed r-f bias with all other factors remaining fixed. Assume the limit curves A and B as well as the developed r-f bias curve as shown in Fig. 3. If the nominal-cutoff i-f tubes of Fig. 3 were replaced with remote-cutoff i-f tubes, the bias required at each signal level would be greater. This means the negative voltage on the plate of the AGC tube is greater at all signal levels. Therefore, the r-f bias is greater at each signal level.

These figures illustrate that comparing two receivers or similar AGC systems (without knowing the tube characteristics) is futile.

Fig. 3 will be called the design center curve. Now let us look at the factors other than tubes that affect the developed r-f bias curve. Tubes determine the limit curves A and B as illustrated in Figs. 3, 4, 5 and 6. Resistors and a delay voltage are used to center the developed r-f bias (Fig. 3) with nominal tubes between curves A and B. The circuit is shown in Fig. 7. The delay voltage is

$$E_d = \frac{E_1 (R_2 + R_3 + R_4)}{R_1 + R_2 + R_3 + R_4}$$

The AGC tube must develop sufficient negative voltage to overcome this positive voltage before any bias is applied to the r-f stage. V_1 is a diode clamp used to prevent positive voltage from being applied to the r-f stage. Any variation in E_1, R_1, R_2, R_3 or R_4 will shift the developed r-f bias curve in Fig. 3. The resistors meet 5% tolerances, and the variations due to these components or E_1 are generally not as serious as tube variations.

AGC SYSTEMS

AGC systems can be divided into three rather broad categories: average, pulsed and gated. The latter two are generally referred to as amplified AGC and may use either a triode or pentode.

AVERAGE AGC

The average AGC system is simply a filter with a long time constant utilizing a voltage from the second detector (see Fig. 8). The average system tends to keep constant the d-c output of the second detector. Consequently, scene variations that affect the d-c component of the video signal cause the level of sync tips to vary at the second detector output. In addition, the second detector output varies with signal level, which means it is desirable to control the acceptance of the first video stage with the contrast control.

This system generally uses a pentode r-f stage with the i-f and r-f bias tied together. The cutoff of the r-f stage must accordingly be adjusted to go along with the i-f bias requirements. When a "totem" type of r-f stage (two triodes in series across the B supply) is used with an average AGC, normally an r-f bias control is provided in the form of a local-distance switch or potentiometer. There are other versions of this circuit which use an "assist voltage" from the sync separator grid.

PULSED AGC

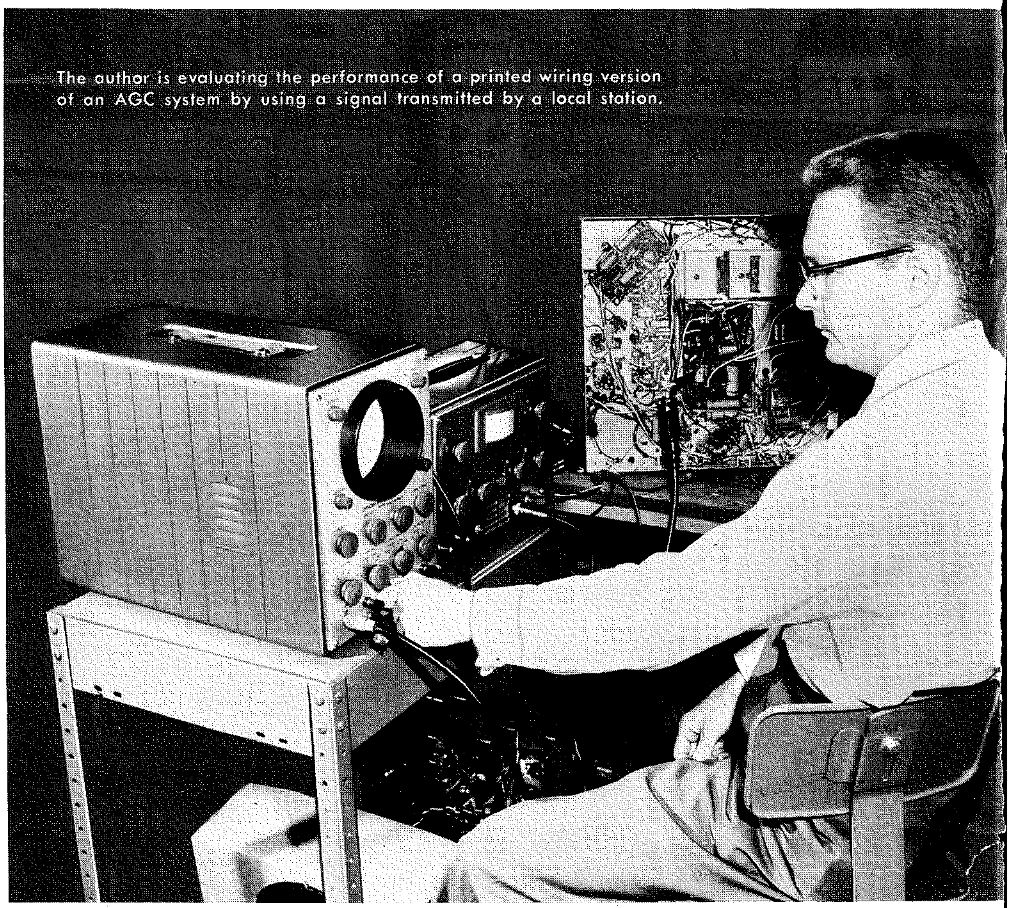
This system uses a tube to develop a d-c voltage proportional to the height of the tips of sync, which is applied to the grid of a tube whose plate is pulsed at the horizontal scanning rate. See Fig. 9.

R_1C_1 is tailored to give a voltage proportional to the tips of horizontal sync; thus, the cathode of V_1 (Fig. 9) acts as a peak detector. V_1 conducts only on sync tips and horizontal sync can also be taken from the plate of V_1. The d-c voltage developed on the cathode by R_1C_1 is applied to the grid of V_2 to give amplified AGC on the plate of V_2.

The high positive pulse on the plate of V_2, Fig. 9, causes a great number of electrons to collect on the plate, and thus as the tube current increases, so does the negative voltage on the plate. If the signal level tries to increase (represented by tips of sync as shown in Fig. 1), the voltage across R_1C_1 becomes more positive, decreasing the bias on the grid of V_2, thus increasing the plate current and the negative voltage on the plate of V_2, which increases r-f/i-f bias to hold video signal level constant.

The divider circuit shown in Fig. 7 would be connected to the plate of V_2 (Fig. 9) to control the r-f bias as already illustrated.

The pulse system is not dependent


The author is evaluating the performance of a printed wiring version of an AGC system by using a signal transmitted by a local station.

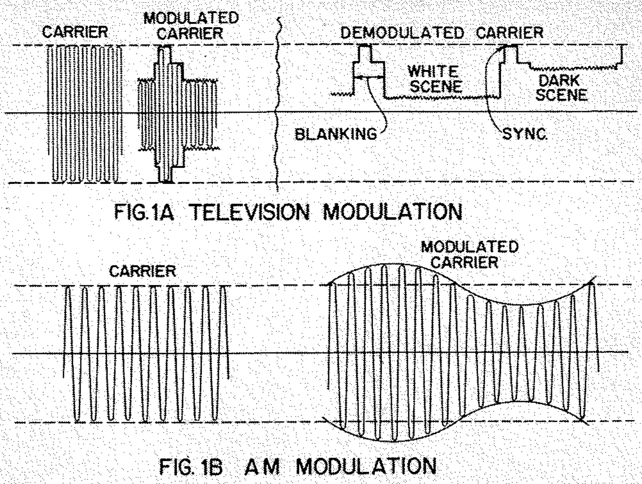


Fig. 1—Television and AM Broadcast modulation envelopes

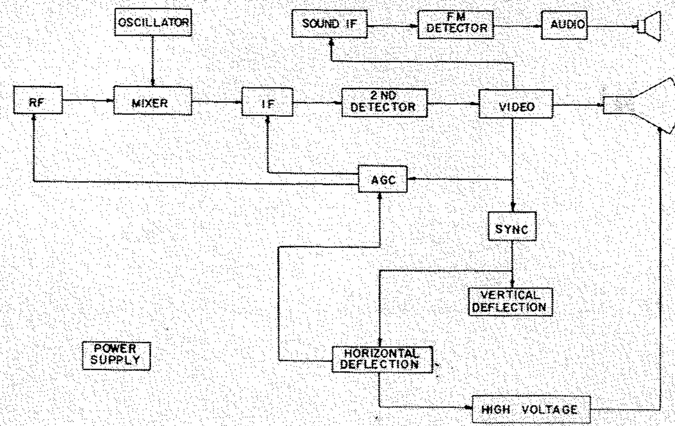


Fig. 2—Television receiver block diagram

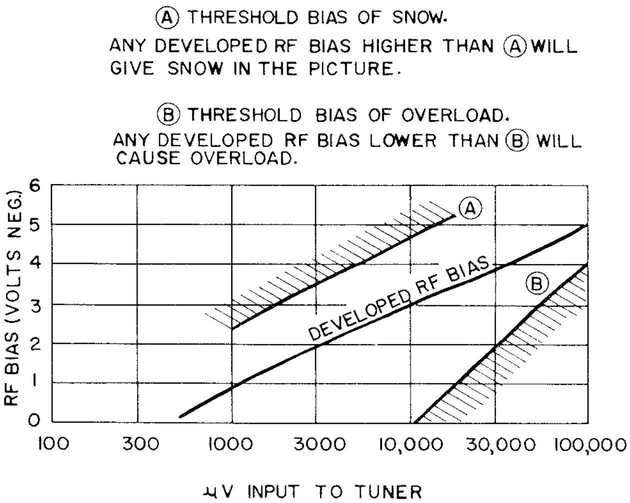


Fig. 3—R.F. bias limits vs. signal level with nominal cut off I.F. and R.F. tubes

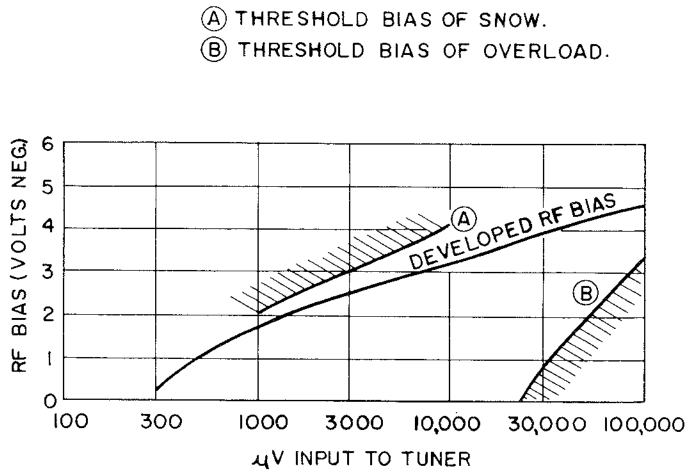


Fig. 4—Effect of sharp cut off R.F. tube and remote cut off I.F. tubes on (1) R.F. bias limits and on (2) developed R.F. bias curve

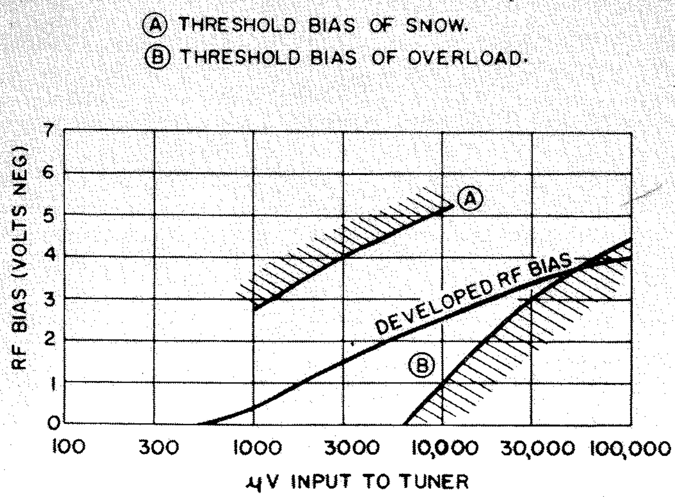


Fig. 5—Effect of remote cut off R.F. tube and sharp cut off I.F. tubes on (1) R.F. bias limits and on (2) developed R.F. bias curve

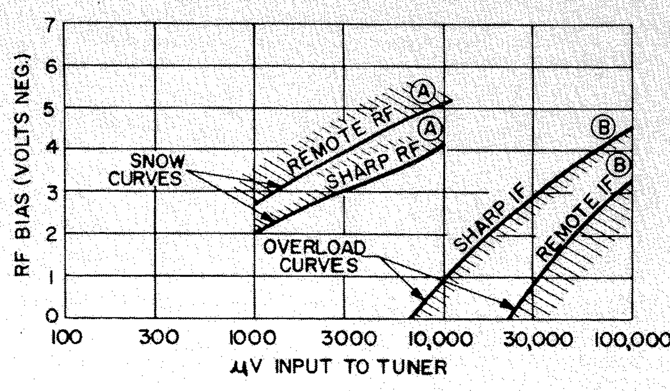


Fig. 6—Overall effect of tubes on R.F. bias limits

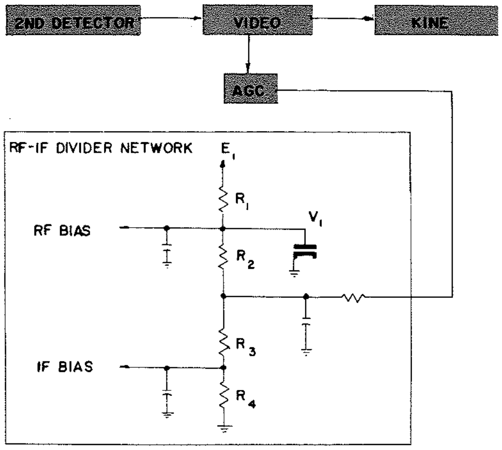


Fig. 7—Circuit that determines R.F.-I.F. bias ratio

on the horizontal circuit of a receiver being synchronized with the transmitted sync pulses. If the time constant R_1C_1, Fig. 9, is too long, noise immunity of the AGC system will be poor. If the time constant is too short, the cathode circuit of V_1, Fig. 9, will not function as a peak detector.

GATED AGC

This system is called a gated system because the AGC tube conducts normally when the plate gating pulse, derived from the horizontal deflection system of the receiver, and the transmitted horizontal sync pulses are coincident. See Fig. 10. Thus, the tube does not conduct on noise pulses that occur at any time between horizontal gating pulses. There are ways to prevent the AGC system from "blocking out" when the set is out of sync horizontally with either a triode or pentode gated AGC. The AGC tube normally conducts only on sync pulses, thus developing a voltage proportional to sync tips. The tips of sync represent the peak carrier output of the TV transmitter. It should be obvious then, that when the receiver is out of sync horizontally, the gating pulse (derived from the receiver's horizontal scanning system) and the transmitted sync pulses are no longer coincident. This requires some special design techniques to prevent the AGC bias from decreasing to such a level as to cause the set to overload and block when the receiver is out of sync horizontally.

Gated AGC provides amplified AGC voltage at a reasonable cost as well as having excellent noise immunity and airplane flutter characteristics.

In order to eliminate scene components, both gated and pulse systems must be d-c coupled to the second detector.

One example of an unusual problem that arose during the design of a triode-gated AGC circuit for one of our television receivers occurred when the writer was observing a western movie on the developmental receiver, and indicates how AGC circuits get involved with other portions of the TV receiver.

The triode-gated AGC circuit was carefully designed for adequate gain, airplane flutter, noise immunity, and r-f bias tracking (see Fig. 3). The circuit was given the usual checks with a signal generator modulated with the familiar Indian Head test pattern. Additional checks were made with on-the-air daytime programming on the local television stations. The circuit appeared to have excellent performance. During a casual observation, however, the hero of the 6:00 PM western movie rode across the kinescope on his white horse in the dead of night. With this circuit he also rode through the AGC!

The reason for this phenomena may be explained in the following manner: the triode AGC circuit was gated by a pulse from the horizontal scanning circuit. The amplitude of the gating pulse is a function of kinescope beam current, since beam current represents a load on the horizontal scanning system. The western movie scene was a sharply contrasting one; the cowboy's horse drew appreciable beam current, while the black background drew none. The scene therefore caused a fluctuation of the gating pulse as the horse galloped across the screen. It is generally known that the output of a triode varies as a function of plate voltage. The triode AGC tube hence produced a fluctuating AGC bias to the r-f/i-f stages.

The average televised scene or test pattern has a fairly constant average video level, which explains why this condition did not present itself earlier.

The solution to this problem was found, fortunately, without increasing the cost of the receiver: it is known that a ripple voltage, which is a function of scene variations, is present in the "B-boost" supply originating in the horizontal circuit. By returning one of the filter capacitors in the plate of the AGC tube to "B-boost", the ripple in AGC caused by the cowboy scene was cancelled.

AGC THRESHOLD CONTROL

In either the pulsed or gated system, the AGC threshold control is adjusted to operate the second detector output level just under the point (threshold) at which sync would be clipped in the first video stage.

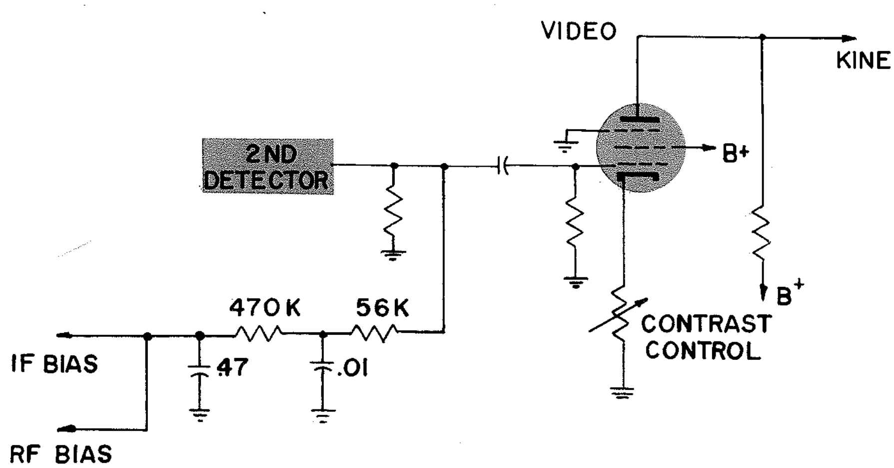
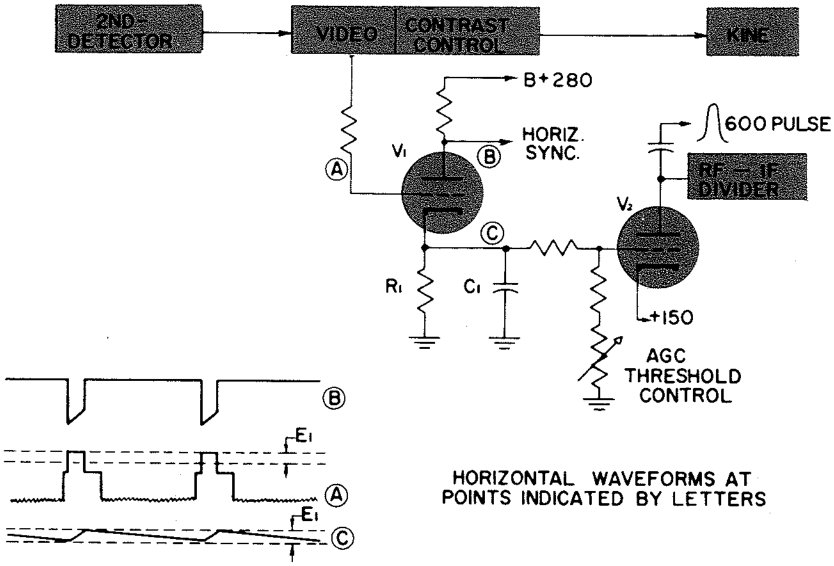


Fig. 8—Average AGC



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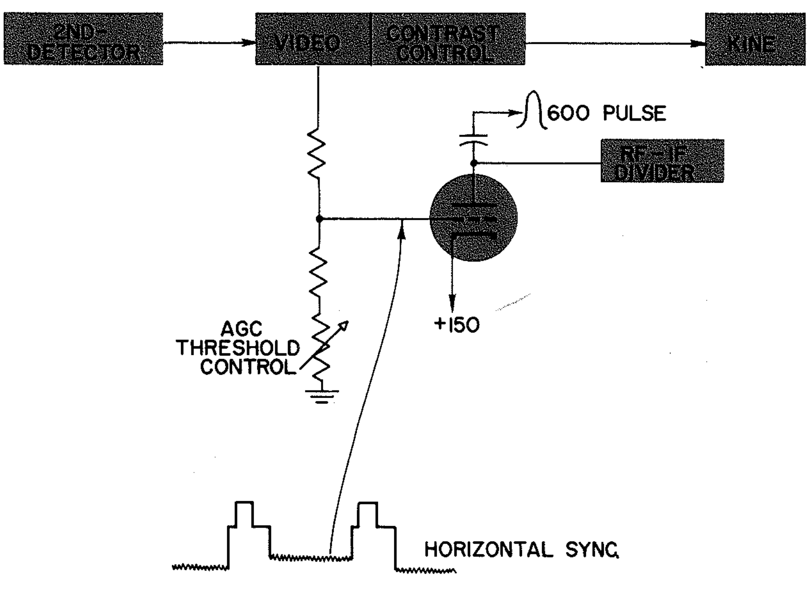


Fig. 10—Gated AGC

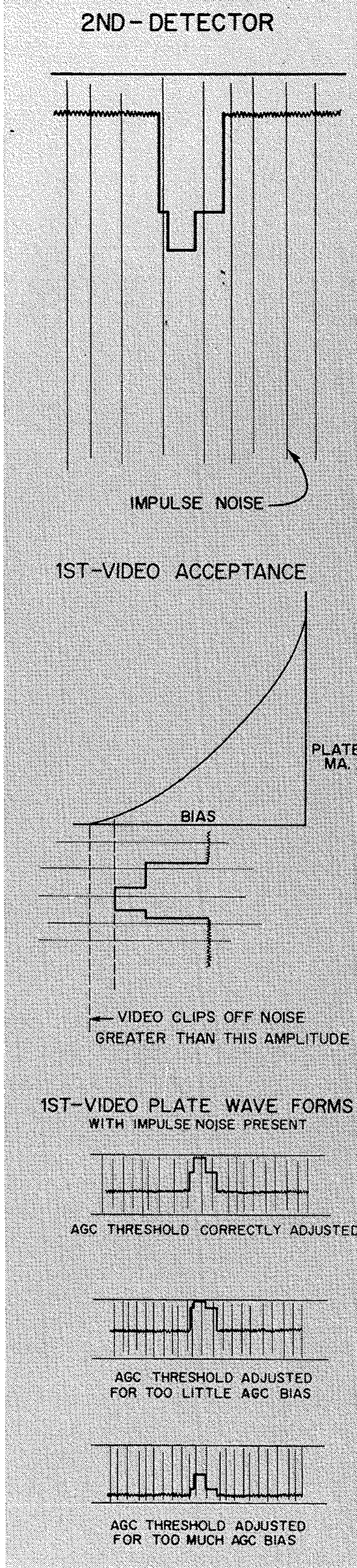
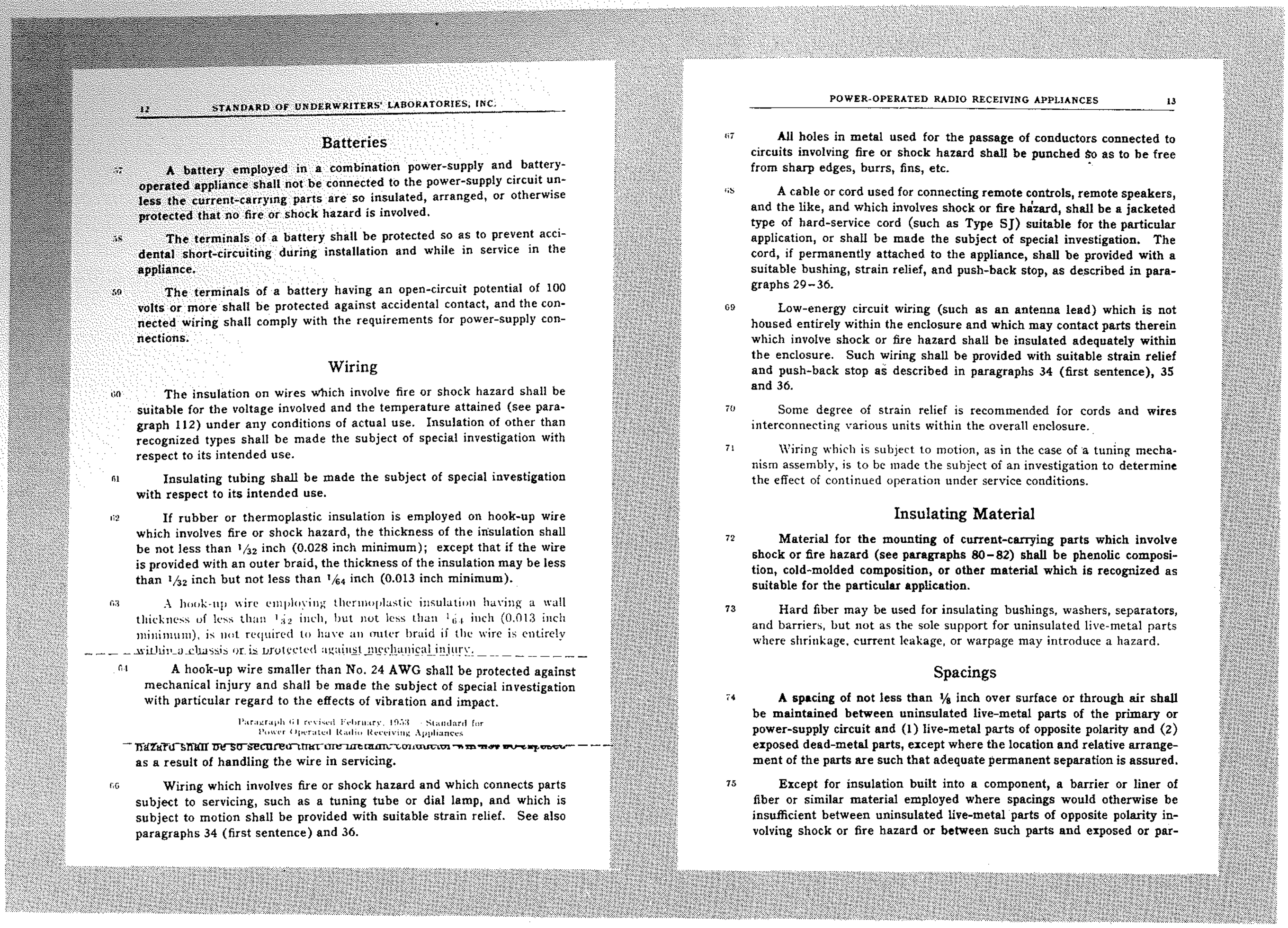


Fig. 11—Effect of AGC threshold adjustment (see text)

UNDERWRITERS' LABORATORIES REQUIREMENTS—THEIR IMPORTANCE TO THE DESIGN ENGINEER



12 STANDARD OF UNDERWRITERS' LABORATORIES, INC.

Batteries

57 A battery employed in a combination power-supply and battery-operated appliance shall not be connected to the power-supply circuit unless the current-carrying parts are so insulated, arranged, or otherwise protected that no fire or shock hazard is involved.

58 The terminals of a battery shall be protected so as to prevent accidental short-circuiting during installation and while in service in the appliance.

59 The terminals of a battery having an open-circuit potential of 100 volts or more shall be protected against accidental contact, and the connected wiring shall comply with the requirements for power-supply connections.

Wiring

60 The insulation on wires which involve fire or shock hazard shall be suitable for the voltage involved and the temperature attained (see paragraph 112) under any conditions of actual use. Insulation of other than recognized types shall be made the subject of special investigation with respect to its intended use.

61 Insulating tubing shall be made the subject of special investigation with respect to its intended use.

62 If rubber or thermoplastic insulation is employed on hook-up wire which involves fire or shock hazard, the thickness of the insulation shall be not less than 1/32 inch (0.028 inch minimum); except that if the wire is provided with an outer braid, the thickness of the insulation may be less than 1/32 inch but not less than 1/64 inch (0.013 inch minimum).

63 A hook-up wire employing thermoplastic insulation having a wall thickness of less than 1/32 inch, but not less than 1/64 inch (0.013 inch minimum), is not required to have an outer braid if the wire is entirely within a chassis or is protected against mechanical injury.

64 A hook-up wire smaller than No. 24 AWG shall be protected against mechanical injury and shall be made the subject of special investigation with particular regard to the effects of vibration and impact.

Paragraph 64 revised February, 1953 — Standard for Power Operated Radio Receiving Appliances

hazard shall be so secured that the metallic conductor will not be exposed as a result of handling the wire in servicing.

66 Wiring which involves fire or shock hazard and which connects parts subject to servicing, such as a tuning tube or dial lamp, and which is subject to motion shall be provided with suitable strain relief. See also paragraphs 34 (first sentence) and 36.

POWER-OPERATED RADIO RECEIVING APPLIANCES 13

67 All holes in metal used for the passage of conductors connected to circuits involving fire or shock hazard shall be punched so as to be free from sharp edges, burrs, fins, etc.

68 A cable or cord used for connecting remote controls, remote speakers, and the like, and which involves shock or fire hazard, shall be a jacketed type of hard-service cord (such as Type SJ) suitable for the particular application, or shall be made the subject of special investigation. The cord, if permanently attached to the appliance, shall be provided with a suitable bushing, strain relief, and push-back stop, as described in paragraphs 29–36.

69 Low-energy circuit wiring (such as an antenna lead) which is not housed entirely within the enclosure and which may contact parts therein which involve shock or fire hazard shall be insulated adequately within the enclosure. Such wiring shall be provided with suitable strain relief and push-back stop as described in paragraphs 34 (first sentence), 35 and 36.

70 Some degree of strain relief is recommended for cords and wires interconnecting various units within the overall enclosure.

71 Wiring which is subject to motion, as in the case of a tuning mechanism assembly, is to be made the subject of an investigation to determine the effect of continued operation under service conditions.

Insulating Material

72 Material for the mounting of current-carrying parts which involve shock or fire hazard (see paragraphs 80–82) shall be phenolic composition, cold-molded composition, or other material which is recognized as suitable for the particular application.

73 Hard fiber may be used for insulating bushings, washers, separators, and barriers, but not as the sole support for uninsulated live-metal parts where shrinkage, current leakage, or warpage may introduce a hazard.

Spacings

74 A spacing of not less than 1/8 inch over surface or through air shall be maintained between uninsulated live-metal parts of the primary or power-supply circuit and (1) live-metal parts of opposite polarity and (2) exposed dead-metal parts, except where the location and relative arrangement of the parts are such that adequate permanent separation is assured.

75 Except for insulation built into a component, a barrier or liner of fiber or similar material employed where spacings would otherwise be insufficient between uninsulated live-metal parts of opposite polarity involving shock or fire hazard or between such parts and exposed or par-

J. W. FULMER

RCA Victor Television Division

Cherry Hill, N. J.

IN DESIGNING electronic products, design engineers must consider those construction details that assure safe operation to be just as important as meeting prescribed performance requirements and cost limitations.

It is RCA's practice to obtain Underwriters' Laboratories approval on all power-operated domestic equipment such as Television Receivers, Radio Receivers and on many lines of commercial and industrial equipment such as Phonographs, Air Conditioners, etc. Underwriters approval of equipment indicates that hazards incident to its use have been reduced to an acceptable degree.

Engineers should be well informed on Underwriters' Laboratories requirements so that safety features are incorporated in early designs. Failure to do so may require extensive and costly changes in the final design which may seriously change the price level or operational characteristics originally established.

UNDERWRITERS' LABORATORIES, INC.—ITS ORGANIZATION, PURPOSE AND METHODS

It seems appropriate at this point to acquaint the engineer with some of the more important aspects of Underwriters' Laboratories, Inc. It is chartered (as a non-profit organization without capital or stock) to establish, maintain, and operate laboratories for the examination and testing of devices, systems and materials. Founded in 1894, the enterprise is sponsored by the National Board of Fire Underwriters, and is operated solely as a service.

Underwriters' testing stations at New York, Chicago and San Francisco provide facilities for conducting investigations to determine the relation of various materials, devices, constructions and methods to life, fire, and casualty hazards. They ascertain, define and publish standards, classifications, and specifications. This published information deals with materials, devices, constructions and methods that tend to reduce hazards and prevent loss of life and property from fire, crime and casualty.

The engineering staff of Underwriters' Laboratories is comprised of the following departments: Electrical, Fire Protection, Gases and Oils, Chemical, Casualty and Automotive, and Burglary Protection. Each department is concerned with the investigation of products applicable to the class, and prepares requirements under which the submittor's product is investigated.

Products which comply with the existing Standards and/or Requirements are "listed." This constitutes an official registration and these listings are promulgated on printed cards filed according to product classification. Complete files of these cards are maintained at the following locations: (1) Offices of the principal boards of Underwriters, (2) Inpection bureaus in the United States, (3) at many of the general offices of insurance companies, (4) in certain Federal, state and municipal departments and, (5) at offices of Underwriters and at the headquarters of its representatives in many of the larger cities. The submittor also receives copies of these cards.

SIGNIFICANCE OF UNDERWRITERS' LABORATORIES, INC. LISTING

Listing of electrical equipment, for instance, by Underwriters' Laboratories implies that fire and accident hazards incident to its use have been reduced to an acceptable degree. Electrical equipment frequently incorporates other features which require consideration by divisions other than Electrical. Air conditioners and dehumidifiers are subject to investigation by the Casualty Division as well as the Electrical Division in view of operation which depends on a refrigerant plus electrical power. The refrigerant and its enclosure may well involve toxic and explosion hazards, and if investigation of this detail has resulted acceptably it could then be stated that these hazards have also been reduced to an acceptable degree.

WHY OBTAIN UNDERWRITERS' LISTING?

Over the years the remark has often been overheard, "If Underwriters can't accept our equipment which is perfectly safe the way we have designed it—we will take our business elsewhere!" As far as can be determined these were idle threats, although instances have been reported where television equipments were submitted to local city inspection departments having jurisdiction, were investigated for a fee, and were subsequently accepted by that local inspection authority.

RCA, and other electronic manufacturers consider Underwriters' Laboratories listing particularly valuable because:

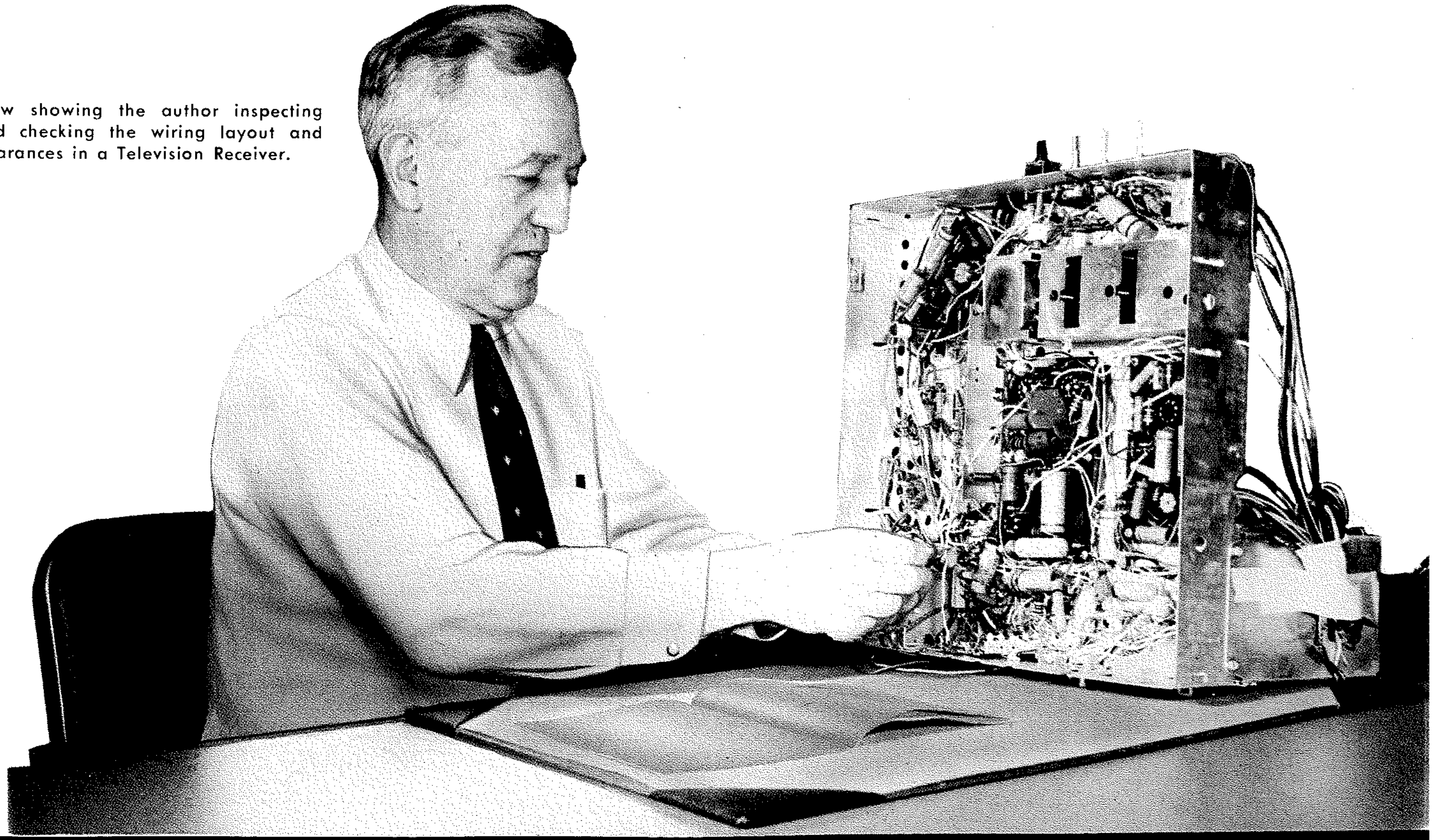
(1) The product approved by Underwriters' Laboratories has been designed and manufactured so that it can be operated safely.

(2) The fact that a product is Underwriters' Laboratories listed attaches important significance in the event of a serious court case involving casualty to life.

(3) The product can be marketed in any town or city in the United States without fear that the local city electrical inspector, backed by city ordinance, may request the dealer to remove the product from sale.

(4) Merchandising experience indicates that public acceptance of an instrument is enhanced when the product bears the Underwriters' Laboratories label.

Acceptance of a product by any testing facility of Underwriters' Laboratories must be followed up by periodic inspections at the Manufacturers plant so that official acceptance lists used by subscribers may be kept up to date. To the best of the author's knowledge, no testing organization other than Underwriters' Laboratories, Inc. provide follow-up inspection service at the factory. It is this control feature which resolves the practical aspects of the written Standard.



View showing the author inspecting and checking the wiring layout and clearances in a Television Receiver.

UNDERWRITERS' LABORATORIES
continued

DEVELOPMENT OF UNDERWRITERS' STANDARDS AND/OR REQUIREMENTS

To assist the engineer in understanding "the why's and wherefore's" of the various Underwriters' Laboratories Standards, it may be well to say something of the manner in which they are developed.

The basic requirements of the Standards are in accordance with sound engineering principles, research, records of test and field experience. Underwriters' Laboratories representatives have an appreciation of the problems of production installation, and use which they derive from consultation with manufacturers, customers, inspection authorities, and others having specialized knowledge. Standards are subject to revision as further experience or investigations indicate a need.

In the whole gamut of Standards prepared by the Electrical Department (there are 62 covering individual classifications) probably none is subject to more revision and supplementary releases to provide for new equipments than is the Radio Standard. The eighth edition of this standard is available and now includes material on printed circuitry.

Thus far, mention has been made of the Standard—the final printed product issued in booklet form. In the late 1920's the Radio Standard was in an embryonic stage, consisting of nothing more than several typewritten sheets, and was made available only to Underwriters' Laboratories personnel. After submittals of radios by several manufacturers, mimeographed copies of proposed requirements were submitted to the manufacturers, based on the experience derived from tests conducted. At this point Underwriters' Laboratories solicited the opinions of qualified personnel of the Radio Industry on proposed Requirements, appointing those people as Industry representatives of the Underwriters' Laboratories Industry Advisory Conference. The product of the deliberations of this Committee was then forwarded for comment to all subscribers whose products were listed by Underwriters' under the Radio classification. When mutual agreement was reached on major differences, the proposed requirements were subsequently classified, finally edited, and printed as a Standard. Substantially the same procedure is followed today in the development of Standards or Requirements.

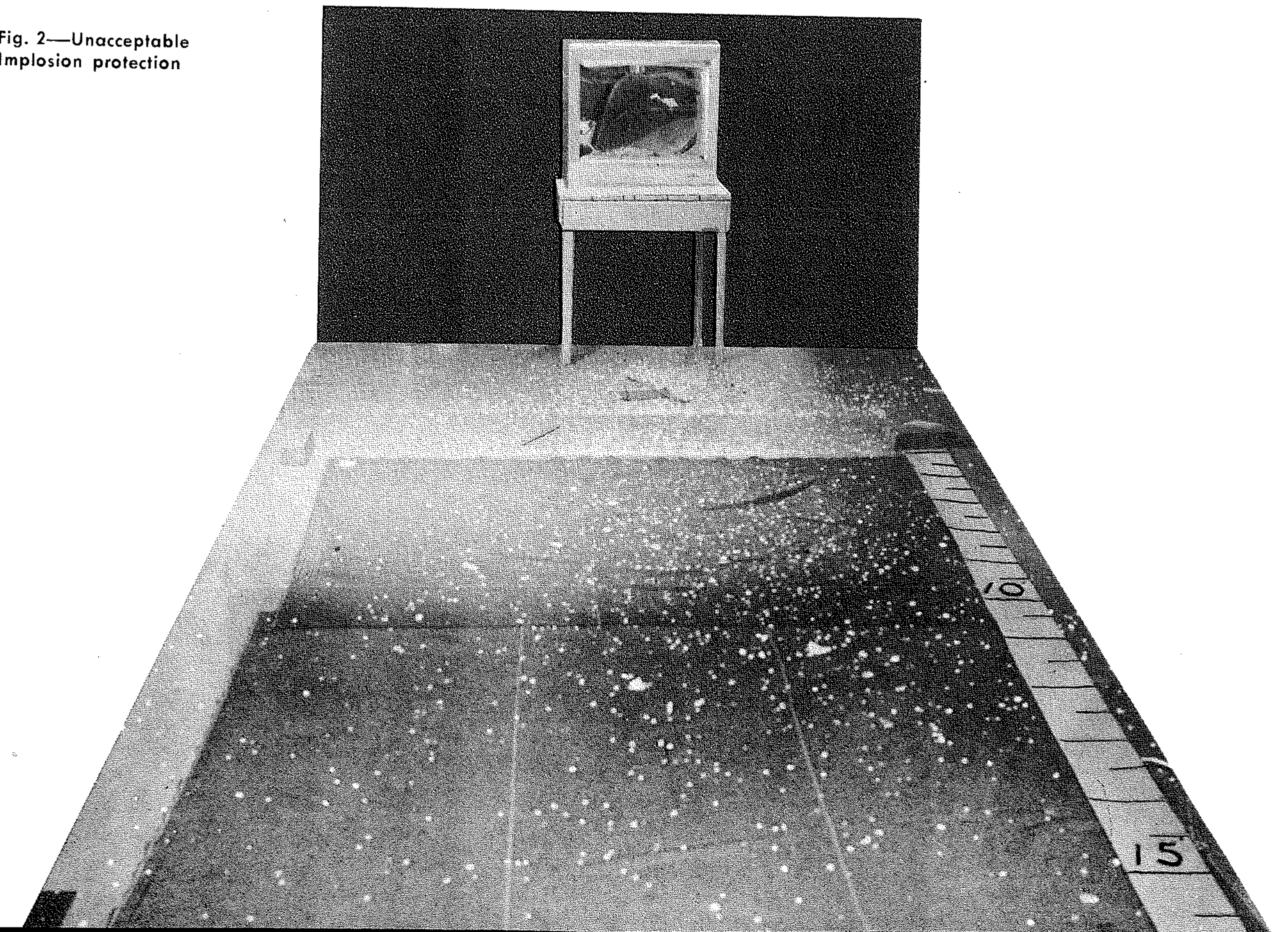
UNDERWRITERS' LABORATORIES REQUIREMENTS USED BY ELECTRONICS ENGINEERS

The requirements for radio, television, sound and allied equipments are incorporated in the following:

A. *Published Requirements* — (1) Radio Standard, (2) Television Requirements, (3) Color TV Requirements, (4) Sound Recording and Reproducing Equipment Standard, (5) Lightning Arrestor Requirements, (6) The National Electrical Code.

B. *Written Requirements* — available upon discussion with Underwriters' Laboratories personnel and not generally published in bulletin form for Industry—(1) Interpretations on specific requirements resolved upon investigation of equipment. (2) Memoranda on acceptance or criticism of individual constructions and/or test results which either meet or are in conflict with the intent of the requirements. (3) Constructions and test requirements covering intimate details prescribed in Underwriters' Laboratories Standards for other classifications.

Fig. 2—Unacceptable Implosion protection



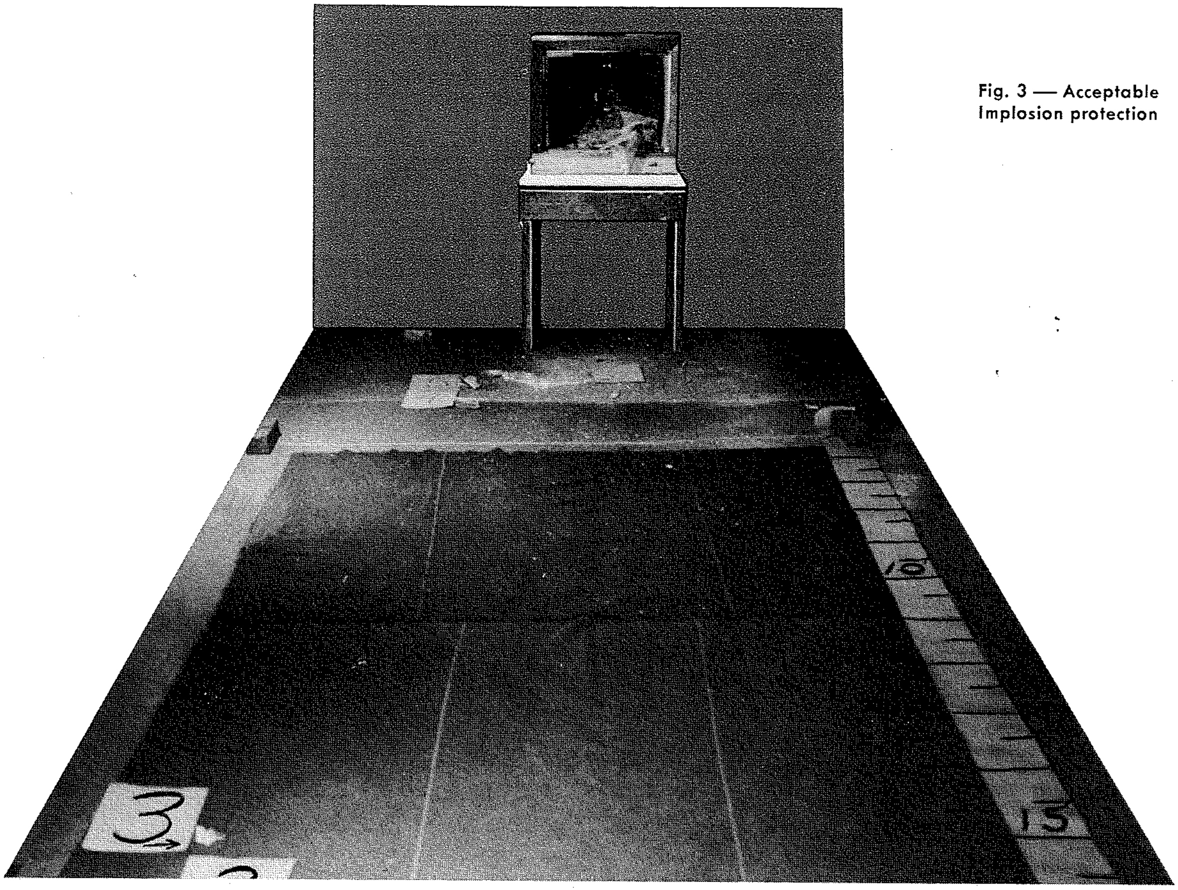


Fig. 3 — Acceptable Implosion protection

Items 1-5 under (A) indicate the general types of equipment covered by the respective Standards. Item 6, however, mentions that consideration must also be given to the National Electrical Code. This publication is a manual of safe installation practice prepared by the National Board of Fire Underwriters. One of the first considerations that should be given by the engineer to the design of any equipment is the manner in which it may be installed. The type of flexible cord or the provision for rigid conduit installation (whichever is required by the Code) obviously influences not only cost and design but merchandising aspects as well.

It is important that design engineers understand the various Underwriters' Laboratories requirements and incorporate necessary provisions during design. They will be repaid by avoiding expensive changes after the over-all design has been pretty well crystallized.

Applicable Underwriters' Laboratories Standards, interpretation of requirements and information on listings of complete equipments or components are available from the author, or from RCA engineers who act as liaison men between the company and Underwriters' Laboratories.

UNDERWRITERS' CLASSIFICATION OF RADIO, TV, SOUND AND ALLIED PRODUCTS

All of the electronic equipment is assigned to either one of two major groups:

(A). That equipment which incorporates or has provision for connection of an antenna.

(B). Equipment which does not include either of these details.

Products under (A) include radio receivers, monochrome and color TV receivers, clock-radios, radio-phonographs and television-radio-phonographs. These are classified as Radio Appliances. Where the product is intended for commercial (viz., Hotel) use, one of the significant changes over the domestic version requires the use of a hard service type of flexible cord such as Type SJT.

Products under (B) include record players and tape recorders. Special items from both groups are indexed under the following general classifications:

General Classifications which appear on listing cards

(1) *Radio Accessories:* Record Players, Radio Lightning Arrestors, TV Signal Boosters, Home Recording Discs, Antenna Distribution Units, Antenna Rotating Units, Interference Capacitors, UHF Converters, Magnetic Tape Recorders.

(2) *Musical Instruments:* Phonographs, electric organs.

(3) *Sound Recording and Producing Equipment:* Amplifiers, Magnetic Tape Recorders, Intercommunicating Units, Sound Systems, Wire Recorders, Centralized Sound Systems.

(4) *Toys:* Phonographs.

Items (1), (2), and (3) above are self-explanatory, but the majority of engineers will not hesitate to ask questions on Item (4), such as, "Since when is RCA in the toy business?" or "Why do I have to design a phonograph differently just because Merchandising decides to apply a decal of Mickey Mouse to the cabinet?" In this class of devices Underwriters' Laboratories feel that "Junior" is very likely to abuse and tamper with the product. For this reason it is required that a phonograph, for instance, be provided with a more completely insulated power cord (viz., Type SPT-2) than ordinarily used in radio and TV receivers. Again the complete assembly must be capable of withstanding a test consisting of four individual drops from a table onto a hardwood floor in such a manner that each corner is subjected to impact. While criticism is not made if portions of the cabinet are broken away, such damage must not expose live parts. The possibility of removing the chassis from the cabinet by use of an ordinary tool must also be avoided. A special screw designed to be tightened with an ordinary screw driver but which cannot be removed with the same tool has proven effective in this respect.

HAZARDS OF ELECTRICAL APPLIANCES

As mentioned elsewhere in this article, electrical appliances may involve fire and accident hazards during use, unless proper design and construction features are incorporated. Any product, to be saleable, must be constructed in a manner that will make it useable, competitive with similar types of merchandise, and reasonably free of possible hazards.

As the design engineer ponders the TV requirements on accessibility of live parts, for instance, he is apt to remark, "Why on earth does Underwriters' Laboratories insist that the leakage current of this small part to earth ground be no more than five milliamperes, when any one can get killed by simply poking a finger into a lamp socket, or by touching the live elements of a broiler or portable air heater — which are Underwriters' listed?" The answer of course lies in the economic and use factor, plus a widespread knowledge that most people realize that to touch those parts results in an unpleasant shock. As a counter-measure, imagine an Underwriters' Laboratories Standard on lamp sockets, for instance, calling for an interlock cover to prevent access to the lamp-center contact, when the lamp is removed from the socket! A broiler with metal barrier interposed between element and substance to be broiled would suffer from the utility standpoint, and so on down the line.

SHOCK HAZARD OF RADIO, TV AND ALLIED APPLIANCES

But now let us consider the TV receiver. It has always been conventional to assume that the user will remove and take the tubes to his local dealer for checking upon faulty operation of his receiver. During this act of user servicing, be it the housewife or man of the house, there is no reason for them to realize that there may be live parts in tube servicing areas, involving serious shock hazard. It is for this reason that the original requirements drawn up by Underwriters' Laboratories recognized possible shock hazards and correspondingly required suitable barriers or isolating impedances to effect constructions which would insure safety during tube servicing and other legitimate user servicing functions.

The control over servicing is not limited to the user, but it is extended to certain details coming within the scope of the service man as well. For instance a direct-connected TV receiver providing a metal cabinet is required to provide a suitable resistor from B minus (chassis) to cabinet for the purpose of preventing a build up of voltage between cabinet and chassis (substantially earth ground). This must not exceed 1270 volts peak as a result of voltage induced in the cabinet by the high-voltage picture tube anode lead. Obviously, the resistor must be high enough in resistance to keep below the maximum 5 milliampere current leakage limit—the current flow possible from exposed cabinet to earth ground. On the other hand, the resistance must be low enough to attenuate the induced voltage. With that detail resolved, consider a typical assembly. A particular mounting bracket otherwise insulated from a hot chassis conductively is connected by a 100 K ohm resistor. A mounting screw pierces the metal cabinet and threads into the mounting bracket, and conductive connection through the resistor from the hot chassis to cabinet is made automatically. But suppose the serviceman lost or forgot to assemble this particular mounting screw, and a small air gap occured between mounting bracket and cabinet. In that event, the connection is open and Underwriters' Laboratories would require whatever detail is necessary to insure positive connection from bracket to cabinet. In this particular case, a metal spring clip over the bracket foot effected the necessary connection. The importance of the 1270 volt peak value lies in the fact that voltages somewhat higher are likely to damage the insulation between the exposed and live sections of the power control switches, primary by-pass capacitors and transformers. If such damage occurs, it is quite likely that exposed metal parts, such as controls, antenna terminals, etc., are now directly connected to the power line and present serious fire and accident hazards.

Again consider the isolation of the 300-ohm antenna twin lead from the r-f unit coils and terminals at power line potential. It is obviously necessary to isolate this twin lead by blocking capacitors in each leg. On the basis of certain field reports disclosing short circuiting of power supply circuit to chassis, it was concluded that cloud static charges may have been responsible for breaking down the capacitor primary by-pass insulation, which consequently resulted in a direct connection of the twin lead and antenna to the power supply circuit. Two fatalities, at least, have been known to have occurred as a result of contacting antenna systems, and the fault was traced to the failure of the isolating capacitor. Similarly Underwriters' Laboratories require a resistor shunting this isolating capacitor so as to attenuate moderate potential surges to lower voltages not likely to result in failure of the capacitor.

FIRE HAZARDS OF RADIO, TV AND ALLIED APPLIANCES

Fire hazard is also all important in considering the design of the complete product. Where a power transformer is provided it is required that a complete non-combustible enclosure be constructed without openings except for leads and with a maximum excess area assigned for the lead exits. The story behind this design requirement goes back to the depression days of 1931 and 1932, when manufacturers were particularly cognizant of saving on construction costs. Transformers deleted the end bell at that section facing the chassis interior; and some designs provided large openings in the top bell to secure more ventilation, and thereby permit decrease in the overall size without serious difference in output characteristics. Reports of fires showed that this opening up of the transformer enclosure was a step in the wrong direction. Tests subsequently showed that to insure a design which will not fire the insulation within the enclosure, or fire combustibles external to the enclosures, the volume of air in the enclosure must be reduced to a negligible amount, and the opening for the leads must be just small enough to permit the exits of the leads and thereby prevent expulsion of molten metal or combustibles from the enclosure.

The horizontal output transformer used in TV receivers involving voltages as high as 20 KV or more is likely to become a fire hazard if precautions are not taken to provide adequate spacings between parts of opposite polarity, and to reduce corona to an absolute minimum. Altitude chamber tests on new designs are conducted by the RCA Victor Television Division, requiring operation of the complete receiver at atmospheric pressures of 25,000 feet or more for a period of 24 hours, during which time there must be no indication of corona or breakdown.

The pertinent constructions discussed above and reflecting typical fire and accident hazards have been described to show why a TV receiver, for instance, necessarily involves more consideration, than an electric clock, if safe operation is to be assured. Hot chassis radio and TV receivers involved features not common to isolated power transformer designs. Printed circuitry adds further complications. The impact of all this is a very comprehensive set of requirements mentioned elsewhere in this article; and which are supplemented or revised quite frequently. These facts alone should suggest that the design engineer should "stop, look, and listen" at various stages in the design of the new product. Precedent is always an aid, but what is accepted by Underwriters' Laboratories may not necessarily be accepted tomorrow and vice versa.

JOHN W. FULMER received his BS in EE degree from Lafayette College in 1926. From 1926 to 1942 he was engaged in fire prevention engineering at Underwriters' Laboratories, Inc. He served as Lt. Cdr., USNR, 1942-1946 as Radio Material Officer, Naval Operations Base, Trinidad, and Officer in Charge, New Construction, at the NY Navy Yard. Mr. Fulmer joined RCA in 1946 as U. L. Liaison engineer, coordinating the activities of the RCA Victor Television and Radio-Victrola Division with Underwriters' Laboratories, Inc. He is a Member of the IRE, and a Licensed Professional Engineer, State of New York.

IMPLOSION HAZARD OF THE PICTURE TUBE

Discussion thus far has included fire and shock hazards, but another very important hazard—the implosion hazard—has to be reckoned with in receivers providing picture tubes. In the manufacture of picture tubes, notably the glass tube types, the stresses may not be completely relieved, and as a result are likely to increase with time. These may be carried to a point where further unbalancing and eventually complete instantaneous breakdown of the glass envelope occurs, accompanied by a loud report. In an improperly designed cabinet and protective window, the force of the implosion may be sufficient to propel a relatively large particle of glass from the picture tube and/or protective window considerable distances from the front of the TV receiver. Fig. 2 illustrates the destructive work done on the picture tube and protective window in a non-acceptable assembly where the thickness of the tempered glass and/or window mounting was found inadequate and was not used for production. Fig. 3 illustrates acceptable implosion test results with substantially all glass particles confined to the area between the receiver and the first barrier.

Among other details, the basic requirement covering the implosion hazard of picture tubes stipulates that the enclosure of a picture tube shall be so constructed that no material will be expelled with excessive force when the tube is imploded within the enclosure. Implosion must not damage the enclosure.

In the practical resolution of the requirement, the picture tube is artificially imploded and note made of the dispersal of glass particles on a blanket draped over the floor in front of the TV receiver. Implosion tests which yield a display of shattered glass on a blanket directly in front of the receiver behind a nominal 10″ high barrier which is placed three feet ahead of the receiver is satisfactory. A limited number of small particles is permissible in the zone two feet ahead of the first barrier; and only a few smaller fragments should be observed beyond a barrier placed 5 feet in front of the receiver.

The picture tube is imploded by striking the face plate at the rim with a 1″ diameter steel pin which receives an impact of approximately 100 foot-pounds from a falling weight. The amount of impact is varied depending on the size and type of picture tube and must always be sufficient to result in good implosion.

CONCLUSION

In product design of all consumer products (and certain commercial products) the design engineer should give early consideration to standards if the product is to be eligible for Underwriters' Laboratories listing. This is best accomplished by consulting the liaison engineer while the product is in the early design stages. It is to RCA's advantage from a legal and merchandising standpoint to have its products Underwriters' Laboratories approved and listed. Because of this fact RCA has made it a regular practice to obtain approval on all pertinent products.

INTRODUCING ENGINEERING PRODUCTS EDITORIAL REPRESENTATIVES

Several years ago the Engineering Products Division organized an Editorial Board for the purpose of stimulating interest in the presentation and publication of engineering papers. This Editorial Board is composed of engineers representing each of the phases of engineering in the Engineering Products Division. There are twenty members including Editorial Chairman, Engineering Editor, and Assistant Engineering Editor, covering the various activities of the many product design groups.

The Editorial Board meets at regular intervals to discuss and schedule technical papers of timely interest for the RCA ENGINEER, RCA REVIEW, ENGINEERS DIGEST and a number of other publications.

In working with the RCA ENGINEER contacts are made through the Engineering Editor, and schedules for technical papers are arranged by the Editor, working with the Board. Suggestions for new material and possible authors may originate from the Board, the publication, and from authors. Editorial Board members, who also serve as Editorial Representatives for the RCA ENGINEER, assist the magazine in any way practicable to further the interests of the publication and the author.

J. A. BAUER
Editorial Representative
Theater and Industrial Engineering
Camden, N. J.

Mr. Bauer attended Drexel Institute Evening School in Philadelphia, Pa., and graduated in Electrical Engineering. He joined RCA in 1939 as a Factory Engineer. Since 1940 he has been with the Engineering Products Division as Design Engineer, Leader and Group Manager of Measurement and Requisition in Theatre and Industrial Engineering. He represents this section on the Editorial Board, the Educational Committee as well as the Automation Committee.

Mr. Bauer served part time on the faculty of Temple University Technical School. He is a Senior Member of the IRE. Recently, he acted as Chairman of the RCA-NBC Liaison Committee on Instrumentation for Color Television. His publications include several papers on the general subject of testing television receivers.

J. F. BIEWENER
Editorial Representative
Aviations Systems Development
Moorestown, N. J.

Mr. Biewener graduated from Carnegie Institute of Technology in 1950 with a BS in EE. He joined RCA in June of that same year. From that time until 1954, he was in the Engineering Reports Group of EPD General Engineering Development. In this capacity he wrote and edited technical reports, progress reports, proposals, specifications, brochures, highlight reports, etc. In December 1954, he transferred to Aviation Systems Development for special assignments on the Black Cat Project.

Mr. Biewener is a member of Eta Kappa Nu and Tau Beta Pi.

E. D. BLODGETT
Chairman, Editorial Board
Engineering Products Division
Camden, N. J.

Mr. Blodgett received his BA degree from Amherst College. The summers of his college years were spent with RCA Communications working on Facsimile Development. Upon graduation he took full time employment with RCA, working on Facsimile, in New York and San Francisco. Mr. Blodgett came to RCA Camden in 1931 and as Group Leader on Navy equipments continued working on Direction Finder Development for ship, shore and aircraft use. From 1939-42 he was Group Leader in Commercial Communications Receivers; from 1943-45, Group Leader on Advanced Development for Microwave Relay; and from 1946-53, Manager of Government Receivers and Mobile Equipment. Mr. Blodgett's present post is in Technical Administration, Engineering Products Division.

Mr. Blodgett is a senior Member of IRE, Chairman of the D F Measurement Committe, and Chairman of Publications and Publicity Committee of Philadelphia Section of IRE. He has been awarded seven patents.

MARY BOCCIARELLI
Assistant Engineering Editor
Engineering Products Division
Camden, N. J.

Mary Bocciarelli, Assistant Engineering Editor for Engineering Products Division, studied at Temple and Columbia University, and was employed by Brown Instrument, a division of Minneapolis-Honeywell Regulator Co., in administrative staff work before joining RCA in 1953.

Mrs. Bocciarelli is also managing editor of the IRE Bulletin, Philadelphia section and Assistant Editor for the ENGINEERS DIGEST.

T. T. N. BUCHER
Editorial Representative
Surface Communications Engineering
Camden, N. J.

Mr. Bucher graduated from Drexel Institute of Technology in 1941 with a BS in EE. He received his MS in EE from Moore School of University of Pennsylvania in 1947. After graduating from Drexel, Mr. Bucher joined the engineering staff of Proctor Electric Co. as a Patent Engineer.

Mr. Bucher came to RCA in 1942 and was assigned to the Aviation Receiver Engineering Group. After working on receiver problems for two years he was transferred to special radar projects, later becoming a Group Leader in the Receiver and Mobile Group, of Radiation Engineering. It was here that development work was done on Man Pack Radio Sets, and Navy Receivers.

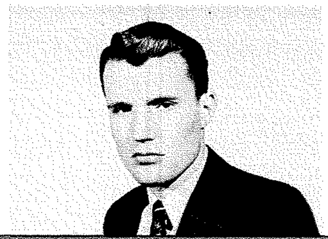
Mr. Bucher is a member of the IRE, AIEE and the Engineer's Club of Philadelphia.

H. E. COSTON
Editorial Representative
Engineering Administration
Standards & Services
Camden, N. J.

Mr. Coston graduated from Virginia Polytechnic Institute in 1925 with a BS in EE. He has since completed numerous specialized courses with other colleges and universities. Following his graduation in 1925, he entered the employ of the G.E. Company as Student Engineer. In 1928 he transferred to RCA, as a Service Engineer and was made Supervisor of the Photophone Instruction Book Section in 1929. In 1932 Mr. Coston

Report Your Activities and News Items To These Representatives


J. A. BAUER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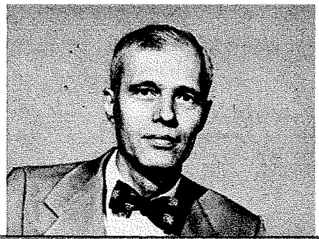
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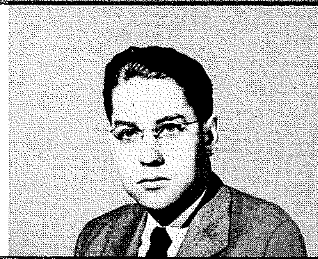
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W. K. HALSTEAD


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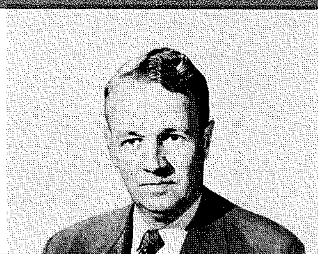

J. H. ROE


H. E. ROYS


L. M. SEEBERGER


B. F. WHEELER

transferred to Engineering in Camden, and in 1936 he accompanied the Photophone Engineering Group in its move to Indianapolis, where he served as Supervisor of Engineering Services and Standards until he was called into the service of the Signal Corps. He received the Army Commendation Medal for services performed in design of public address, office intercommunications, and sound recording systems for use in Air Force bases.

In 1946 Mr. Coston joined Standards Engineering. His present position is Technical Consultant of Standards Engineering and Components Design.

J. P. GILMORE
Editorial Representative
Shoran and Specialties Engineering
Camden, N. J.

Mr. Gilmore received an ME degree from Stevens Institute of Technology in 1944 and his MS in EE in 1951. In 1944 he joined the U. S. Navy as an electronic technician working on radio, radar, sonar and loran equipment. From 1946 to 1951 Mr. Gilmore worked first with the M. W. Kellogg Co. on Guided Missiles Research and then with the American Meter Co. on Industrial Telemetering Devices. He joined RCA in 1951 as a Systems Engineer responsible for design of large electronic fire control systems for shipboard application. In his present position, Mr. Gilmore is responsible for directing the Project and Systems Group of Information Handling and Photoelectronics Engineering.

Mr. Gilmore is a Senior Member of IRE, a Member of the AIEE, the Society of American Military Engineers, and the Professional Group on Engineering Management of IRE.

T. G. GREENE
Editorial Representative
Missile and Radar Engineering
Moorestown, N. J.

Thomas G. Greene joined RCA in 1942 as a Radar Testman and then served as a Radar and Electronics Officer in the U. S. Air Force. In 1946 he returned to Rensselaer Polytechnic Institute where he obtained a BS degree in Electrical Engineering. After an additional year studying Management Engineering at RPI he returned to RCA. Mr. Greene served for five years on the staff of EPD Engineering Division doing Engineering Personnel work. This included responsibility for administering the Specialized Engineering Training Program, college and field recruiting and labor relations. In 1953 he joined Missile and Radar Engineering as leader of General Electrical Engineering Unit.

W. K. HALSTEAD
Editorial Representative
Computer Engineering
Camden, N. J.

Mr. Halstead graduated from Massachusetts Institute of Technology with a BS in EE in 1939 and from Ohio State University with the MS degree

ENGINEERING REPRESENTATIVES
(continued)

in 1941. From 1939 to 1941 he taught as an assistant and instructor in the Electrical Engineering Department at Ohio State University, and from 1941 to 1944 in similar positions at MIT. From 1944 to 1947 he was employed by the Polaroid Corp., Cambridge, Mass. and from 1947 to 1950 as Chief Engineer of the W. S. MacDonald Co., Inc., Cambridge. In 1950 he joined RCA in the Advanced Development Section, and became associated with the BIZMAC project. He was Supervisor in charge of the development of the BIZMAC Laboratory System and in 1953 transferred to the Computing Systems Engineering Section where he is now Manager of Computer Systems and Advanced Product Development.

Mr. Halstead is a member of Tau Beta Pi, Eta Kappa Nu, an associate of Sigma Xi, Senior Member of IRE, a member of the Association for Computing Machinery and of the Society for Industrial and Applied Mathematics.

H. KRIEGER, JR.
Editorial Representative
Engineering Personnel
Camden, N. J.

Mr. Krieger graduated from Colgate University in 1942 with a Bachelor's Degree in Political Science and Economics. During the war, Mr. Krieger served in the U. S. Marine Corps as an air base communications officer and as a bomber group communications training officer.

At RCA he has been continuously associated with personnel activities, starting in the first Plant Training function at Indianapolis in 1946. In 1948 he joined the General Office in the recruiting of experienced personnel and college graduates, and in 1950 became Operations Section Manager in the General Office Research and Employee Services Division. This latter responsibility involved coordination of personnel services.

In December, 1951, he was given responsibility for establishing and administering the new Engineering Personnel Section to serve engineering operations at Camden.

D. G. C. LUCK
Editorial Representative
Aviation Electronics Engineering
Camden, N. J.

Dr. D. G. C. Luck majored in Physics at Massachusetts Institute of Technology, receiving a BS degree in 1927 and a PhD in 1932. He was an Assistant in the Department of Physics at MIT from 1929 to 1932. Dr. Luck joined the Research Division of RCA Victor in 1932, continuing with the Victor Division of the RCA Manufacturing Company from 1935 to 1941. He became a Member of the Technical Staff of RCA Laboratories Division upon its formation in 1942, and remained with them through 1953. Since January, 1954, he has held the position of Staff Engineer, Aviation Electronics Engineering.

Work done by Dr. Luck at RCA Victor before World War II included the development of a metal detector, and of the first fully operative omni-directional range for aircraft guidance, as well as a study of pulse communication. During the war, he studied radio direction finders, and worked on special applications of airborne FM radar. Since the war, he has studied problems of aircraft communications, position finding, and fire control systems, and of color television systems. Dr. Luck has published a number of technical papers and a book on FM radar, and holds approximately 50 U. S. patents. He is a member of Institute of Navigation, Sigma Xi, and American Physical Society, and a Fellow of IRE. He has been active on Radio Technical Commission for Aeronautics Special Committees on long range navigation aids, helicopter navigation, and "private line" communication.

For outstanding contributions in airborne electronics, Dr. Luck received the "Pioneer in Airborne Electronics" Award of the National Conference on Airborne Electronics. He has also been awarded the Ballantine Medal of the Franklin Institute, in recognition of his invention of an omni-directional radio range for air navigation, which led to the system adopted by the Civil Aeronautics Administration for all U. S. airways.

C. F. McMORROW
Editorial Representative
Aviations Communications
and Navigation Engineering
Camden, N. J.

Mr. McMorrow graduated from Rensselaer Polytechnic Institute in 1949 with a BEE degree. In addition, he attended Northwestern University from 1939-1941, majoring in Business Administration, and completed courses in Business Administration at Drexel Institute. Mr. McMorrow's occupational experience includes work as a Commercial Shipboard Radio Officer; Toolmaker, American Bosch Corp.; Tool Design Engineer, Wico Electric Co.; Program Director, WHAZ; and Transmitter Engineer, WMAS-FM. He joined RCA in 1949 as a Design Engineer in Aviation Communications and Navigation Engineering. He is presently responsible for the product design and operation reliability of UHF airborne communications equipment.

Mr. McMorrow is a Member of the AIEE, IRE and the American Ordnance Association. He is an amateur radio operator (W2GAG) and a licensed pilot.

W. M. PATTERSON
Editorial Representative
Aviation Engineering
Camden, N. J.

Mr. Patterson graduated from Cornell University in 1932 with a BS in ME. He did post graduate work in Physical Metallurgy and Aeronautical Sciences. Mr. Patterson's occupational experience includes employment with Sellers Injector Corp., as Chief of the Valve Division and with Kellett Aircraft Corp., as Chief Materials and Process Engineer. He joined RCA in 1954 as Manager of Mechanical Standards and Drafting, Airborne Fire Control Engineering. In this capacity he is responsible for operation of the drafting activity and for coordination of mechanical design activities. He has additional staff functions in integrating work of Airborne Fire Control Engineering with other activities.

Mr. Patterson is a Registered Professional Engineer in Pennsylvania and a Member of the American Society of Metals.

J. L. PETTUS
Editorial Representative
Hollywood Engineering

Mr. Pettus attended William Jewell College (1930-33) majoring in mechanical engineering. His first employment was with the Refinoil Corporation, Kansas City, Mo., as an Installation Engineer of oil processing equipment. In 1937 he joined RCA at Indianapolis. He was assigned to the Quality Department, working on sound reproducing and recording equipment. In 1940 he was transferred to the Engineering Department and assigned to the Instrument Design Group. Here his efforts were concentrated on design of film recording galvanometers, noise reduction shutters and optical systems. Just prior to World War II he was assigned the design of high-vacuum equipment for production of low-reflection optical films and dichloric reflectors. Early in 1940 he transferred to Camden and assumed responsibility for film recording equipment design. This assignment was soon incorporated into a general reorganization of Film activity by a transfer to the Hollywood group. At the present time Mr. Pettus is a Leader, Mechanical Design for Film Recording.

Mr. Pettus is a Member of the SMPTE and a registered mechanical engineer in the state of California. He is currently serving on the SMPTE Progress Committee. A member of Kappa Alpha Fraternity, he has fifteen patents to his credit.

J. H. PRATT
Editorial Representative
Los Angeles Engineering

Mr. Pratt, Leader, Development and Design Engineers, Los Angeles Engineering, graduated from the general course in Communication Engineering at RCA Institutes, New York, in 1938, and has taken graduate engineering courses at McGill University, Montreal. He joined RCA Engineering Products Department, Montreal, in 1939, where he was engaged in design and development of aircraft transmitters, ground-based air-navigation and radar. He became Manager of Radar Engineering in 1951, then transferred to Los Angeles, where he worked on air-borne radar and Loran equipment. At present his group is engaged in radar development.

Mr. Pratt has been awarded three patents, and is a Senior Member of IRE.

J. H. ROE, *Editorial Representative*
Broadcast Studio, Antenna
and Transmitter Engineering
Camden, N. J.

Mr. Roe received his BS in EE in 1930 and his MS in EE in 1932 from the University of Minnesota. He was employed by the University until 1933 where he worked on a research project. 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, Group Manager, TV Cameras and Microwave, 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 on kinescope recording and large-screen TV projection.

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

H. E. ROYS, *Editorial Representative*
Optics, Sound and Special Engineering
Camden, N. J.

Mr. Roys received his BS in EE from the University of Colorado. After graduation he was with G. E. Co. in Schenectady until he joined RCA at Camden in 1930 and became associated with the phonograph section. In 1937 he became a member of advanced development group of the Photophone section. From 1941 to 1946 he was located with this group in Indianapolis, working mainly on disk recording and reproducing problems. He returned to Camden in 1946, where he is now Manager of Optical and Recording Systems Development in General Engineering Development.

Mr. Roys is a member of Tau Beta Pi and Eta Kappa Nu and has a number of patents to his credit. He is a Fellow of the Audio Engineering Society, the Acoustical Society of America, and IRE. He has actively participated in the Recording and Reproducing Standards Committee of IRE since its formation in 1949 and served as Chairman for two times during 1950-52.

L. M. SEEBERGER
Editorial Representative
General Engineering Development
Camden, N. J.

L. M. Seeberger received a BS degree in EE in 1943 from the University of California at Berkeley. He served with the U. S. Army Signal Corps during the second World War as a radar officer. In 1946, he joined RCA and contributed to development of the television system for the Teleran Link Demonstrator. Later he developed the camera for the Teleran System. He was subsequently associated with the design and evaluation that led the Graphecon storage tube from the research stage to practical use. Since 1951, Mr. Seeberger has directed a group of engineers engaged in advanced development of display devices, the most recent of which used the Direct View Storage Tube. In 1952, he was a member of the group that formed the preliminary recommendations for "The Eyes of the Army" (TEOTA). His association with the Study of Army Television Problems began in 1953, and in 1954, he became project coordinator for a comprehensive military television program. Mr. Seeberger is presently Leader of the Military Television and Data Handling Development group in General Engineering Development, EPD. He is a Senior Member of the IRE.

B. F. WHEELER
Editorial Representative
Communications Engineering
Camden, N. J.

Mr. Wheeler is a graduate of the University of Kansas with a BS in EE degree. He operated an amateur radio station and was employed at Broadcast Stations WREN, Lawrence, Kansas and WKY, Oklahoma City from 1929 to 1940 as operator and Assistant Chief Engineer. In 1940 Mr. Wheeler joined RCA and spent one year in design of FM Broadcast Transmitters. Following an assignment at the MIT Radiation Lab., he engaged in the design of naval fire control radar. In 1945, Mr. Wheeler joined the group responsible for pioneering a 1000 mile, 4000 megacycle multichannel microwave relay system. In 1949 the RCA 960 mc microwave relay equipment was developed, followed by the RCA 2000 mc relay equipment in 1950. Until 1952, when a Communication System Engineering was formed, Mr. Wheeler was also responsible for system application engineering. He has been Manager of Microwave Communication Engineering since 1947.

Mr. Wheeler is a member of the RETMA Committee TR-14 on Microwave Communication Systems, a Senior Member of IRE, a Member of the AIEE and a Licensed Professional Engineer in New Jersey. Mr. Wheeler has been issued nine U.S. Patents.

TECHNICAL STANDARDS FOR COLOR TELEVISION

by
JOHN W. WENTWORTH, Mgr.
TV Terminal Engineering
Engineering Products Division
Camden, N. J.

SUCCESSFUL STANDARDIZATION has played an important part in making the "vision at a distance" we know as television a commonplace reality in American homes. Electronic engineers have devised a great many methods for producing and transmitting television pictures, but the thriving television broadcasting industry is founded on a specific set of signal specifications that were agreed upon by the industry's engineering pioneers and approved by the Federal Communications Commission following comprehensive field tests. It should not be assumed, however, that standardization in the broadcast television industry has stifled the imagination or ingenuity of its engineers. The only part of a broadcast television system that requires strict standardization is the radiated signal. There are still many possible techniques for putting this signal together at the broadcasting plant and for utilizing it to produce pictures in home receivers. The past decade has seen tremendous progress in the development of improved apparatus for both ends of the television system.

One of the most significant new developments in the television art is the evolution of compatible color television which operates within the broad framework of the older monochrome standards but which requires the introduction of new features in the standard radiated signal. It is the purpose of this paper to trace out a logical technical derivation of the compatible color television signal specifications, with particular emphasis on the importance of standardization of certain parameters. To provide an appropriate background for this derivation, it is reasonable to begin by reviewing briefly the major technical principles employed in monochrome television.

BROADCAST STANDARDS FOR MONOCHROME TELEVISION

A television system must necessarily embody some technique for converting images into electrical signals capable of conveying visual information. The technique used in practice is the scanning process, whereby a sampling aperture is moved in a regular geometric pattern over the image area. Because the scanning aperture must be moved with extremely great velocity to cover the entire picture area in a short period of time, it usually takes the form of an electron beam in a vacuum tube, which can be deflected readily by electric or magnetic fields. In the television camera tube, an optical image is converted into some sort of an electrical charge pattern. As the scanning beam moves over this charge pattern, it develops a signal voltage which varies according to the brightness of the picture element being scanned. This signal voltage is amplified, processed in various ways, and broadcast by radio transmission techniques to distant receivers. In the television receiver, the signal voltage controls the intensity of an electron beam which sweeps over the surface of a phosphor screen in perfect synchronism with the original scanning beam in the pickup tube. The beam excites the phosphor in such a way that each small area of the screen emits light in proportion to the brightness of the corresponding picture element, and thus the complete image is re-created. Certain standards must be established with respect to the scanning process if all broadcast receivers are to utilize signals from any broadcast transmitter. The scanning pattern used for broadcast television in this country is a pattern of parallel lines generated by moving the scanning aperture rapidly from left to right and somewhat more slowly from top to bottom; this motion is comparable to the motion of the eye when one is reading a printed page. The scanning pattern is *interlaced;* this means that only half the lines are scanned each time the beam moves down the screen. The set of lines traced out during each vertical motion of the beam is known as a *field.* On the first field, only the odd-numbered lines are scanned, while on the second scan the even-numbered lines (which

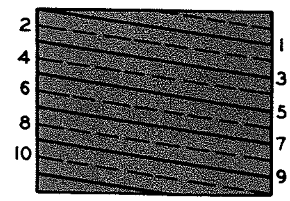
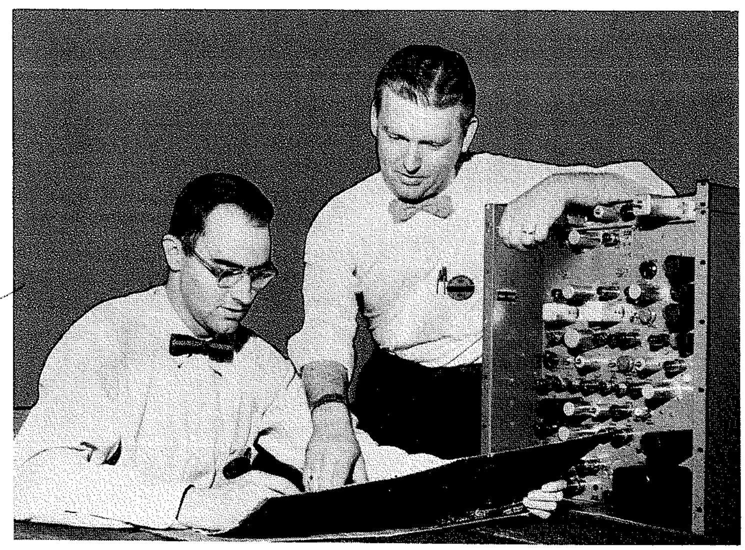


Fig. 1—Sketch of a television raster or scanning pattern, showing line interlace. The solid lines are traced out during the first downward vertical movement of the beam, while the dotted lines are traced out during the second vertical scan.



The author (left) discusses with Mr. E. E. Gloystein a design change in the Colorplexer, a device which may be regarded as the "heart" of a compatible color television system. The Colorplexer encodes the red, green, and blue primary signals provided by a color camera to form a compatible color signal in accordance with the FCC color television standards.

are interlaced relative to the odd-numbered lines) are traced out. Two fields make a *frame*, which is the technical term for a complete television image. The complete set of lines in a television frame comprises a rectangular image area with an *aspect ratio* (that is, a ratio of width to height) of four to three.

The standard field and line frequencies in this country are nominally 60 cycles per second and 15,750 cycles per second, respectively. The major factors which influenced the choice of the field frequency were as follows:

(a) *Portrayal of objects in motion.* As in motion pictures, a television system must transmit a series of still images at a sufficiently rapid rate to give the illusion of smooth motion in the scene. A field frequency of 60 cps corresponds to 30 complete frames or images per second, which is a sufficiently high rate (the motion picture standard is only 24 images per second).

(b) *Flicker.* The large-area flicker frequency of 60 cycles per second provides somewhat better performance (i.e., it permits brighter pictures for a given level of flicker perceptibility) than does the motion-picture standard of 48 light flashes per second.

(c) *Power Supply Frequency.* Certain hum pickup problems are minimized by making the television field frequency at least nominally the same as the power line frequency, and it is somewhat easier under these conditions to design certain types of motor-driven studio equipment (such as film projectors). The prevalence of 60-cycle power lines in this country was a definite factor influencing the choice of this same number as the number of fields per second.

The line frequency is made an odd multiple of the frame frequency so as to achieve line interlace automatically. 15.75 KC is 525 times the frame rate, or 262½ times the field frequency. The ratio of the line frequency to the frame frequency determines vertical resolution in the pictures. The 525-line standards in use in this country provide images with about 480 active scanning lines; the remaining 45 or so are "blanked out" to allow time for the scanning beams to return from the bottom of the picture back to the top.

Additional aspects of the monochrome signal that have been standardized are the channel characteristic, the synchronizing waveform, and the modulation characteristic. 82 six-megacycle bands in the radio-frequency spectrum have been allocated for use as broadcast television channels. 12 of these are in the so-called VHF (very high frequency) portion of the spectrum, interspersed with various other services in the range from 54 to 216 megacycles. The remaining 70 channels are in the UHF (ultra high frequency) portion of the spectrum extending from 470 to 890 megacycles. Within each six-megacycle channel, there is an amplitude-modulated picture carrier located 1.25 megacycles above the lower limit and a frequency-modulated sound carrier located 0.25 megacycles below the upper limit. The techniques used in transmitting and receiving the sound signal are very nearly the same as those used in FM broadcasting, except that the maximum deviation (frequency swing) permitted is 25 kilocycles instead of 75 kilocycles. The picture signal is transmitted by the vestigial sideband technique; this means that most of the useful picture information is transmitted in the upper sideband, while only enough of the lower sideband is transmitted to permit a relatively simple technique to be used for the detection or demodulation of the signal. The maximum bandwidth permitted for the picture signal within the broadcast channel is approximately 4.1 megacycles per second. This bandwidth limitation determines the horizontal resolution capabilities of the system, since it limits the maximum number of possible changes in the signal voltage during the fixed period of time available for the transmission of each scanning line.

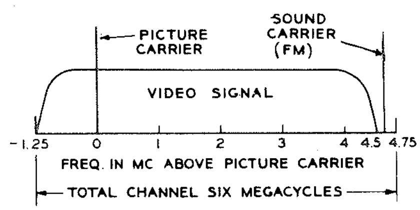


Fig. 2—Spectrum sketch of a standard television broadcast channel.

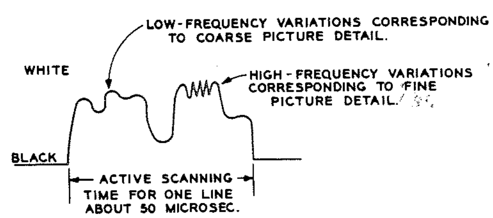


Fig. 3—Sketch of a typical television signal for one scanning line, showing the relationship between signal frequency and pictorial detail or resolution.

Synchronizing information to keep the scanning circuits in receivers in step with those in the television camera is transmitted in the form of a train of pulses which occur during the blanking or retrace periods when no useful picture information can be transmitted. The standard synchronizing waveform is quite complex, but consists essentially of pulses that occur at line frequency plus a wide, serrated pulse that occurs at field frequency. Several techniques have been developed for the separation of line-frequency and field-frequency components from this waveform in television receivers to provide synchronization for the horizontal and vertical deflection circuits, respectively.

The composite signal formed by adding synchronizing and picture information is amplitude-modulated on a carrier frequency in such a way that an increase in brightness in the picture causes a decrease in the carrier output.

During the active scanning periods, the signal is always somewhere between the "reference white level," which is set at 12.5% of the maximum carrier level, and the "reference black level," which is set at 75% of maximum carrier. The synchronizing

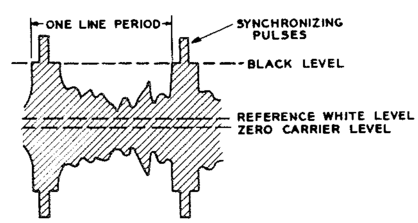


Fig. 4—Waveform sketch of a television picture signal after modulation on an RF carrier for transmission.

pulses, transmitted during the blanking periods, are added in such polarity that they swing "blacker than black" up to 100% carrier level. Use of a separate amplitude range for the sync pulses makes it relatively easy to separate the synchronizing information from the picture information by simple clipping circuits.

A complete discussion of all the technical features of monochrome television systems is beyond the scope of this paper, but the foregoing summary includes those signal characteristics which are most pertinent as building-blocks upon which to build the technical framework of compatible color television.

THE COLORIMETRIC ASPECTS OF COLOR TELEVISION

A color television system is required to transmit information pertaining to the three visual variables known as hue, saturation, and brightness, while a monochrome system is required to transmit brightness information only. Brightness is readily understood as that property of a color which enables us to locate it in a scale ranging from black to white or from dark to light. A monochrome television image controls the sensation of brightness by means of varying shades of gray, but additional information is needed to control the sensation of hue (which enables the observer to place the color in some such category as red, blue, yellow, green, purple, or the like) and the sensation of saturation (which tells the observer how far the color departs from the neutral condition toward a highly vivid state).

The primary color concept is used in nearly all practical processes for reproducing images in full color. It is an experimental fact that nearly all everyday colors can be matched by an appropriate combination of three *primary* colors. There are a great many possible sets of primaries, but those most useful for color television purposes are highly-saturated red, green, and blue. All the information required by the eye to perceive images in full color can be transmitted by means of three independent television signals controlled by the red, green, and blue components of the original scene. Considered as a colorimetric device, a color television

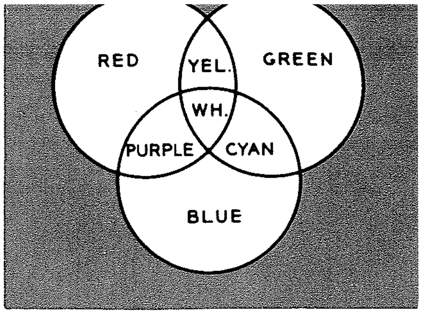


Fig. 5—The primary-color mixing process, showing how various mixture colors can be achieved by the addition of red, green, and blue "primary" colors.

system is essentially a means for connecting red, green, and blue reproducing devices through suitable transmission channels to three pickup devices made sensitive to red, green, and blue light. Means must be provided for achieving registration of the primary images at both ends of the system. The most widely-used color cameras at the present time employ three separate pickup tubes with special optical systems for forming three images that are identical in all respects except for the wavelengths of light employed. The most common type of viewing device is the tri-color kinescope in which the three primary images are produced in the form of very closely intermingled primary-color dots or lines which are too small to be resolved individually.

COLOR TELEVISION AS A TRANSMISSION PROBLEM

The application of the principles of colorimetry to color television is quite straightforward, thanks largely to the work of such groups as the International Commission on Illumination in the preparation of standardized data, diagrams, and techniques. The most difficult problem to be worked out during the evolution of a color television system suitable for broadcast use lay in the area of transmission techniques. These problems arose through the necessity of handling three independent signals as opposed to the single signal required for monochrome television. Factors which had to be considered in connection with the transmission problem in color television were:

(a) *Spectrum Conservation.* The radio frequency spectrum is one of the scarcest of our natural resources, and there are many broadcast and communications services clamoring for frequency allotments. The bandwidth requirements for television are quite great, even for monochrome pictures, because each television picture contains a tremendous amount of information. The FCC announced in 1949 that it considered the ability to operate within the same six-megacycle channel used for monochrome one of the basic criteria for color television systems. This presented a real challenge to the industry's engineers, and emphasized the need for techniques permitting maximum effectiveness in the use of the limited spectrum available.

(b) *The Multiplexing Problem.* The necessity for handling three independent signal components in a color television system results in a need for *multiplexing* techniques for transmitting these independent signals through a single channel. For many years, various sequential or time-division multiplex systems were explored as possible answers to this problem, but the signal specifications finally adopted are based on techniques known as frequency interlace and two-phase modulation, which will be discussed below.

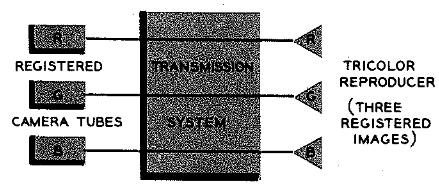


Fig. 6—Simplified block diagram showing the application of the primary color process to color television.

C. R. Monro and R. G. Thomas examine the signal waveform produced by the WA-7A Linearity Checker. This unit was developed to facilitate the testing of amplifiers, transmitters, and other television broadcast equipment for compliance with the transmission standards required for handling color television signals.

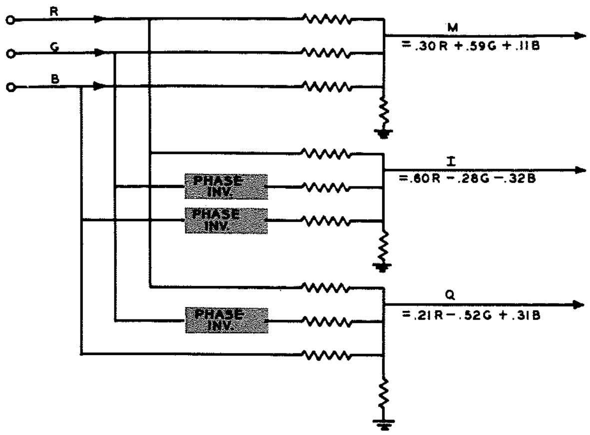


Fig. 7—A typical matrix circuit for re-packaging the primary video signals in a compatible color television system.

(c) *The Compatibility Issue.* Since monochrome television was already well established as a broadcast service before color television was developed to a point where commercialization was possible, it was necessary to consider the economic conditions under which a color telecasting service would have to be introduced. The Radio Corporation of America pioneered in the development of a *compatible* color television system — one in which the transmitted signal would be capable of rendering service to monochrome receivers, and which would permit receiver designs suitable for the reception of either monochrome or color programs without readjustment. The feature of compatibility enables broadcasters to initiate color broadcasting service without loss of audience, and makes it possible for the owners of color receivers to continue to receive monochrome programs as well as those broadcast in color.

The remainder of this paper will be devoted to a discussion of four basic techniques used to achieve spectrum efficiency and to solve the multiplexing problem in compatible color television. These are: (1) matrixing, (2) band-shaping, (3) two-phase modulation, and (4) frequency interlace.

THE "PACKAGING" OF COLOR PICTURE INFORMATION

Color picture information as it leaves a simultaneous color camera is "packaged" in the form of three video signals controlled by the red, green, and blue components of the image. Electronic engineers have discovered that by re-packaging this information in the form of a different set of three independent signals it is possible both to satisfy the compatibility requirement and also to adjust the bandwidths of the three signal components so as to achieve maximum efficiency in the use of the radio frequency spectrum. The re-packaging is accomplished by so-called *matrix* circuits, which cross-mix the three primary-color signals in accordance with the following equations:

$$M = .30\,R + .59\,G + .11\,B$$
$$I = .60\,R - .28\,G - .32\,B$$
$$Q = .21\,R - .52\,G + .31\,B$$

The signal component designated by M is very nearly identical to the output of a monochrome television camera, and consequently is capable of rendering good service to monochrome receivers. This signal component is handled in all respects like an ordinary monochrome signal; that is, it is generated in accordance with the conventional scanning standards, it is combined with the standard synchronizing waveform, and it is modulated on a carrier in a conventional television transmitter. The other two signal components, designated as I and Q above, are known as *color-difference* or *chrominance* signals; they indicate how the color being transmitted differs from a white or neutral in two independent directions on a color diagram in which white is plotted at the center. The I signal conveys information pertaining to color differences in the orange to cyan (blue-green) direction, while the Q signal conveys information pertaining to color differences in the green to purple direction. Note that both I and Q go to zero when $R = G = B$, designating a white or neutral condition. To recover red, green, and blue signals suitable for the control of a tricolor reproducer, the M, I, and Q signals are passed through a second matrix circuit in the color television receiver which performs a cross-mixing operation that is the inverse of the original cross-mixing operation at the transmitting end of the system.

Use of the matrixing or cross-mixing technique not only satisfies the compatibility requirement by providing a signal component comparable to an ordinary monochrome signal, but also results in two signal components whose bandwidths can be greatly restricted without significant loss of useful information. Recent studies of the acuity or resolving power of the human eye have diclosed that the normal acuity for hue and saturation differences is much less than for brightness differences, and that acuity for color differences in the green to purple direction is considerably less than for color differences in the orange to cyan direction. This knowledge has been exploited by adjusting the bandwidths of the M, I, and Q signals used in compatible color television so as to transmit no more than the required amount of information in each case. The M signal component, being comparable to an ordinary monochrome signal, is transmitted with a bandwidth of approximately 4.1 megacycles, so that the brightness resolution in color images is nominally the same as for monochrome images. The bandwidth of

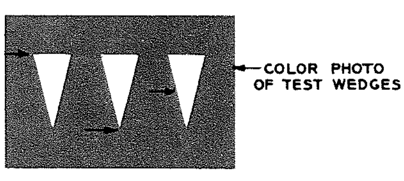


Fig. 8—Test wedges for measuring resolving power for black-to-white, orange-to-cyan, and green-to-purple information. The black arrows indicate relative acuity characteristics for a typical observer at the critical viewing distance where the center wedge can just be resolved down to the bottom.

the I component is limited to approximately 1.5 megacycles, while that of the Q component is further restricted to only about 0.5 megacycles. Although the resolution of the final color images is not great with respect to color differences, enough information is transmitted to produce perfectly satisfactory images at the normal viewing distance. The eye cannot perceive color differences in very fine detail, so it is pointless to use spectrum space to transmit high-resolution color difference information. It was once thought that the reproduction of high-quality color television images would require three times as much spectrum space as for a comparable monochrome image (i.e., space for three primary signals, each 4.1 megacycles wide). Thanks to the matrixing and band shaping techniques, it is now possible to transmit high-quality color images with a maximum bandwidth of only 4.1 + 1.5 + 0.5 = 6.1 megacycles, an increase of only 50% above the requirement for monochrome alone. Through techniques which are discussed below, it is possible to achieve even greater savings in spectrum space.

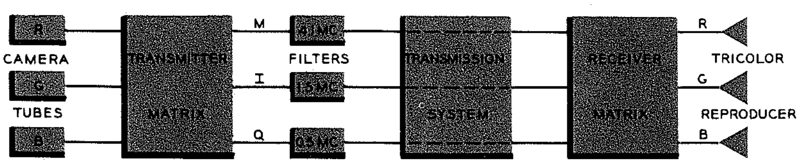


Fig. 9—Simplified block diagram illustrating the application of matrixing and band-shaping techniques to compatible color television.

MULTIPLEXING PRINCIPLES FOR COMPATIBLE COLOR TELEVISION

A casual examination of the channel characteristic used for monochrome television gives one the impression that the available spectrum space is already fully occupied by the monochrome signal component alone, leaving no space for the chrominance components. A more sophisticated study of the characteristic discloses, however, that the spectrum apparently occupied by a television signal is really not completely filled. Since the great majority of the information contained in a television image is repetitive at frame frequency, the signal energy in a video signal tends to be concentrated at harmonics of the line, field, and frame frequencies, leaving relatively vacant spaces in between. Through the so-called *frequency interlace* technique, these relatively vacant gaps can be filled with additional signal components. Frequency interlace is achieved by modulating an additional video signal (like the I and Q components) upon a *subcarrier* which falls within the pass band of the main video signal but which is chosen as an odd multiple of one-half the line frequency. Through such a choice of the subcarrier frequency, the frequency components in the sidebands of the subcarrier tend to fall in the gaps in the main video signal. Two independent signals added together in this fashion can later be separated through the persistence of vision effect. A subcarrier added to a monochrome signal tends to produce a pattern of spurious dots whenever the subcarrier reaches a kinescope. These dots are effectively cancelled out through persistence of vision, because the subcarrier frequency is so chosen that on the second time a specific area in the image is scanned (one frame period later) the dots are automatically reversed in polarity. That is, the areas that were first made too bright by the subcarrier are now made too dark, and vice versa. Any residual effect resulting from incomplete cancellation of the dots is inconsequential at normal viewing distances.

An additional technique known as *two-phase modulation* is employed to permit the two independent chrominance signals (I and Q) to be modulated upon two subcarriers of the same frequency, nominally 3.6 megacycles. The two subcarriers employed are 90 degrees apart in phase. They are each amplitude-modulated in suppressed-carrier fashion, and the two waveforms are simply added together. Whereas an ordinary AM signal varies with respect to amplitude only, the sum of two such signals varies both in amplitude and in phase. Study of the resultant subcarrier in a compatible color television system discloses the interesting fact that the phase varies as a function of hue, while the amplitude varies as a function of saturation.

The I and Q components can be demodulated from the subcarrier in color receivers through a technique

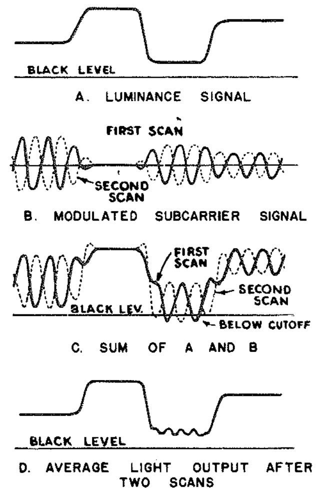


Fig. 10—Waveform sketches for a small section of one scanning line, illustrating the frequency interlace principle. By choosing its frequency as an odd multiple of one-half the line frequency, a subcarrier signal to be added to a normal monochrome signal can be made to reverse its phase between successive scars of the same line. The effect of the subcarrier on a monochrome display can thus be effectively cancelled by the averaging process caused by persistence of vision.

known as *synchronous detection.* This is accomplished by heterodyning the incoming subcarrier signal against two locally generated subcarriers of the same frequency but 90 degrees apart in phase in two modulators. The reinserted subcarriers must be synchronized in frequency and phase

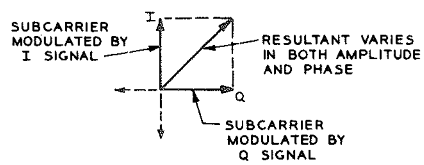


Fig. 11—Vector diagram illustrating the two-phase modulation process.

with the original subcarriers back at the broadcasting plant. The special synchronizing information required to accomplish this is transmitted in the form of "bursts" of at least 8 cycles of the subcarrier frequency at a pre-determined phase timed so as to occur during the horizontal blanking periods immediately after each horizontal synchronizing pulse. These bursts are separated from the rest of the signals by time-gated circuits in the receiver, and used to control a

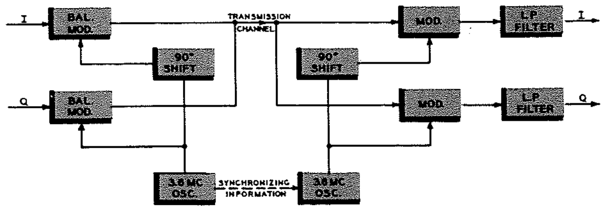


Fig. 12—Block diagram for two-phase modulation as used in color television.

local oscillator through some type of automatic frequency control circuit.

REVIEW OF COMPLETE COLOR TELEVISION SYSTEM

To clarify how each of the techniques and principles discussed above is related to the total system, it should be helpful to review a complete system from camera to kinescope, pointing out the major areas where standardization has been applied.

A color television camera contains an optical system and some arrangement of pickup tubes suitable for generating red, green, and blue signals from corresponding optical images. Colorimetric requirements for the camera are actually specified in terms of standardized receiver primaries. The FCC color television standards "pin down" the red, green, and blue primaries by specifying them in terms of "chromaticity coordinates" in the standardized CIE system of colorimetry. From this information, it is possible to work through a series of calculations from standardized data to determine exactly what spectral response (response versus wavelength) each pickup tube should have to achieve proper control of one of the primaries. The signal amplitudes are "balanced" by adjusting them for equality when the camera is directed at a white or neutral object, and a specific reference white (comparable to the quality of typical daylight or CIE Illuminant C) is recommended for use in receiver. Since kinescope characteristics are known to be nonlinear, a technique for *gamma correction* is recommended, whereby the red, green, and blue camera signals are passed through nonlinear stages with curvature opposite from that encountered in kinescopes.

The deflection circuits in the color camera are controlled by pulses derived from a *synchronizing generator*. In compatible color television, there must be a definite relationship

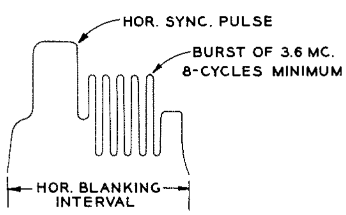
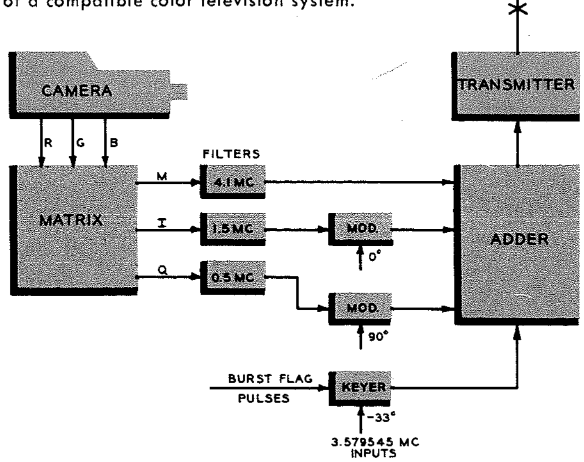


Fig. 13—Waveform sketch showing the subcarrier burst used to synchronize the receiver oscillators in a compatible color television system.

between the subcarrier frequency and the horizontal and vertical deflection frequencies. The color subcarrier frequency is chosen as the reference, and is set at 3.579545 mc ± 10 cycles in the FCC standards. Since it is necessary for the subcarrier to be an odd multiple of one-half the line frequency for proper working of the frequency interlace technique, the line frequency is specified as 2/455 times the subcarrier frequency. This corresponds nominally to the 15.75 KC line rate used for monochrome television, although the precise number is 0.1% lower. As in monochrome television, the field frequency is specified as 2/525 times the line frequency, which is nominally 60 cycles per second (actually 0.1% lower).

Fig. 14—Simplified block diagram for the transmitting end of a compatible color television system.



The gamma-corrected red, green, and blue signals from a color camera are further processed in a piece of equipment known as a *colorplexer* or *encoder*. Here they are first matrixed or cross-mixed to form the three signals designated M, I, and Q above. Equations for this matrixing process are set forth in the FCC standards, and the bandwidths to be allotted to each signal component are also specified. As noted earlier, these bandwidths are nominally 4.1, 1.5 and 0.5 megacycles for M, I, and Q, respectively. Filters are employed in the colorplexer or encoder to achieve this bandshaping. Delay networks are also included, since the standards specify that all signal components shall match each other in time within 0.05 microseconds (if no delay compensation is used, the narrow-band filters would tend to introduce more delay than the wide-band filters). The colorplexer also includes modulators for modulating the I and Q signals upon two subcarriers in phase quadrature. A keying tube controlled by *burst flag pulses* derived from the synchronizing equipment is used to generate the color synchronizing bursts. The standards specify that the phase of the burst shall lead the I component by 57°, and that the I component shall lead the Q component by 90°. The bursts are also fully specified with respect to duration, timing relative to the sync pulses, and amplitude. Finally, the colorplexer includes adder circuits for combining the monochrome or M component, the two-phase-modulated subcarrier, and the color synchronizing burst.

The amount of handling to which a color television signal is subjected after leaving the colorplexer depends upon the complexity of the broadcast plant. In small stations, the signal may be sent almost directly (usually through some sort of simple switching system) to the transmitter. In more elaborate plants, the signal may pass through a number of distribution amplifiers, switchers, stabilizing amplifiers, and microwave relay links before it reaches the transmitter. Somewhere along the line (usually at the output of a switcher), the standard synchronizing waveform must be added to produce a complete composite signal. All of the equipment handling the color signal (including the transmitter) must be designed to operate within relatively narrow tolerance limits with respect to the following parameters:

(a) *Amplitude versus frequency.* A change in response at the color subcarrier frequency relative to the lower frequencies causes an undesirable increase or decrease in the saturation of colors.

(b) *Envelope delay versus frequency.* All signal components must arrive in time coincidence at the second detector of the receiver if certain edge effects or transients are to be avoided. The FCC standards provide for envelope delay compensation at the transmitter for normal receiver errors in this resepct.

(c) *Differential gain.* (Subcarrier amplitude as a function of monochrome level.) If an amplifier or other device compresses the signal in either the black or white region, there is a corresponding loss of color saturation in either the highlights or the shadows.

(d) *Differential phase.* (Subcarrier phase as a function of monochrome level.) If subcarrier components transmitted near white level (corresponding to bright colors) are distorted in phase relative to those transmitted near black level (dark colors), there will be objectionable hue shifts as illumination conditions are varied in the televised scene.

The FCC standards do not specify performance requirements for each individual piece of studio equipment, but overall tolerance limits are placed on the signal as radiated. It is considered the manufacturer's responsibility to design equipment using no more than a fair share of the available tolerances. Several RETMA committees are now exploring the problem of determining reasonable tolerance limits for individual pieces of equipment.

As noted in the introduction to this paper, strict standardization in broadcast television is applied only to the radiated signal. Receiver design engineers know the capabilities of the signals radiated by broadcast stations, and know what must be done to produce high-quality images from those signals. While many variations in receiver design are possible, the basic functions which must be performed are outlined below.

The signal brought in from a television receiving antenna is heterodyned down to an intermediate frequency range (usually in the vicinity of 40 megacycles) and amplified in a multi-stage IF amplifier. The bandwidth of the RF and IF portions of a color receiver must be somewhat wider than that normally provided in a monochrome receiver so as to pass the color subcarrier at full amplitude. A rectifier-type second detector is used to demodulate the composite video signal from its carrier. A sound channel consisting of a 4.5 MC intermediate frequency amplifier, an FM detector, an audio amplifier, and a loudspeaker, is usually fed from the output of the video IF amplifier. The video signal from the second detector is utilized in four circuit branches as follows:

(1) The sync separator, which provides pulses for control of the deflection and convergence operations associated with the color kinescope.

(2) The burst separator, which is turned "on" by pulses derived from the horizontal deflection circuit. The separated bursts are used to control a local 3.6 MC subcarrier oscillator.

(3) The monochrome channel, which passes the monochrome signal component and rejects or attenuates the color subcarrier frequency.

(4) The chrominance channel, which consists of a band-pass filter centered around 3.6 MC, plus a pair of synchronous detectors adjusted to recover the two independent components of the modulated subcarrier.

The monochrome signal and the demodulated chrominance signals are cross-mixed in a matrix network to produce red, green, and blue signals suitable for driving the corresponding guns of a color kinescope. The complete color image is then produced on the kinescope's phosphor screen.

Compatible color television system as approved for broadcast use in this country is the culmination of an engineering program of tremendous scope, so it is impossible to give more than superficial treatment of its many new and interesting features in a brief survey paper of this sort. It is interesting to note, however, that standardization has played an important role along the way. Now that the basic signal specifications have been established, we can expect an era of rapid progress in the development of improved apparatus and circuits for both broadcasting plants and receivers.

JOHN W. WENTWORTH graduated from the University of Maine in 1949 with a B.S. degree in Electrical Engineering. He came to RCA in July, 1949 and since 1950 has specialized in color television, and has done development and design work on color cameras, colorplexers, and other studio equipment. His present position is Manager, TV Terminal Equipment Engineering. During the past 4 years, Mr. Wentworth has taught courses in color television engineering for RCA engineers in Camden and NBC, New York. Mr. Wentworth is a member of Tau Beta Pi and Phi Kappa Phi, an associate in the Society of the Sigma Ki, and an associate member of the IRE.

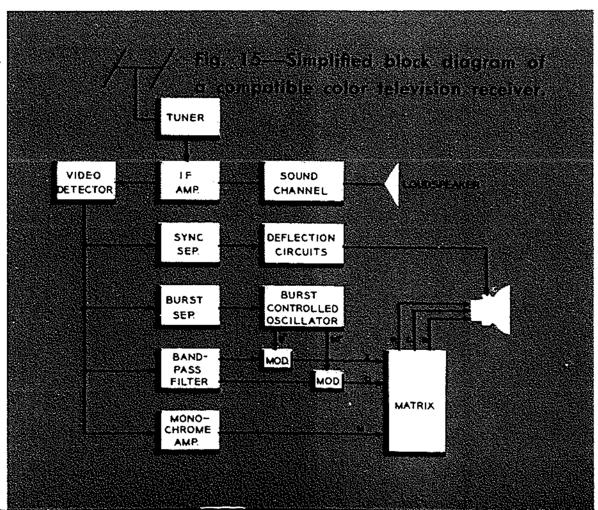
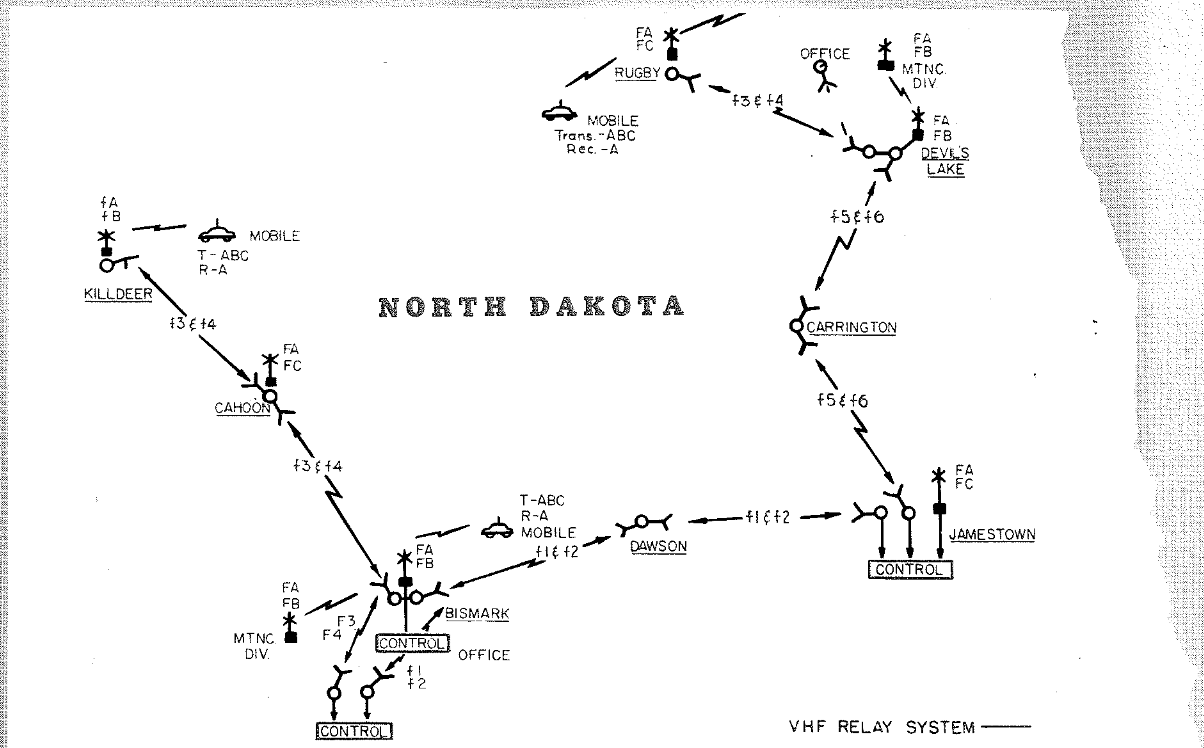


Fig. 15—Simplified block diagram of a compatible color television receiver.



LAND-MOBILE COMMUNICATIONS

by

J. R. NEUBAUER, Mgr.

Communications Systems Engineering

Engineering Products Division, Camden, N. J

JOHN R. NEUBAUER—Mr. Neubauer received his technical training at Colorado University and Colorado A & M College. His activities prior to joining RCA in 1950 included broadcast station engineering, vocational school teaching, airline communication supervision, consulting engineering and radio-engineer for the State of Wyoming. Mr. Neubauer is presently Manager of Communications Systems Engineering. He holds two patents and has published several papers on communications. He is a Senior Member of the IRE, an associate of the AIEE and a member of RETMA Committee on VHF Systems Standards of Good Engineering Practice.

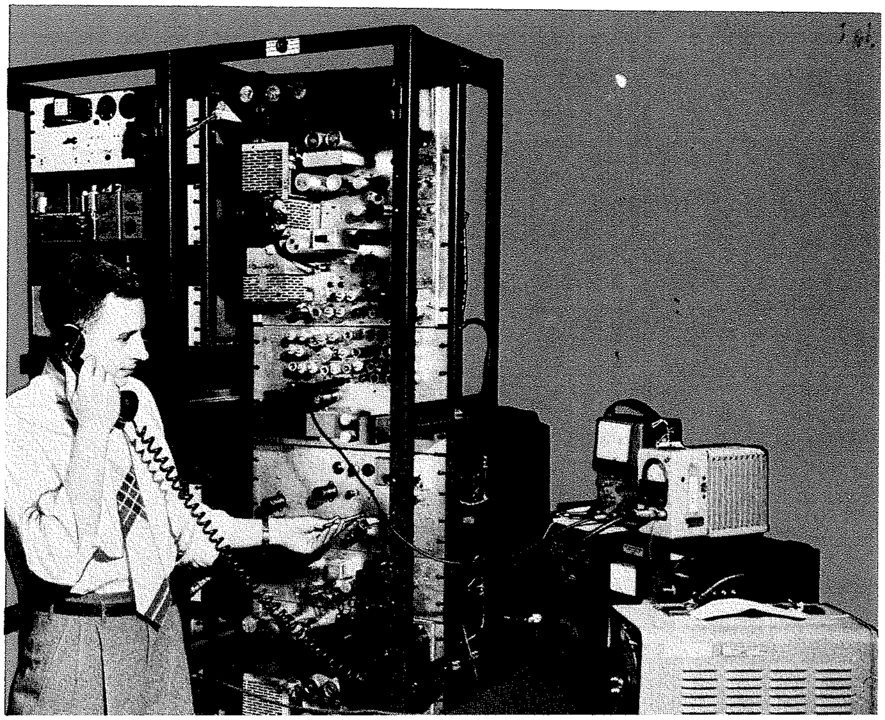
THE MAJOR growth and development of land-mobile radio has occurred over the past ten years; however, the use of vehicular communications dates back more than 30 years. The most familiar application has been in the public safety organizations, such as the police and fire cars and trucks. Improvements in design effecting better and more reliable performance and substantial reductions in cost has opened many new industrial markets. Organizations whose major activities extend over large areas have found two-way radiotelephone an important tool for expediting better customer service and reducing operational cost. The land transportation services, petroleum and natural gas pipelines and public utilities, have pioneered in many new applications, which have provided instant coordination of their complex activities. In recent years, the use of short range, low power equipment has established its usefulness to large manufacturing plants and public works construction contractors. These users have need of rapid, flexible communications within a confined area. There are many more applications in urban or metropolitan communities, such as taxis, towing, water and heating services, etc., which have been able to provide improved lower cost service. The aforementioned two-way radio users represent only a portion of the total variety of activities, of which land-mobile radio has become an essential operating facility.

FREQUENCIES USED

In the United States, the equipment available has been designed to utilize frequency modulated carriers in order to obtain the improved transmission efficiency and better receiver signal to noise performance. These characteristics are particularly advantageous in the mobile unit. Propagation of signals is permitted by the Federal Communication Commission on three groups of frequencies. The lowest, which is 30-50 mc, is used by organizations needing coverage up to 50 miles. The middle range, which is 152-174 mc is used, where coverage limited to 25 miles is adequate. The highest range is 450-460 mc, which is effective over a radius of 10-20 miles, depending to a considerable degree on the nature of the terrain and the height of the antenna.

BASIC SYSTEMS

The average operational requirements are fulfilled with three basic system arrangements. The most frequently used is a centrally located base station, which communicates with a number of mobile units, whose range will be determined by the height of the antenna, nature of terrain, transmitting power, receiver sensitivity, and local interference. The range of coverage often requires the location of the station equipment at a site, not convenient, by reason of distance or otherwise, to direct local control. These stations are dispatched by remote control over a telephone line. The second basic system function is intercommunication between fixed stations within a common group. This is usually accomplished by using an alternate frequency to avoid interference to the mobiles, which, in many systems are provided with an alternate frequency, in order that they might intercommunicate with each other. Another less frequently used system is the repeater station. These provide an effective solution to the problems of economically extending the range of the base station, either as a substitute for uneconomically long or non-existent telephone lines, or as an unattended automatic booster. In special applications, VHF fixed stations are used to automatically transmit telemetering signals or receive supervisory control signals at remote power substations, petroleum tank farms or water control projects.



J. L. Santoro adjusting standby monitoring unit of automatic repeater station before being shipped to customer.

SYSTEM REQUIREMENTS

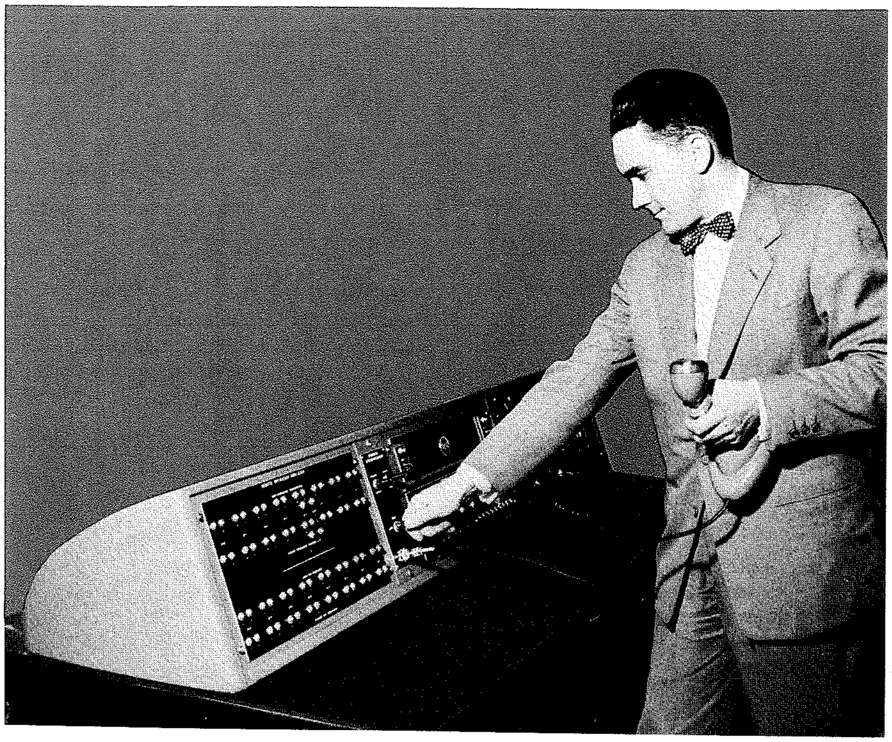
The communication engineer must analyze and consider a wide variety of physical, electrical and economical problems in the design of land-mobile communication facilities. The physical aspects range from station location, buildings, towers, and standby power to the units operational effectiveness over a wide range of environmental conditions, such as vibration, shock, temperature, and humidity. Electrically, he must recognize the limiting effects of propagation, interference, noise, distortion and existing frequency assignments. Considerable thought on system supervision, both manual and automatic, is required to provide reliable operation. Competition is keen in the communication industry and the engineer must always be alert to improvement of performance and reduction of cost.

STANDARD UNITS

The standard transmitter-receiver and control system fulfill the most frequent demand for voice communication; however, the effectiveness of even the simplest arrangement is often determined by the degree of engineering planning. In our discussion of problems related to custom engineered systems, it will be noted that many of them also influence the operational effectiveness of the standard station. The locally controlled station, while relatively simple to install and operate, requires evaluation of propagation, frequency allocation, and interference. The telephone line remote control station requires similar consideration, and in addition, needs a determination of the wire line characteristics. Standard mobile communication units are basically designed as a package unit with several stock options, such as power output, multiple channel and 6 or 12 volt primary power supply to allow application in most systems.

CUSTOM ENGINEERED SYSTEMS

The custom engineered system demands detailed consideration of a number of related equipment characteristics, which have an accumulation effect in reducing the system performance. These problems, which include desensitization, intermodulation, spurious emission and response,



H. S. Wilson makes test transmission over Ohio Turnpike centralized dispatch console.

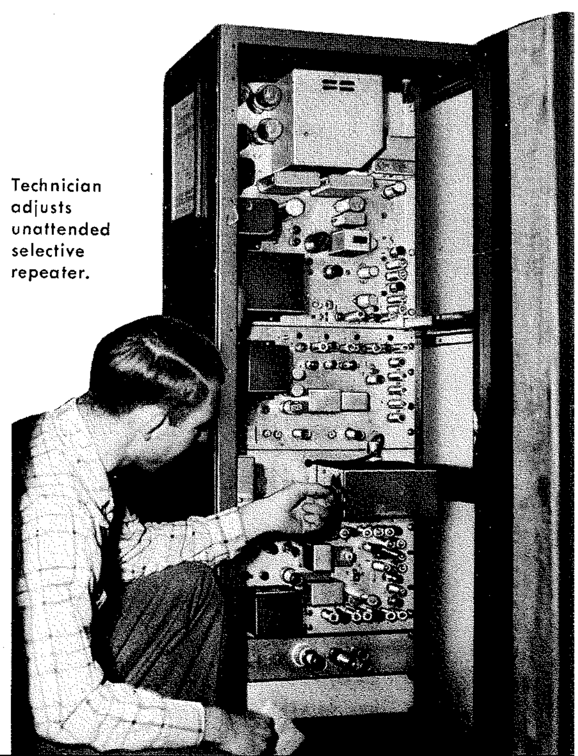
noise and distortion, must all be evaluated, when planning radio link controlled stations, automatic repeaters (or "boosters") and multiple repeater chains for extended control. Other types of custom engineered installations include stations for effecting supervisory or selective control of remote facilities. There are many installations where a complete sequence of operations can be initiated and confirmed by sequential pulsing or multiple tone signals. Petroleum pipeline pump stations can be operated without any human attendant from distances of 50 miles or more and further when the VHF control circuit is extended through a microwave repeater system. Such an operation consists of starting and stopping pumps, opening and closing by-pass and main valves, and by telemetering; observation of pressure, flow and reservoir tank level. A similar degree and variety of functional operations at an electric power substation is also possible. With the recent expanded development of microwave systems has come the practice of integrating land-mobile stations with multiplex voice and control signal circuits to provide an even greater degree of effective coverage and control. The last decade has witnessed the growth of the nation's superhighways, and RCA engineers have played a vital role in developing the very flexible communications required. The functions of administration, maintenance, patrol, and customer service would be completely ineffective, without centralized communications. These systems require the design and development of master control systems which are equal to, and often exceed, the circuit complexity of the major broadcast networks.

Though standardization of system components is desirable, the specific requirements of some users demand special engineering of the mobile unit as well. To permit interference-free communication in areas where stations in the same system overlap in their coverage, controllable directional antennas have been designed. These bi-directional antennas permit the vehicle operator to select the strongest of two signals. To solve the problem of privacy and system traffic loading, the mobile units are equipped with a selective ringing device, which can be made to operate in both station-to-car and car-to-station communications.

PROPAGATION ANALYSIS

The analysis of all land-mobile system equipment design requirements, both standard and custom engineered, requires a study of the propagation effectiveness of the terrain which is encompassed by the functional area of the various vehicles. This subject has received considerable attention in recent years and theoretical study has been proven by practical experience to a degree which permits a useful calculation of the communicating range. Such factors as free-space attenuation, atmospheric diffraction, obstruction losses and surface conductivity all contribute to the design requirements which determine frequency, radiation efficiency, carrier power, receiver sensitivity and allowable interference. The rapid increase in the number of users has made the selection of frequencies increasingly difficult as each portion of the spectrum has become more crowded. Recently, the FCC has suggested new rules in the lower frequency bands, which will reduce the allowable bandwidth from 40 kc to 20 kc. This permits doubling the number of assignments but introduces new system design problems in intermodulation and adjacent channel interference. Another aggravating phenomena of the 30 to 50 mc frequency band is long range ionospheric propagation, which occurs as a result of ducting in the E & F layers. This phenomena reaches its peak during the height of the 11-

Technician adjusts unattended selective repeater.



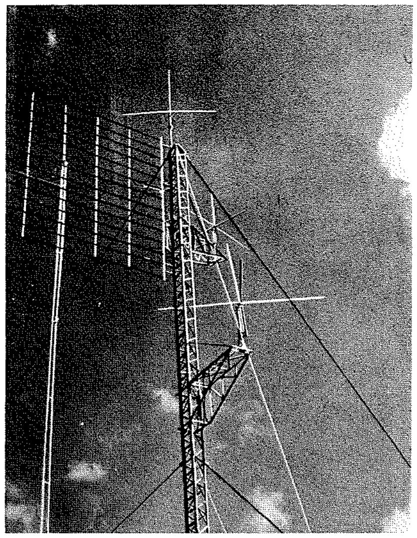
year sunspot cycle and produces signals having perfect free space characteristics, allowing usable signals to propagate over 1500 or more miles from transmitters of relatively low power.

ANTENNA SYSTEMS

The r-f propagation characteristics will govern to a large degree the design of the antenna system. The most effective station-to-mobile coverage is provided by antennas having an omnidirectional low angle of radiation with the lobe maximum directed at the horizon. This is also effective in reducing co-channel interference. Such antennas are usually vertically polarized to accommodate the most convenient vehicle type and are mounted over a $\frac{1}{4}\lambda$ ground plane or are collinearly stacked as dipoles and fed in phase to produce a flat doughnut-shaped pattern. The ground-plane type is limited to a power gain of 1.64X as compared to the stacked dipoles which will yield 2.5 to 3X gain on lower frequencies, in practical designs, and up to 14X at UHF. In point-to-point control applications, it is the usual practice to use yagis or corner reflectors, to provide up to 7.5 db forward gain. In special system designs where the shape of the area to be covered needs to be controlled, antennas having special patterns, such as cardioidal or figure 8, are installed.

PROPAGATION SURVEY

A propagation analysis can be made with reasonable accuracy, using U. S. Coast and Geodetic survey maps or other comparable topographical charts, which allow a determination of the physical profile of several radials whose origin is the transmitting antenna. More accurate information can be derived by a physical inspection and an actual series of test transmissions from selected locations. The usual procedure is to combine these operations to effect an economical compromise. The results of these observations and studies can be used mathematically to obtain the useful margin of signal which exceeds the quieting threshold of the receiver. The minimum excess signal will be determined as being that which is required to provide a stable noise-free circuit having less than



Typical multiple antenna system of a repeater station.

10% distortion over the normal speech range of 300-3000 cycles per second. In our discussions on performance limits and design methods, we will detail those characteristics which contribute negatively or positively to this goal.

PERFORMANCE LIMITS

Throughout this discussion we have briefly mentioned equipment characteristics which degrade the overall performance, when their accumulated effects exceed the minimum system limit of noise, distortion and reliability. Whenever receivers are an active part of the system simultaneously with a nearby transmitter, i.e., radio control or automatic repeaters, they are subjected to desensitization or loss of effective quieting. This occurs as a result of loss of gain in the first stage of the receiver, from bias developed by the strong r-f field at the receiving antenna, or intermodulation products developed by the carrier and harmonics of the injection oscillator, in the first converter due to non-linearity, which is an inherent mixer characteristic. Intermodulation not only occurs in the receiver but is also experienced when two or more transmitters having a near-field relationship of less than 60 db attenuation, will generate new signals of several microvolts at distances up to 5 miles. This is a result of mixing of carrier energy in the non-linear Class C power output stage of transmitters operating on frequencies within 5 to 10 mc of each other. Problems in intermodulation not only arise within common systems, but are often encountered in connection with adjacent systems whose physical location and frequency assignment are such as to produce undesirable interference. Another source of interference is encountered in the harmonic radiation of the transmitter, originating in the exciter. The harmonic energy of the exciter multiples will be amplified through all the stages of transmitter and will appear in the tunable range of the output stage as high as 70 to 80 db down from the desired carrier.

The ratio of signal improvement in terms of the number of db gained by increases in power to the economic factors of first cost, plus maintenance, limits the maximum useful transmitted power to 250 watts; the average installation provides excellent service with 60 watts. The need for additional frequency allocations has demanded improved selectivity in the receiver; but again, there is a limit which must be considered as the bandwidth is reduced. The deterioration in noise improvement becomes the lower limit as the linear portion of the modulation band is reduced.

DESIGN METHODS

The communication engineer has several tools he can employ in designing an effective system. The problems of desensitization, intermodulation and spurious emissions are primarily solved by a thorough study of available frequency allocations to determine the best compromise assignment. Additional improvement can be obtained by use of decoupling. This can be accomplished by physical separation, selective filters and the inherent rejection characteristics of the antenna systems. To keep the accumulation of noise at an acceptable level requires the application of several known methods. The assurance of adequate reserve r-f signal, low distortion automatic control of audio levels, and proper choice of operating levels will have the greatest effect in maintaining good intelligibility. These methods plus limiting the modulation to no more than the level necessary for an adequate signal-to-noise ratio, will keep the distortion to a minimum. When interconnecting a number of transmitters and receivers with other control devices and other station combinations, either through direct control circuits or radio relay links, it will always be necessary to provide interlocking control systems to assure smooth operation. The design of switching circuits is a major activity in all large communication networks. This discussion has only attempted to give a panoramic view of the principal aspects of the design and development of land-mobile communications. We will summarize by describing two typical systems currently in operation.

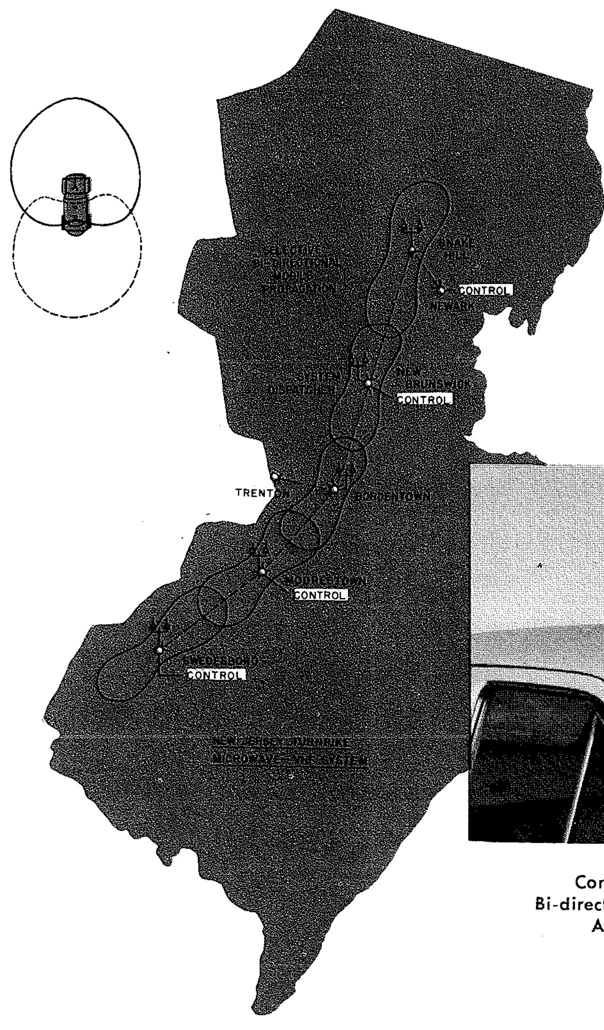
TYPICAL VHF REPEATER SYSTEM

An excellent example of a VHF land-mobile system, which has a full variety of functional arrangements, is a Government operated system located across the State of North Dakota. This system employs repeaters not only to control remote base stations, but to provide point-to-point communications as well. In addition, the mobile units are able to intercommunicate with each other, either directly car-to-car or through any part of the repeater chain. There are eight stations, two of which are equipped with local control so arranged as to permit breaking the system to allow independent operations in each portion. Two of the stations (Dawson and Carrington) act as connecting repeaters only; the remainder each having a local base station operated through the repeater system, from either a car or one of the dispatching stations (Bismarck or Jamestown). The frequency assignments are arranged to minimize interference and each car is capable of selectively transmitting to the base station of whichever area in which he is located. To describe in any detail the design considerations of this system is beyond the scope of this article, but the reader should recognize from the foregoing discussions some of the typical problems which would be encountered.

INTEGRATED MOBILE-MICROWAVE SYSTEM

Another type of land-mobile system is that which is integrated into a microwave system. RCA pioneered in this application in the development of the New Jersey Turnpike system and is currently in the process of installing a similar facility for the Ohio Turnpike Commission. These systems provide centralized control to many fixed and mobile units. These include fixed stations at the toll interchanges, maintenance centers and patrol headquarters. The mobile units can communicate not only with the central dispatcher and each other, but with all other fixed stations as well. At all times each fixed station is under direct control of the administrative operator, but in addition, the main fixed stations will operate as automatic repeaters and re-transmit the received signal at all other main transmitters. All of these functions are performed by control signals and multiplexed voice carriers which are carried upon the wide band microwave beam. Each of these derived channels carries out all the functions of a physical pair of wires. In systems of this type several multiplex channels are used to enable a wide variety of interlocking control functions and audio switching and routing. To prevent audio energy from more than one source from simultaneously modulating the transmitters, an elaborate sequence of protective lockout signals maintain preferential paths for audio information. In all cases, however, the central dispatcher has the privilege of supervisory control. In such a system as this, where many types of voices are in use, an automatic level control maintains a 4 db output range over a 30 db input variation. The use of bi-directional station antennas restricts the propagation to the right-of-way and the area of interference between adjacent stations is overcome by the controllable bi-directional mobile antenna.

As has been indicated by these brief system descriptions, the scope of mobile system design is a broad one. There are no fixed set of rules, since the users keep their ideas of communication adequacy in step with every new development. The growth of land-mobile radio will always be paced by the industrial growth of the nation.



Controllable
Bi-directional Mobile
Antenna

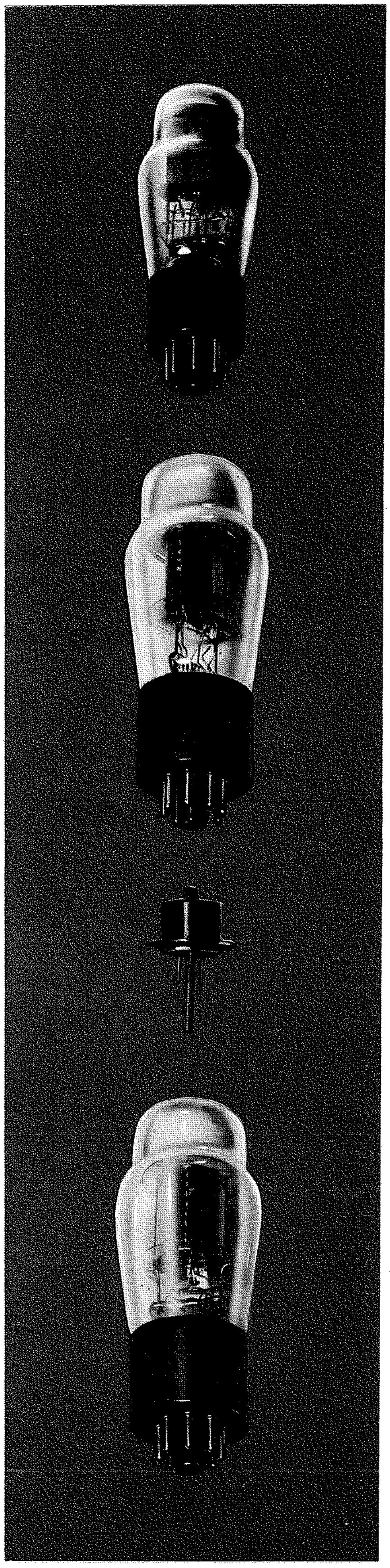


Fig. 1—Photograph of small gas-filled tubes and a developmental power transistor.

LOOKING AHEAD IN RESEARCH ON GASEOUS CONDUCTION PROCESSES

by
EDWARD O. JOHNSON
RCA Laboratories
Princeton, N. J.

DURING THE first quarter of the present century there was much interest in the conduction of electricity through gases, and the field engaged the attention of many of the best physicists of the day. Studies in this field led to the birth of atomic and nuclear physics and these lusty new infants soon relegated gaseous conduction phenomena to a minor role in physics. During the recent war, interest was revived because of the need for special electronic devices in radar, for example. This interest increased after the war and rapid research progress was made largely because of greatly improved measurement techniques based on microwave and high-speed oscilloscope methods. From the practical standpoint there was an intensive search for new devices and means for improving existing ones such as TR tubes, thyratrons, and Geiger counters.

In 1947 a program of fundamental research in the field was initiated at the Princeton Laboratories. The hope that an understanding of the conduction processes in gases would lead to practical progress soon bore fruit and a number of promising new devices were born. The potential importance of these, however, has been largely overshadowed by the rapid development of solid-state devices such as the transistor. Confronted by such competition, research efforts in the gaseous conduction field were redirected to regions which, it is believed, solid-state devices would be least likely to invade. The considerations involved in the selection of these new regions of research can be appreciated if a brief and elementary comparison is made between electrical devices that operate with different modes of conduction.

INVESTIGATIONS PRODUCE NEW GAS-FILLED TYPES

In vacuum tubes one is primarily concerned with one type of current carrier, the electron. In gas-filled tubes, on the other hand, the concern is not only with mobile electrons but also with mobile positive ions. The addition of positive charges to the roster of current carriers in a tube greatly increases the complexity of operation and makes possible many new types of devices. For example, the positive ions can be used to neutralize the electron space charge so that high currents can be passed at low anode voltages. Because of this, the hot-cathode gas tube, such as the small thyratron[1] shown at the extreme left in Fig. 1, passes about a hundred times as much current as a comparable sized vacuum tube when operated with an anode potential of ten volts. This feature makes the thyratron attractive for power applications where efficiency is impor-

[1] The Thyratron was invented by G. W. Pierce in 1914.

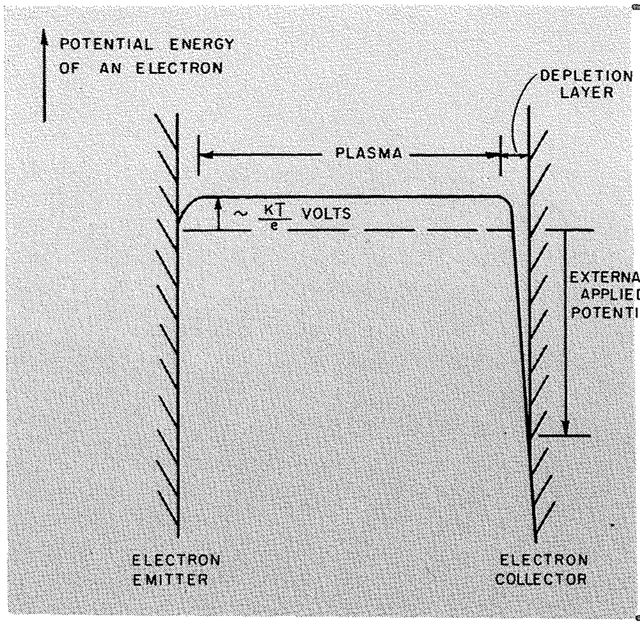


Fig. 2—Potential distribution in a plasmatron gas tube.

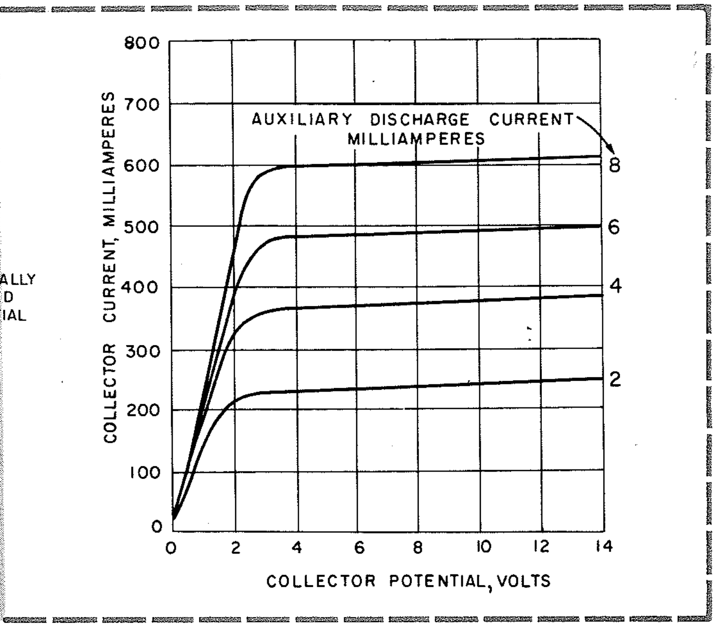


Fig. 3—Volt-ampere characteristics of a typical developmental plasmatron.

tant. Unfortunately, however, once started the anode current cannot be conveniently switched off by the control grid as is the case with the vacuum tube. A major part of the Princeton group's efforts was aimed at understanding this troublesome phenomenon and devising means to circumvent it. As hoped, an understanding of the conduction mechanism quickly led to a number of inventions. The first of these, the plasmatron,[2] combines the high-current low-voltage operation of the thyratron with the continuous control feature of the vacuum tube. The second, the tacitron,[3] operates like the ordinary thyratron shown in the photograph but has far less spurious noise output and is capable of very rapid grid cutoff. A third new type of tube, the low-drop thyratron, is similar to the conventional thyratron in operation and construction yet only requires one-half or one-third as much anode potential for rated current output. These characteristics have made the low-drop thyratron desirable for use in low-voltage applications.

From top to bottom in Fig. 1 are shown a conventional small thyratron, a developmental plasmatron, a developmental power transistor, and a developmental tacitron. The low-drop thyratron is not shown; the transistor will be considered later in the discussion.

[2] *Proc. I.R.E.*, pp. 645-659, June, 1952.
[3] *Proc. I.R.E.*, pp. 1350-1362, September, 1954.

THE PLASMATRON AND HOW IT OPERATES

The plasmatron is the most interesting of these new gas tubes to consider since it clearly illustrates the very close similarity between gas and solid-state devices, points up the advantages and potentialities of the latter, and indicates the best directions for research in the gaseous conduction field. In Fig. 2 is shown the distribution of electrical potential between the emitter and collector of a plasmatron tube. On the left of the figure is an ordinary hot oxide cathode which acts as an electron emitter; on the right is the electron collector or anode. Both electrodes are spaced about one centimeter apart in a low-pressure atmosphere of a noble gas such as helium. As a result of the ionization produced by energetic electrons in an auxiliary discharge (whose electrodes are not shown in the figure), a cloud containing equal densities of free electrons and positive ions is produced in the region between the emitter and collector. Such a cloud, called a plasma, is characterized by the almost complete absence of electric field and is electrically similar to the situation which exists inside a solid conductor or semiconductor where the total densities of positive and negative charges are equal. Electrons injected at the emitter diffuse through the plasma by virtue of density gradients and very small electric fields. Unimpeded by the space charge that limits electron current flow in a vacuum tube, these electrons travel to the edge of the depletion layer which covers the collector. The relatively high electrical field inside the depletion layer rapidly propels the electrons into the collector.

Control of the electron current flowing to the collector is achieved by modulation of the electron current flowing in the auxiliary discharge. The latter current determines the density of the free electrons and ions in the plasma and hence the plasma conductivity. Because of long ion lifetimes in the plasma and efficient charge generation in the auxiliary discharge, the plasmatron has a substantial current and power gain.

HAS "TRANSISTOR-LIKE" CHARACTERISTICS

The potential distribution in Fig. 2 will be recognized as having the same form as the one associated with the n-p-n transistor. This similarity follows because the pertinent phenomena in the two devices are basically the same. For example: 1) the base region in the transistor is also plasma-like in behavior and conduction though it occurs by a diffusion process; 2) the depletion layer at the collector is physically the same thing in both devices; and 3) the barrier height at the emitter is approximately kT/e volts in both the plasmatron and the transistor. Consequently, it is not surprising to find that the volt-ampere characteristics of a plasmatron, of which a typical example is shown in Fig. 3, are also similar to those of a junction transistor.

The control action in the n-p-n transistor is achieved by variation of the base-to-emitter potential. This serves to vary the emitter barrier height and hence the emitted current. However, this cannot be done in the plasmatron because of difficulties associated with "getting hold," electrically speaking, of the gaseous plasma.

The close analogy between plasmatron and solid-state operation is further emphasized by the similarity of operation of the unipolar "field effect" transistor and the plasmatron when the latter has a grid structure placed in the plasma between the emitter and the collector. In both devices the collector current is modulated by the action of the depletion layer which surrounds the grid electrode.

E. O. JOHNSON received his B.S. in E.E. from Pratt Institute of Brooklyn in 1948 and has continued his studies at Princeton University and the Swiss Federal Institute of Technology, Zurich, Switzerland. From 1948 to 1954 he was engaged in research at the Princeton Laboratories in the gaseous conduction field. Since his return from a year's leave of absence at Zurich he has been pursuing research in the solid state field. Mr. Johnson is a member of the IRE, Sigma Xi, and Tau Beta Pi.

SEMICONDUCTORS OFFER ADVANTAGES

Some of the basic advantages of semiconductor devices are immediately obvious. First of all, no heated cathode is necessary to provide carrier emission. Secondly, devices with the emission of either sign of carrier can be constructed. For example, the n-p-n transistor previously discussed could just as well have been a p-n-p transistor in which the current carriers would have been positive charges, or "holes," instead of electrons. Thirdly, the plasma-like region is automatically present without requiring auxiliary means of generation. Besides these obvious advantages there are a number of other important ones such as: 1) a semiconductor device can be much smaller in size than a gaseous conduction device for the same current-handling capability because of the much higher plasma densities that are quite naturally obtained in a solid; 2) there is no mechanical damage from the motion of heavy charged particles since these are securely anchored in the crystal lattice instead of being free to move and "sputter" the electrodes as is the case in gaseous conduction devices; 3) a multitude of new devices and types of operation are possible because the semiconductor possesses fixed and mobile charges of both signs. Item 1 is dramatically emphasized by the difference in size between the transistor and the tubes shown in the photograph of Fig. 1. All have approximately the same current rating.

It is interesting to note that the solid surfaces (electrodes, insulators, tube envelope, etc.), which necessarily surround the active volume in a gas tube, behave in a predictable manner with respect to the gaseous conduction process and thereby introduce relatively few technological problems. Unfortunately, quite the opposite is true with a solid state device which has its active volume surrounded by a gaseous atmosphere. Difficulties arising from this fact are presently a major concern in the research, development, and production of semiconductor devices.

MERCURY-POOL RESEARCH INDICATED

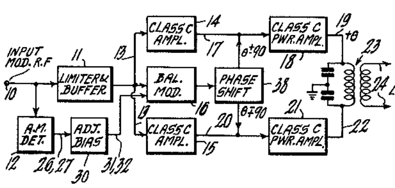
Comparisons of the sort discussed above have made it seem judicious to concentrate research in the field of gaseous conduction on the mercury pool discharge. Tubes which operate with this type of discharge do not appear to be so basically at a disadvantage when compared to solid-state devices. These tubes, which presently find wide application for very high power rectification and control purposes, require no hot cathodes or artificially generated plasmas, operate with extremely high currents and current densities (perhaps a million amperes per square centimeter), and have very long life largely because of a cathode surface that renews itself as fast as it is sputtered away. Very encouraging progress has been made in understanding this complicated discharge, and it is anticipated that this will lead to the development of improved means for overcoming the discharge's main drawback, the relatively high power required to initiate conduction in a low-power tube. This project, along with one on the phenomenon of sputtering, is intimately concerned with the little understood and potentially important processes that take place at the interface between a solid or liquid surface and a gas.

Patents Granted
TO RCA ENGINEERS

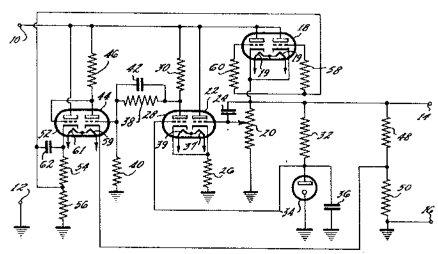
Based on Summaries Received over a period of about two months

MODULATED RADIO FREQUENCY SIGNAL AMPLIFIER (Patent No. 2,714,634)—granted Aug. 2, 1955 to J. R. Hall, Engineering Products Division, Camden, N. J. A modulated RF input signal is separated into its phase components by limiter 11 and its amplitude component by detector 12. The phase component is amplified in two parallel paths 14, 17, 18 and 15, 20, 21 and cancelled out in output circuit 23. The amplitude component, thru modulator 16, applies quadrature modulation components in the two paths so that the resultants are differentially phase modulated signals. The modulation components add in the output circuit to recreate the input signal in amplified form.

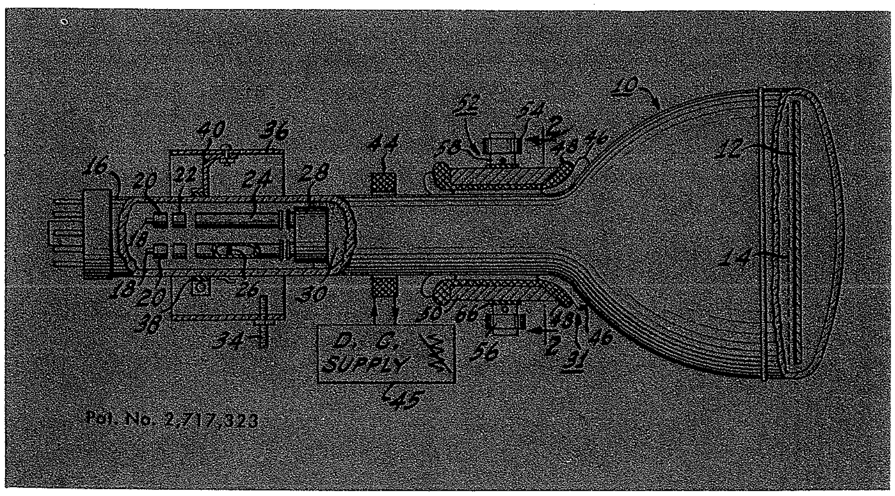
VOLTAGE REGULATING SYSTEM (Patent No. 2,711,507)—granted June 21, 1955 to M. Siskel, Engineering Products Division, Camden, N. J. In order to provide "fail-safe" operation in a voltage regulating system of the type having a degeneratively operated series control tube 18, a tube 52 is connected to the tube 18 as a cathode follower, and a tube 44 has its anode coupled directly to the grid of the tube 52. The heater elements of the tubes 44 and 52 are connected in series. A sample voltage, proportional to the voltage across the load, is fed back to the tube 44 in such a manner that its plate impedance is varied inversely with variation in the magnitude of the sample voltage.



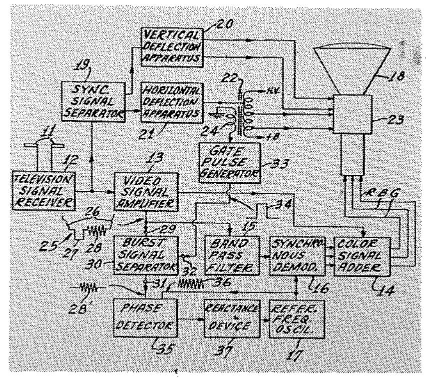
Pat. No. 2,714,634



Pat. No. 2,711,507

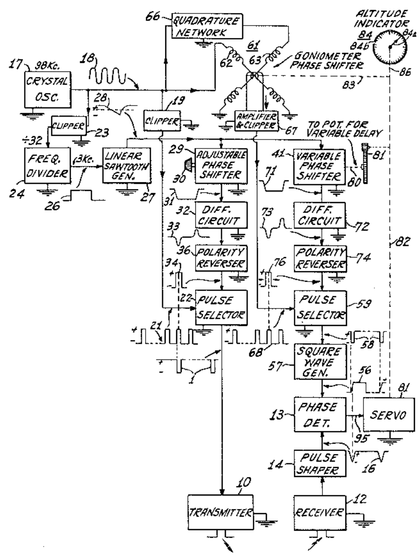


Pat. No. 2,717,323



Pat. No. 2,713,608

COLOR TELEVISION SYNCHRONIZING SIGNAL SEPARATOR (Patent No. 2,713,608)—granted July 19, 1955 to R. W. Sonnenfeldt, RCA Victor Television Division, Cherry Hill, N. J. To separate color subcarrier burst from composite TV signal, gating tube is made operative during burst intervals by gate pulses impressed upon injector tube, the cathode of which is coupled to the anode of gating tube. Burst is clipped from gate pulse pedestal by injector tube to produce separated burst in its anode circuit.



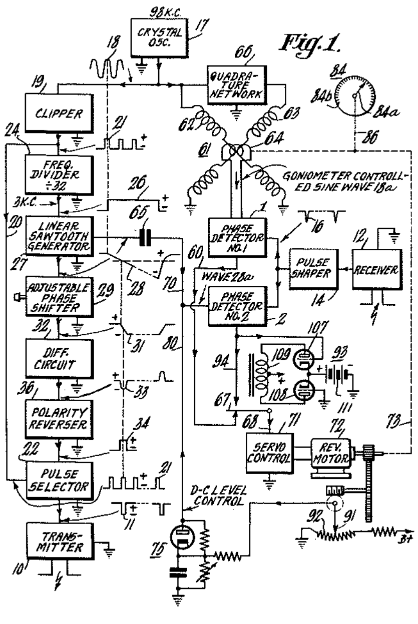
Pat. No. 2,713,160

PULSE-ECHO DISTANCE MEASURING SYSTEMS (Patent No. 2,713,160)—granted July 12, 1955 to R. Trachtenberg and D. H. Westwood, Engineering Products Division, Camden, N. J. A pulse-echo altimeter with a dial type indicator that is servo operated. The invention involves the production of an accurately timed square wave that is applied to a phase detector where it is sampled by the echo pulse.

ELECTRON BEAM CENTERING APPARATUS (Patent No. 2,717,323)—granted September 6, 1955 to B. R. Clay, RCA Victor Television Division, Cherry Hill, N. J. The invention includes: a holder for positioning two permanent magnets on diametrically opposite sides of a cathode ray tube neck. The holder is such as to permit the magnets to be turned about in axis normal to the tube axis.

PATENTS GRANTED

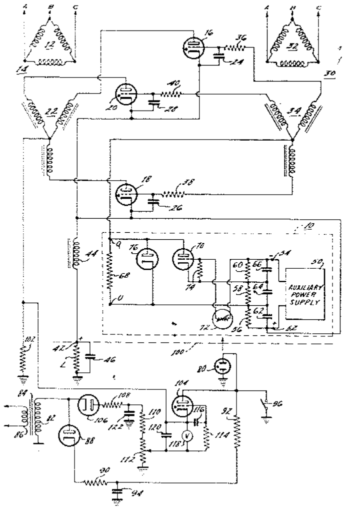
continued



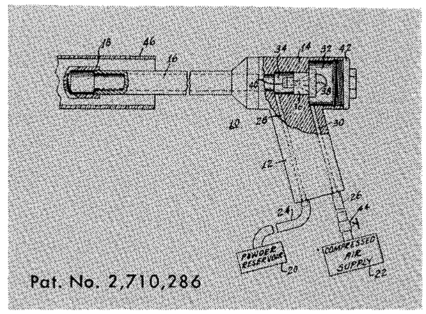
Pat. No. 2,716,233

RECTIFIER CONTROL SYSTEM (Patent No. 2,711,505)—granted June 21, 1955 to M. V. Hoover, Tube Division, Lancaster, Pa. In a polyphase rectifier system employing thyratrons 16, 18 and 20 which are fired cyclically by voltage pulses from an impulse transformer 30, a blocking control system 10, comprising a photoelectric cell 72, adapted to unblock, or block, said rectifier system in response to light, or the absence thereof, respectively, from a light source 80. The light source 80 may be extinguished automatically, and thereby block the rectifier system, in response to a short in the load L.

PULSE-ECHO DISTANCE MEASURING SYSTEM (Patent No. 2,716,233)—granted August 23, 1955 to D. H. Westwood, Engineering Products Division, Moorestown, N. J. A pulse echo altimeter with servo dial indication using geared phase shifters, one a sawtooth wave phase shifter and the other a goniometer phase shifter to shift low frequency and high frequency waves respectively. Instead of applying both phase shifted waves to one phase comparison circuit to be sampled by or compared with a received pulse, one wave is applied to one phase comparison circuit and the other wave is applied to a second phase comparison circuit. The servo motor is normally driven by the output of the high frequency phase comparison circuit but is switched to be driven by the other phase comparison circuit if there will be a possible ambiguity.

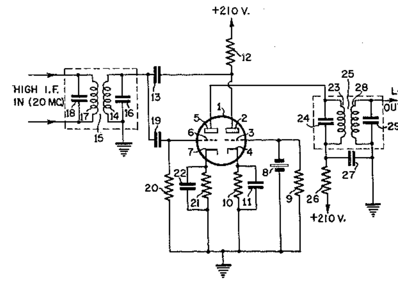


Pat. No. 2,711,505



Pat. No. 2,710,286

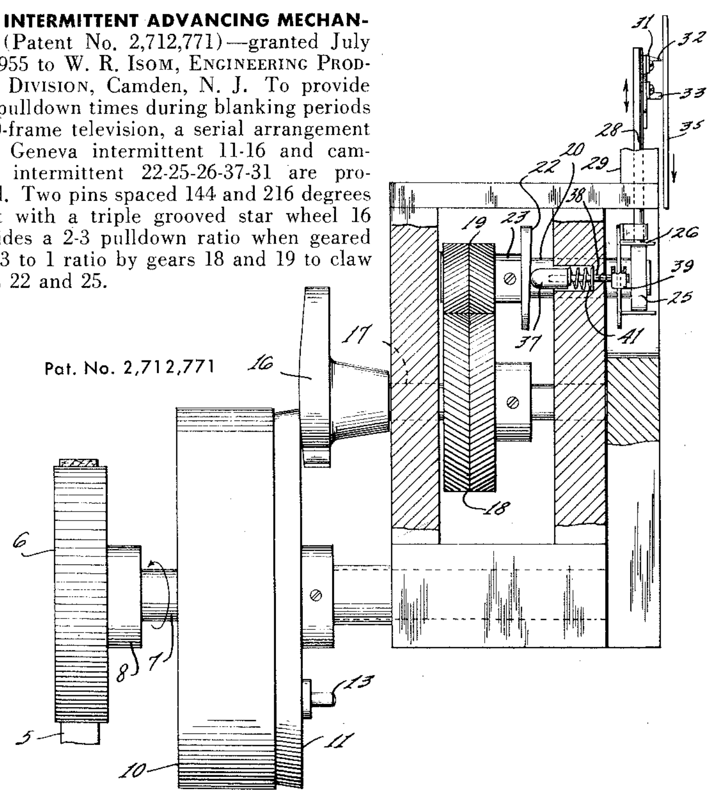
METHOD OF REMOVING AND SALVAGING ADHERENT MATERIALS (Patent No. 2,710,-286)—granted June 7, 1955 to R. H. Zachariason, Tube Division, Lancaster, Pa. A gas-abrasive mixture (usually air and sodium carbonate) in which the abrasive is water soluble is sprayed on the viewing screen of a CR tube to remove aluminized backing, phosphor and binder. Abrasive adhering to tube is removed by a water bath. Phosphors are salvaged by water bath treatment of screen-abrasive residue. Abrasive and binder are water soluble and aluminum backing is soluble in weak basic solution formed when sodium carbonate is dissolved.



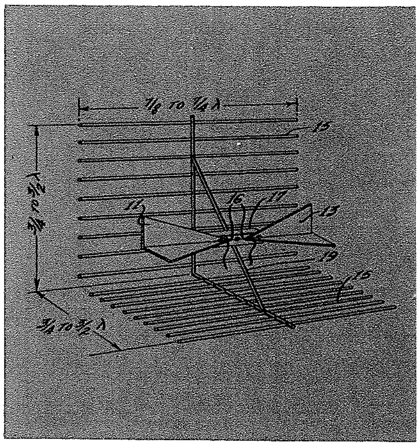
Pat. No. 2,713,634

MIXER CIRCUIT (Patent No. 2,713,634)—granted July 19, 1955 to R. A. Beers, Jr., and W. L. Gensel, Engineering Products Division, Camden, N. J. One triode section of twin triode acts as oscillator-multiplier and other as mixer. Frequency doubling effected in anode circuit of first section through action of secondary on input transformer. Doubled frequency and signal to be heterodyned both fed to grid of second section for mixing.

FILM INTERMITTENT ADVANCING MECHANISM (Patent No. 2,712,771)—granted July 12, 1955 to W. R. Isom, Engineering Products Division, Camden, N. J. To provide film pulldown times during blanking periods of 30-frame television, a serial arrangement of a Geneva intermittent 11-16 and cam-claw intermittent 22-25-26-37-31 are provided. Two pins spaced 144 and 216 degrees apart with a triple grooved star wheel 16 provides a 2-3 pulldown ratio when geared at a 3 to 1 ratio by gears 18 and 19 to claw cams 22 and 25.

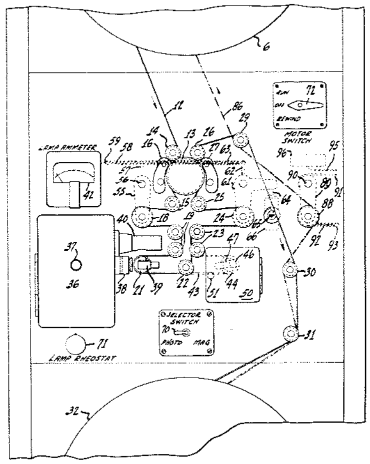


Pat. No. 2,712,771



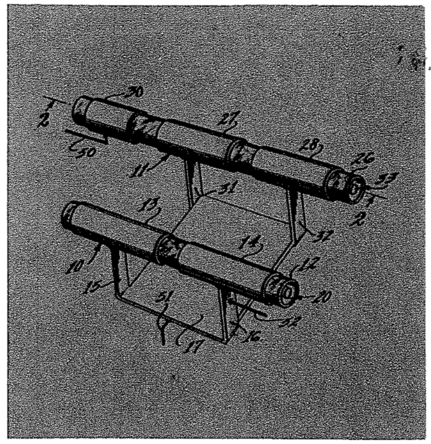
Pat. No. 2,714,659

BROAD BAND UNI-DIRECTIONAL ANTENNA (Patent No. 2,714,659)—granted Aug. 2, 1955 to E. JOHNSON and R. KOLAR, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. A broadband full wave dipole antenna in the form of two conductive sheets of material having a triangular shape is folded along its lengthwise axis and is located within a corner reflector. Each surface of the folded sheet elements is parallel to the adjacent surface of the corner reflector. This arrangement overcomes the wide variations in impedance which have heretofore precluded the incorporation of broadband elements in the corner reflector. In one embodiment a balun or impedance matching section is incorporated in the arm which supports the broadband dipole elements and spaces them from the corner reflector. Very good directional characteristics are secured throughout the entire band for which the antenna is designed.



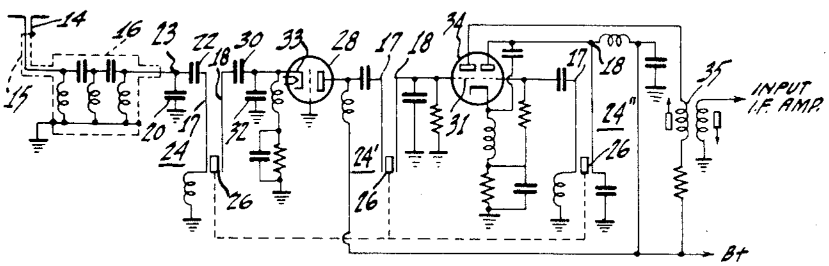
Pat. No. 2,712,941

COMBINATION MAGNETIC AND PHOTOGRAPHIC SOUND REPRODUCER & MAGNETIC RECORDER (Patent No. 2,712,941)—granted July 12, 1955 to J. L. PETTUS and A. C. ALBEE, ENGINEERING PRODUCTS DIVISION, Hollywood, Calif. To reproduce either magnetic or photographic sound records and record magnetic sound records, the same panel type film drive mechanism is used, except that the photographic unit is spaced from the magnetic unit. The photographic and magnetic film paths are the reflections of one another about a vertical central plane. Each unit has its separate drum 21 and 44 which have flywheels 53 and 54 on their shafts. The remainder of the film path for both types of films is symmetrical about a vertical central plane, filtering being accomplished by tensioned rollers 18 and 24, roller 24 being damped by a dashpot 60.



Pat. No. 2,714,192

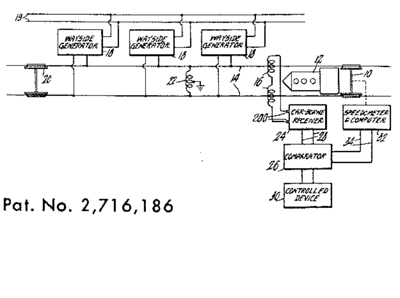
U.H.F. BAND PASS FILTER STRUCTURES (Patent No. 2,714,192)—granted July 26, 1955 to W. Y. PAN and D. J. CARLSON, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The filter structure comprises a pair of resonant structures, the first of which comprises three capacitance members and a movable conductive element to vary the capacity between the members. The second structure includes a pair of capacitance members and a movable conductive element to vary the capacity between these two capacitor members. Conductors constituting inductance are individually connected to two of the capacitor members of the first and second structures and means are provided for connecting the free end of the conductors together. The input terminals to the filter structure comprises the free capacitor member of the first structure and the connecting means.



Pat. No. 2,715,211

ULTRA HIGH FREQUENCY TUNING SYSTEMS (Patent No. 2,715,211)—granted August 9, 1955 to T. MURAKAMI, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The tuning structure comprises a resonant line having a pair of thin tapered conductive elements. The conductive elements are mounted on the outside of a tubular supporting member and are insulated from each other throughout their length. A conductive core element is slidably mounted in the tubular supporting member for tuning the resonant structure over a predetermined frequency range.

SIGNALLING SYSTEM (Patent No. 2,716,186)—granted August 23, 1955 to J. R. FORD, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. A fail-safe system with flashing light. To secure fail-safe operation in a railroad signal system having cab-carried apparatus, e.g., lights, dependent on reception of signals by a receiver, the method of interrupting the signal reception preferably at receiver input to actuate warning lights and then restoring signal to actuate safe lights. As long as safe light and warning light operate alternately, operation is safe; any other indication is one of danger or equipment failure.



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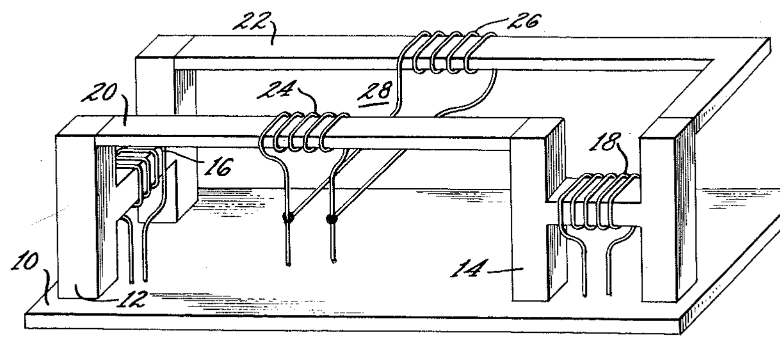

Pat. No. 2,714,187

VARIABLE HIGH FREQUENCY COUPLING TRANSFORMER (Patent No. 2,714,187)—granted July 26, 1955 to H. C. GOODRICH, JR., RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The coupling between the primary and secondary windings is varied by controlling the saturation of the magnetic circuit of the transformer. The transformer core structure is such that the magnetic flux path linking the primary and secondary windings includes a saturating flux path. However, the saturating flux path does not link either the primary or secondary windings, hence changes in saturating flux does not affect the inductance of the windings.

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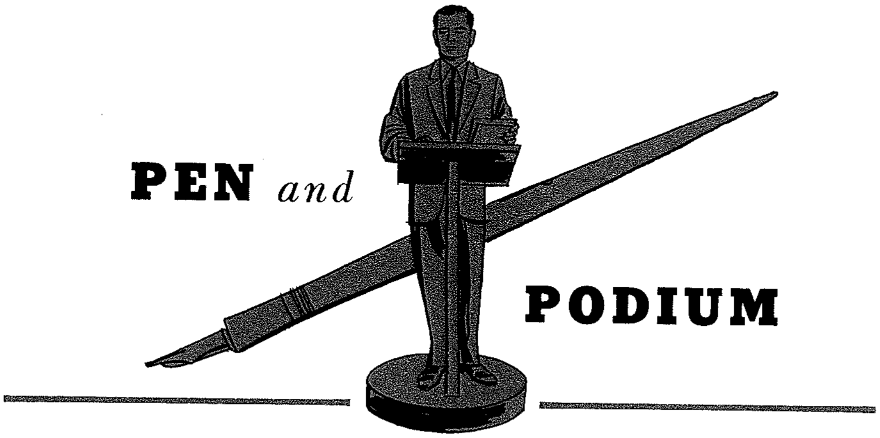


Based On Reports Received Over a Period of About Two Months

NEW ELECTRONIC TECHNIQUES WILL RE-SHAPE INDUSTRY — BOOST NATIONAL ECONOMY . . . By Dr. E. W. Engstrom, Senior Executive Vice President, Radio Corporation of America. Presented at the all-industry luncheon of the Western Electronics Show and Conference. Quotes from Dr. Engstrom's presentation are as follows: "While obsolescence is overtaking the methods and the means upon which we have built our products and services in the past, our horizon is being expanded beyond any limits we may discern today. With an ever-increasing flow of new materials and a wealth of research and engineering skills, the electronic science that was confined, in the past, largely to the field of communications is, today, penetrating into all areas of our technology.

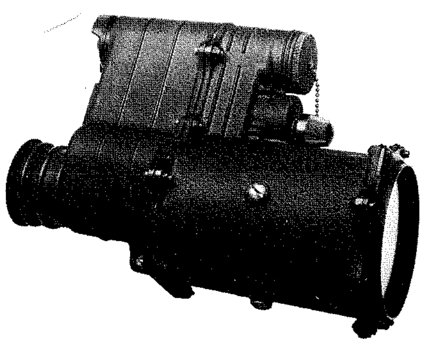
"The results of this invasion already are becoming evident in the changes wrought by electronics in the factory, the office, and the home. But these changes, radical as they may appear, give only a faint indication of the astonishing developments now brought within our reach by recent and continuing scientific discovery in the area of new materials. Tomorrow's systems, based on achievements in the laboratory today, promise to re-shape many of our industrial processes and business methods. They promise to carry our national economy to even higher levels. These trends, together with the perfection of many new electronic systems for the home, promise above all to increase our enjoyment and well-being as individuals."

COMPONENT CONSIDERATIONS FOR PRINTED WIRING IN AUTOMATION . . . By G. H. Goodman, Engineering Products Division, Camden, N. J. Published in August, 1955 in the PROCEEDINGS of Printed Circuit Symposium. The author describes the establishment of basic standards for printed wiring components. The various classes of components and specifications and tolerances for axial lead components, radial lead components and multiple lead components are described.

THREE-VIDICON COLOR FILM SYSTEM . . . By K. H. Hardiman, N. L. Hobson, B. F. Melchionni and A. Reisz, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, August, 1955. The paper describes the RCA 3-vidicon system for the reproduction of color film for use by TV stations. The description covers the complete system including Vidicon Cameras, projectors, multiplexers, and switching systems. The equipment is designed as a complete, integrated package including these items plus necessary control features.

INFRARED RADIATION AND INFRARED SYSTEMS . . . By J. A. Doughty, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-August, 1955. This paper reviews the wartime and postwar developments in infrared. The nature of the infrared region is discussed to establish the detection problems and then detectors of infrared radiation are examined as to spectral response and sensitivity. Their roles as infrared systems are explored and described.

LOSSES IN MAGNETIC FERRITES . . . By G. S. Hipskind, Tube Division, Camden, N. J. Published in ELECTRICAL MANUFACTURING, August, 1955. This article describes the measurement of losses due to hysteresis and eddy current in typical manganese-zinc ferrites. The losses are shown to be functions of maximum flux density and of temperature. The hysteresis loss for manganese-zinc ferrites can be represented by the Steinmetz law for values of maximum flux density from zero to 2000 gausses. The eddy-current loss depends on the geometry of the core, the resistivity, the flux density, and the frequency. An equation for calculating total power loss from the core is given.



Infrared Radiation

THE RCA "AMPLIPHASE" FIFTY, A NEW CONCEPT IN AM BROADCAST TRANSMITTERS . . . By C. J. Starner, J. Q. Lawson and C. D. Mulford, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, August, 1955. The transmitter described utilizes phase-to-amplitude modulation, wherein high efficiency is obtained by performing the phase modulation at a low power level and amplifying to the final power level thru high efficiency Class C amplifiers. A brief review of the phase-to-amplitude modulation theory is presented, and a detailed electrical and mechanical description of the transmitter is included.

RADIATION MEASUREMENTS AT UHF AND VHF . . . By Dr. A. B. Glenn, Engineering Products Division, Camden, N. J. Presented before the National Electronics Conference and WESCON Convention, August 24-26, 1955 at San Francisco, California. A progress report on VHF-UHF radiation, representing IRE Subcommittee 27.3 was given. The function of this committee is to develop techniques for the measurement of radio interference generated by FM and TV receivers. The proposal of maximum radiation levels meant that the FM and TV receiver manufacturer was faced with the problem of reducing the spurious radiation from their receivers to meet these limits. The two primary objectives that were established were: (1) to determine the type and magnitude of the variations which can be expected and (2) if necessary, to suggest alternate methods for making the measurements. The results of the measurements show that variations as high as 6db at VHF and 12db at UHF can be expected with the present open field techniques. The major part of our effort will be placed on an indoor method, such as a "Free Space" room.

CHARACTERISTICS OF THE "PERFECT" LENS AND THE "PERFECT" TELEVISION SYSTEM . . . By O. H. Schade, Tube Division, Harrison, N. J. Presented at the IRE Western Electronic Show and Convention (WESCON), San Francisco, Calif., August 24-26, 1955. A "perfect" image is defined optically as an image in which the light-intensity distribution is determined by diffraction alone. In this case the finite boundary (lens stop) of a lens acts as a low-pass filter which determines the sine-wave spectrum of the perfect lens. A perfect television system can hence be defined as a system in which the performance is limited only by the electrical cutoff filter of the system and the optical filter requirements imposed by the raster process. It is shown that the performance of a "perfect" television system differs in many ways from that of a perfect lens and photographic system, and that a close approach to its performance is possible with practical systems.

NEW BEAM POWER TUBE FOR UHF SERVICE . . . By W. P. Bennett, Tube Division, Lancaster, Pa. Presented at the IRE Western Electronic Show and Convention (WESCON), San Francisco, Calif., August 24-26, 1955. Continued development work on uhf beam power tubes similar to type 6448 has resulted in a developmental design capable of delivering an output in excess of 25 kilowatts in uhf broad band black-and-white and color television service. This out-

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continued

put surpasses by a considerable margin the initial design objective of 15 kilowatts for the 6448. This paper describes the performance of such tubes in CW service in which gains of 80 and continuous power outputs of 20 kilowatts are possible. Typical operating conditions for various types of service are given and the novel tube design features which make this performance possible are described. Considerations for use of these tubes in pulse service are also included and novel r-f cavity circuits for pulse applications are described.

NOMOGRAPHS FOR MODIFICATION OF ELECTRON-TUBE PARAMETERS . . . By R. D. Reichert, Tube Division, Harrison, N. J. Presented at the IRE Summer Seminar, Emporium, Pa., August 26, 1955. This paper discusses the theory and use of three tube-design nomographs which make it possible to determine quickly the required modifications of physical parameters which will provide desired alterations in tube characteristics. A brief description is given of the electron-tube theory upon which the nomograph design is based. The use of the nomographs is explained by means of the solution of some typical design problems. The nomographs, which are applicable to many diode, triode, and pentode problems, include physical parameters such as interelectrode spacings, wire sizes and grid TPI's, together with tube characteristics. In the use of the nomographs, the parameters and characteristics of an existing tube type are the basis for the determination of the parameters required for a desired complement of characteristics. These design nomographs are useful in both the development of new tube types and the modification of existing types to maintain "bogie" characteristics in factory production.

LITTLE SPARES, BIG BUSINESS, AND BIG PROBLEMS . . . By H. R. Ketchan, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-Aug., 1955. The author describes spare parts as big business which will continue to be important and involve engineering problems. An organizational framework to manage the government spare parts business from a systems standpoint is described.

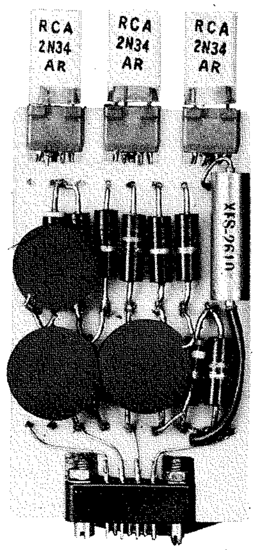
SOME PRACTICAL APPROACHES TO SYSTEMS ENGINEERING . . . By S. R. Parker, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-Aug., 1955. Systems behavior and systems engineering involve comprehending and analyzing overall system problems without becoming enmeshed in detail. Nine points are given as being helpful (1) understanding the problem (2) system simplicity (3) block diagrams (4) test procedures (5) new components (6) reliability (7) systems tests (8) coordination and (9) flow of information.

MINIATURE BROADCAST AMPLIFIERS USE ETCHED-WIRING TECHNIQUE . . . By G. A. Singer, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, August, 1955. A new line of Broadcast Audio Amplifiers which employ printed wiring are described. The new amplifiers effect considerable reduction in space requirement, provide improved performance, better uniformity, easier serviceability and lower power consumption.

NOTES ON INTEGRATION OF COLOR EQUIPMENT AND EXISTING MONOCHROME FACILITIES . . . Adapted from a paper by A. H. Lind, L. E. Anderson and N. J. Oman, Engineering Products Division, Camden, N. J. The paper was delivered at the 33rd NARTB Convention, Washington, D. C. Published in BROADCAST NEWS, August, 1955, the authors describe new equipment and recent techniques which apply to integrating color and monochrome in the TV plant.

HOW TO IMPROVE YOUR TECHNICAL TALKS . . . By J. B. Davis, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-Aug., 1955. The author emphasizes the importance of a logical arrangement of ideas and facts. These four steps are described (1) Select a descriptive title (2) Make a comprehensive outline (3) Write an introduction, and (4) Consult someone else.

TRANSISTORS IN CURRENT — ANALOGUE COMPUTING . . . By B. P. Kerfoot, Engineering Products Division, Moorestown, N. J. Presented at WESCON Conference and Convention, August 29, 1955 at San Francisco, California. A system of electronic analogue computing is described in which current is used as the variable. The paper demonstrates that the circuit properties of transistors make them especially suitable for use in operational amplifiers for this computing technique. Experimental amplifiers are shown which have been built and evaluated using low-power, low-frequency transistors. The factors which determine computing accuracy are analyzed, and a new technique of error prediction is discussed.



Transistor in Current—Analogue Computing

LOW-HUM CONSTRUCTION FOR TRANSFORMERS AND SOLENOIDS . . . By F. L. Putzrath, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-August, 1955. A relatively simple method is described for constructing transformers and solenoids that result in a significant reduction in the intensity of the external field—and therefore in the hum interference. This eliminates in the majority of cases any need for other hum reducing precautions.

EVALUATION OF RELAY DESIGNS . . . By T. J. Buroojy, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, July-Aug., 1955. The author describes five kinds of relays with similar electrical characteristics. Each has specific characteristics which peculiarly suit it to certain applications in the switching field. The advantages of reliability, long life and greater flexibility are pointed out.

DESIGN OF D-C TRACTIVE ELECTROMAGNETS . . . By M. Raymond Alexy, Engineering Products Division, Camden, N. J. Published in ELECTRICAL MANUFACTURING, July, 1955. All but the most complex types of d-c electromagnets may be designed using well established mathematical formulas. However, the calculations involve terms not readily manipulated by the engineer who designs such a device only occasionally. To ease the task, a simplified design method has been developed. The design is based on use of SAE 1113 steel and a set of curves plotted from data on several different sized electromagnets under a variety of conditions. A typical problem is solved to illustrate the procedure.

ALL-PASS AMPLIFIER . . . By Harry J. Woll, Engineering Products Division, Camden, N. J. Published in ELECTRONICS, July, 1955. A five-stage, 10 to 70-mc amplifier which uses parasitic capacitances of tubes as transmission elements beyond useful amplification range of tubes is described. Arbitrarily large gain-bandwidth products can be obtained by cascading a sufficient number of tubes.

APPLICATION OF DECISION THEORY TO COMMUNICATIONS PROBLEMS . . . By R. F. Drenick, Engineering Products Division, Camden, N. J. Presented at the Instituto Superiore Delle Telecomunicazioni in Rome, July 25, 1955. The paper is a brief and somewhat popularized account of the recent application of statistical decision theory to communication problems. In order to explain the connection between the two fields, a typical communication problem, namely, the design of a simple receiver, is formulated as a decision problem. A solution is then obtained for the case where the probability descriptions of signal and noise are known. It is shown that the optimum smoothing filter of Wiener is a special case of this solution. The classical objections are then reported which are often raised to this general type of solution and the modern minimax solution is introduced as a method of meeting these objections. It is illustrated by an example. The paper is concluded with a discussion of the usefulness of the minimax solution.

ANALYSIS OF AUTOMATIC BIAS CONTROL FOR THRESHOLD DETECTORS . . . By J. Dugundji and E. Ackerlind, Engineering Products Division, Los Angeles, California. Presented at the WESCON Conference and Show, August 24, 1955. A description was given of a method for automatically controlling the bias in a threshold detector so as to maintain constant false-alarm time (the average number of crossings with positive slope of a bias level by a noise voltage). An equation is derived for the detection of sure signals when automatic biasing is used.

AN INTRODUCTION TO ECHOSOUNDING . . . By Melvin Schoenfeld, New Products Engineering, Radiomarine Corporation of America. A revised version in English of the German "Echolotfibel" publication (Elac, Kiel, Germany) was edited by Mr. Schoenfeld. This book, written expressly for users of echosounding devices, attempts to equip the reader with a fundamental understanding of the principles of underwater acoustics and to acquaint him with the methods of applying these principles to sounding. Major emphasis is given to the proper techniques of operating chart and "scope" type units while navigating or fishing, and to the interpretation of chart records and scope presentations.

A NOISE HELMET . . . By M. E. Hawley and A. L. Witchey, Engineering Products Division, Camden, N. J. Presented at the summer meeting of the Acoustical Society of America, June 30, 1955. This paper describes a helmet-like enclosure which has been developed to generate high intensity sound fields about the head of the wearer. A cylindrical chamber with a loudspeaker in the top is mounted on the subject by attaching to football shoulder pads. A cooling blower, a window, and fill-in material are provided. 130 db overall noise levels have been obtained with 6 watts of audio power. Although originally conceived as a portable demonstration apparatus, the device has the advantages of being able to generate high sound levels inexpensively and to facilitate experiments involving communication from one kind of noise field to another.

THE EMPIRICAL DETERMINATION OF EQUIVALENT CIRCUIT PARAMETERS IN A FIRST ORDER GRADIENT MICROPHONE . . . By R. M. Carrell, Engineering Products Division, Camden, N. J. Presented at the Acoustical Society of America Meeting, June 30-July 2 at Penn State University. The equivalent circuit of the basic microphone element common to the M-32/A1C, M-33/A1C and M-34/A1C microphones designed for the Air Force set AN/AIC-10 was presented. An empirical procedure used to determine the magnitudes of the equivalent circuit parameters was described. The parameters evaluated include the effective area of the diaphragm, the diaphragm compliance, the mass of the voice coil and the $(Bl)^2$ factor in addition to the inertances and compliances of the acoustic system. An electrical analogue was built and its performance compared with that of the actual microphone element.

A DIRECT-READING ACOUSTICAL IMPEDANCE METER . . . By R. M. Carrell, Engineering Products Division, Camden, N. J. Presented at the Acoustical Society of America Meeting, June 30-July 2 at Penn State University. An acoustical impedance meter was described which uses a ribbon element to monitor the volume current flowing into a small cavity, one wall of which is the unknown impedance. The pressure developed within the cavity is measured by a condenser microphone. The acoustical path length between the ribbon and condenser microphones is minimized to extend the useful frequency range. Additional electronic circuitry can be used to give voltage outputs directly proportional to the total impedance as well as the reactive and resistive components individually. Absolute calibration of the instrument is accomplished with cavities of known volumes. Some measurements on cloth, membranes and metallic screens are presented.

EXPERIMENTS IN PEAK CLIPPING A MIXTURE OF SPEECH AND NOISE . . . By M. F. Hawley and W. F. Meeker, Engineering Products Division, Camden, N. J. Published and presented in the program of the summer meeting of the Acoustical Society of America, June 29, 1955. The paper describes indicative experiments performed to predict the effect on word articulation of various amounts of peak clipping on speech transmitted by a first order pressure gradient microphone used in 120 db simulated propeller aircraft noise. 0, 12, 24, and 36 db of peak clipping and subsequent reamplification were used; +6db/ octave pre-emphasis tilting (differentiation) and —6db/ octave de-emphasis tilting (integration) were also used in some experiments. Listeners in relative quiet (70 db) and in 100 and 120 db propeller aircraft noise heard the signals over headsets. In this situation of noise introduced before any processing, 24 db and 36 db of clipping deteriorated word articulation scores under all conditions; no significant difference was observed between 0 and 12 db of clipping.

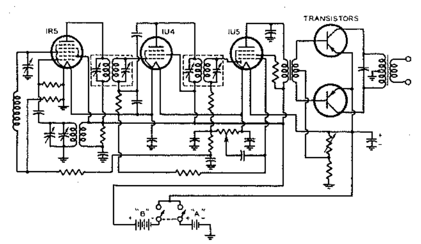
BASIC PROBLEMS IN FILM PICKUP FOR TV BROADCASTING . . . By E. M. Gore, Engineering Products Division, Camden, N. J. Presented at AIEE Summer Meeting, June 27-July 1 and published in TRANSACTIONS OF AIEE. Also published in ELECTRICAL ENGINEERING July 1955. The author describes how film is extensively used in TV programming for monochrome and color. Camera characteristics, receiver luminance, film contrast range and other factors are discussed and measures of film quality reviewed. A commercial color film camera using three vidicon pickup tubes is described.

COLOR EFFECTS AND HOW IT WORKS . . . By C. R. Monro, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, August, 1955. The author describes how a number of different color combinations are possible by feeding video signals into various combinations of one, two, or all three inputs of an RCA Colorplexer. Color patterns are produced in the output signal and combinations of pulses from Color Bar Generator form three primary colors and their three mixture colors. Similarly a monochrome signal may be fed into the Colorplexer to yield a result in two colors.

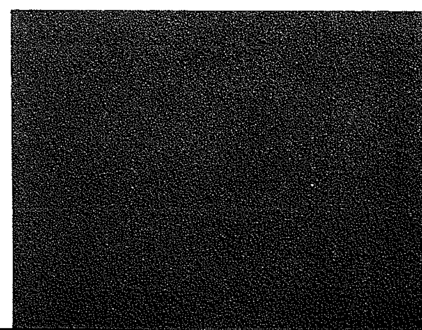
CONTROL OF LIGHT INTENSITY IN TELEVISION PROJECTORS . . . By K. Sadashige and B. F. Melchionni, Engineering Products Division, Camden, N. J. Published in SMPTE JOURNAL, August, 1955. The authors describe RCA's television projectors which are used with vidicon film cameras and are equipped with a light-intensity control unit developed for this purpose. The unit is used to control the video output level of the camera by varying the intensity of the projector light source to compensate for varying film density. The angular position of a continuously variable neutral-density filter wedge placed in the condenser-lens system of a projector is remotely controlled by a servomechanism. Thus the signal-to-noise ratio of the system is maintained at its optimum value since the camera is operating with essentially constant input level.

CLASS B OPERATION OF AUDIO-FREQUENCY JUNCTION TRANSISTORS . . . By K. E. Loofbourrow, Tube Division, Harrison, N. J. Published in ELECTRONIC DESIGN, July and August, 1955. Among the advantages gained by operation of a-f junction transistors in class B in the power-output stages of battery-operated portable amplifiers are high collector-circuit efficiency, low stand-by idling current, and a higher ratio of power output to collector dissipation per transistor than can be realized from operation of the same transistors as class A power amplifiers. The inherently high efficiency of class B service permits the design of portable equipments using small batteries compatible with the low power requirements of the amplifier and, therefore, having extremely small size and light weight, or equipments using conventional battery sizes and thus having substantial improvements in battery life and a reduction in operating cost per hour.

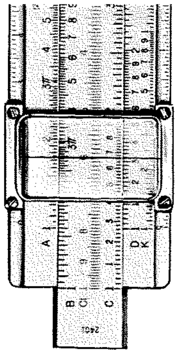
Transistor characteristics applicable to large-signal amplifier operation are discussed in this paper with respect to their effect upon circuit performance. The advantages and the limitations of some of the more important large-signal amplifier circuits are presented, including the effects of supply voltages, load impedance, peak collector currents, collector back currents, mismatched transistor characteristics, and ambient temperature upon circuit performance. Data are included for power output, power sensitivity, input and output impedance, distortion, and dc operating conditions. Methods of temperature compensation and circuit stabilization applicable to transistor class B amplifiers are shown.



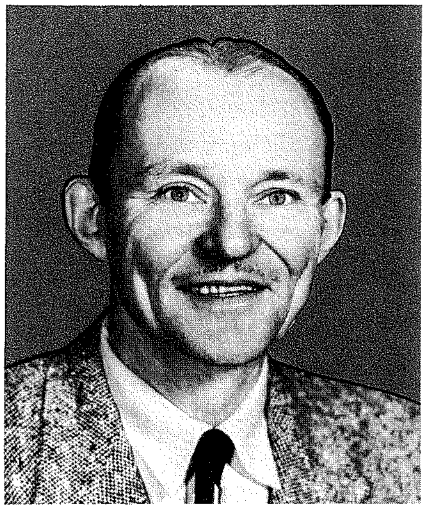
Circuit for Transistorized Receiver



Engineering NEWS *and* HIGHLIGHTS



ENGINEERING PERSONALITIES IN THE NEWS



M. Rettinger

M. RETTINGER ACOUSTICS CONSULTANT TO RCA IN EUROPE . . . During the summer of 1955, M. Rettinger, of Hollywood Engineering, EPD, was called to Europe to act as consultant on acoustics for three of our associated companies there—RCA Photophone Ltd., London, RCA Italiana, at Rome, and Industria Electronica, at Madrid.

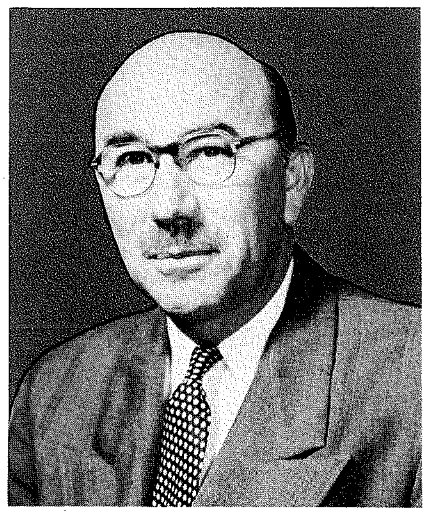
As is well known, in the fall of 1955, television programs in England will no longer be put on by the BBC alone, but will also have commercial sponsors. This condition has resulted in considerable activity for the RCA company in London, which is well equipped with factory space and personnel to build practically any kind of electronic equipment.

In Rome and Madrid, new modernistic record processing factories have recently been constructed. The Italian factory is located just a few miles outside of Rome, while the music recording studio is in Rome proper. The studio can also be employed for the making of Italian versions of American films.

MICHAEL RETTINGER graduated from the University of California at Los Angeles in 1933, receiving his Bachelor's and Master's degrees in Physics. After graduating he joined the Pacific Sound Insulation Company in Los Angeles. In 1936 he joined the Engineering Department of RCA Photophone, Hollywood, where he was active in sound engineering. After the war, when the manufacture of motion picture sound recording equipment shifted to Hollywood, he also became engaged in supervising the construction of microphones and headphones, and in developing magnetic recordings and erasing heads. He is an associate member of the SMPTE and the Acoustical Society of America.

J. R. SHOAF II, engineer in the Radio and "Victrola" Division, recently returned after an assignment of several months in Spain and RCA's Spanish plant, Industria Electronica, S. A., in Madrid. He supervised the setting up of production assembly of record changers and four "Victrola" models, both 45 rpm and 3-speed instruments. This factory, which also produces all types of phonograph records, is one of the newest and most modern of RCA International's world-wide associated companies.

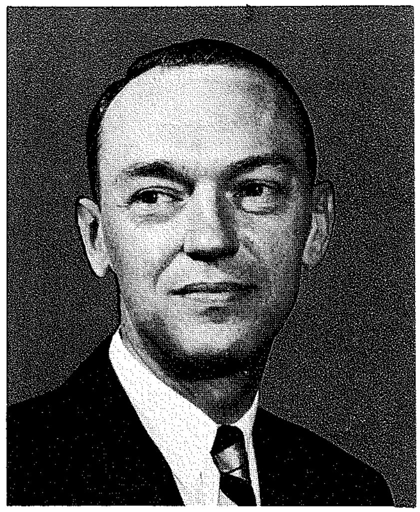
DR. A. H. BENNER, GENERAL ENGINEERING DEVELOPMENT, EPD, was the technical director of the Operations Planning Group of the Army's A-1 priority *Project Monmouth.* This project comprised a two-month study called by the Signal Corps Advisory Board. The program consisted of about 40 of the country's top engineers and scientists recruited directly from Industry.



H. R. WEGE HONORED

The Epsilon Chapter of Sigma Tau, National Engineering Honor Fraternity, of Kansas State College, recently elected H. R. Wege to the Alumni Membership in recognition of outstanding achievement in the field of Engineering Management. Initiation was conducted by the Nu Chapter at Swarthmore College, Swarthmore, Pennsylvania.

Mr. Wege, Chief Product Engineer, Missile & Radar Engineering, recently completed thirty years of service with RCA. He is a graduate of Kansas State College and was a recipient of the 1954 RCA Victor Award of Merit.



T. A. SMITH APPOINTED TO RETMA POST

RETMA STREAMLINES ORGANIZATION . . . T. A. SMITH APPOINTED DIVISION CHAIRMAN—At the final business session of its three-day convention, the Radio Electronics Television Manufacturers Association amended several of its by-laws to streamline the Association to better serve the member-companies. Among other changes, members authorized the establishment of a military products division and approved the consolidation of the former amplifier and sound equipment division as a section within the technical products division. The RETMA board abolished the former radio-television industry committee and the electronics industry committee, and reduced its own membership from 62 to 41.

T. A. Smith, Vice-President of the Engineering Products Division, was appointed Division Chairman, Military Products Division in the RETMA re-organization.

M. S. GOKHALE, MANAGER OF MECHANICAL STANDARDS, Corporate Standards, and President of the Standards Engineering Society, presided at the 4th National Convention of the Standards Engineering Society at the Hotel Statler, Hartford, Conn., September 29, 30 and October 1, 1955.

Mr. Gokhale graduated from Union College in Schenectady with a BS in EE in 1927, and came to work with RCA in 1930, being transferred from General Electric Company. He has been Manager of Mechanical Standards since 1944. Mr. Gokhale is secretary of the RCA Standards Policy Committee, Editor of the RCA Drafting Manual, and represents RCA on a number of subcommittees of ASA Sectional Committee Y14 on drawing room standards for sheet metals, plastics and die castings.

Engineering
NEWS *and* **HIGHLIGHTS**
continued

NEW RCA PLANTS ANNOUNCED

RCA TUBE DIVISION TO EXPAND FACILITIES AT LANCASTER . . . RCA has completed arrangements to purchase an additional 285,000 square feet of building space at Lancaster, Pa., as a part of its program for the accelerated production of color television picture tubes. The property to be acquired consists of a group of buildings formerly occupied by Stehli & Company, Inc. It is located on a 14-acre tract near the present Lancaster plant of the RCA Tube Division.

RCA plans to take possession of the additional facilities as soon as possible. Immediate steps will then be taken to equip the new buildings for the efficient handling of color kinescopes and other electron tubes manufactured by RCA at Lancaster, in order to meet increasing production demands.

RCA SERVICE COMPANY TO OPEN REPAIR SHOP IN NEW YORK FOR COMMERCIAL AND INDUSTRIAL ELECTRONIC EQUIPMENT . . . New facilities in New York City were opened for the repair, modification and overhaul of all RCA commercial and industrial electronic equipment on September 12. Located at 419 West 54th Street, the shop supplements the Company's present similar facilities in Camden.

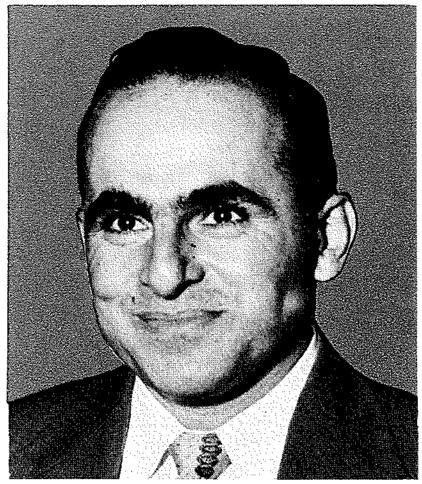
The new shop will serve RCA equipment users in the New York Metropolitan area, such as broadcasters, schools, electronic distributors, and service agencies. The shop is equipped with modern test and measuring devices for the repair, reconditioning and modification of all RCA electronic equipment. Under the management of J. J. Brown, this latest addition to RCA's expanding service facilities will be staffed with factory trained personnel.

EPD LOS ANGELES ENGINEERING EXPANDS FACILITIES . . . Steady expansion of Los Angeles Engineering, of Engineering Products Division, has necessitated obtaining more space. The new building, at 2254 South Sepulveda Blvd., is located a few blocks from the main plant. Approximately 50 engineers, draftsmen, and other personnel are now using this added facility, and are working on one project. Offices are located at the front of the building in both the first and second floors. The rear of the building is used for laboratories.

New engineering facilities at EPD Engineering in Los Angeles

NEW EDITORIAL REPRESENTATIVES APPOINTED IN TELEVISION DIVISION

W. A. Sonntag



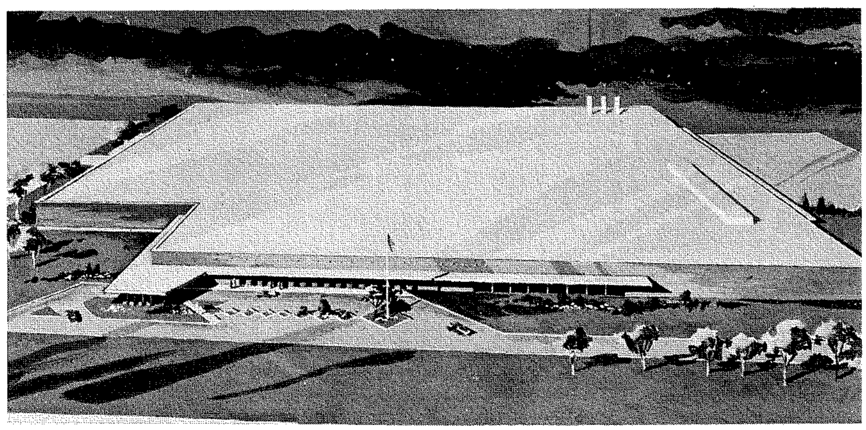
J. Osman

The RCA Victor Television Division has recently appointed Editorial Representatives for the RCA ENGINEER at the Bloomington and Indianapolis Plants. These appointments were made to include Resident Engineering in the scope of coverage of the RCA ENGINEER.

W. A. SONNTAG, Resident Engineering at the Bloomington Plant, received the BS degree in EE from Purdue University in February, 1948. He has been employed by RCA since that date. Mr. Sonntag started with RCA as a Test Design Engineer, and transferred to the Resident Engineering Section in March, 1951. He is a member of the IRE.

J. OSMAN, Electrical Engineer at the Indianapolis Plant, received the BS degree in EE from Rose Polytechnic Institute in 1942. Following graduation he joined the Studio Broadcast Equipment group at RCA, Indianapolis, as a Design Engineer.

From 1943 to 1950 he served as liaison engineer and coordinator on various projects, including the M-7 mechanism, RC-199 Signal Corps project and on two guided missile projects. In 1950 Mr. Osman transferred to the Resident Engineering Department of Home Instruments at Indianapolis, where he is at present electrical group leader, RCA Victor Television Division.



The architect's sketch of the new Tube Division plant to be constructed in Bridgewater Township in N. J. The plant will be used for manufacture of semi-conductor devices.

TUBE DIVISION WILL BUILD $3,000,000 PLANT IN N. J. FOR SEMICONDUCTOR PRODUCTION . . . Construction by the Tube Division of a $3,000,000 plant in Bridgewater Township, near Somerville, N. J., will begin this fall. The new plant, which will be erected on an 83-acre plot, is expected to be ready for operation by late 1956. It will serve as engineering and manufacturing headquarters for the semiconductor activities of the RCA Tube Division, providing facilities in addition to those in Harrison, N. J. for handling the rapidly growing demand for transistors and diodes.

Plans for the Bridgewater plant call for the erection of a one-story structure of modern design having approximately 126,000 square feet of floor space.

COMMITTEE APPOINTMENTS

ENGINEERING PRODUCTS DIVISION . . . N. R. KORNFIELD, Circuit Advanced Development in Section 598, has been appointed to the subcommittee on Ferro-electricity of the AIEE.

M. C. BATSEL, Chief Engineer, Engineering Products Division, has been elected Chairman of the IRE National Administrative Committee of the Professional Group on Engineering Management.

R. H. BAKER of Standards Engineering has been appointed a member of the Technical Program Committee for planning, a joint RETMA-IRE-AIEE Electronic Components Symposium.

SIDNEY KAPLAN of EP Computer Systems Engineering has been appointed Chairman of Session on Sorting, Association for Computing Machinery.

H. C. STARAS of General Engineering Development has been appointed a member of USA National Committee of Commission II, International Radio Scientific Union (URSI).

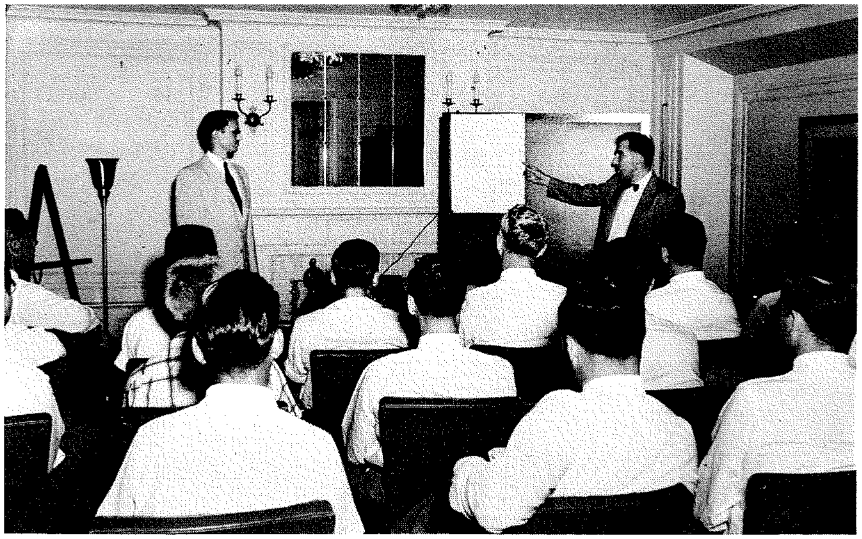
TUBE DIVISION . . . R. S. BURNAP, Manager, Commercial Engineering, Tube Division Harrison, has accepted reappointment to the committee of Standards of the AIEE.

M. H. WATSON, Cost Reduction Engineer of Manufacturing Standards, Lancaster Tube Plant, was elected President of the Central Penna. Chapter of the American Materials Handling Society.

OFFICERS FOR THE 1955-56 SEASON APPOINTED AT PHILA. SECTION IRE . . . The officers for the 1955-56 season of the Philadelphia section of the IRE were elected by the Executive Committee. RCA engineers elected to posts are as follows: M. S. Corrington, Television Division Advanced Development, Cherry Hill, was elected Vice-Chairman.

E. D. Blodgett, EPD Engineering Technical Administration, was elected Chairman of the Publication and Publicity Committee for the second consecutive year, with J. B. Davis, EPD Engineering Editor, continuing as Editor of the IRE Bulletin; M. Bocciarelli, Managing Editor; J. A. Bauer, Theatre and Industrial Equipment Engineering, as Advertising Manager; and L. A. Thomas, General Engineering Development, as Poster Editor.

Other members of RCA elected to posts are: L. H. Good, Optical and Recording System Development, EPD, Chairman of the Meetings and Papers Committee and Vice Chairman of the Professional Group on Audio; H. E. Roys, Optical and Recording Development, EPD, Chairman of the Awards Subcommittee; W. A. Harris, Aviation and Communications Engineering, EPD, Vice Chairman of the Professional Group on Aeronautical and Navigational Electronics; J. F. Underwood was made Secretary of this Group. M. D. Feyerherm, Standards Engineering, EPD, was elected Vice Chairman of the Professional Group on Component Parts; J. W. Leas, Manager, Computer Engineering, EPD, Vice Chairman of the Professional Group on Engineering Management; D. C. Bowen, Corporate Standardizing, Chairman of the Membership Committee; N. R. Kornfield and I. N. Susskind, Computer Engineering, EPD, Co-Chairmen of the Membership Committee of the Professional Group on Electronic Computers; R. H. Baker, Manager of Standards Engineering, EPD, has been appointed to the Membership Committee and will have responsibility for new membership activities in EPD Engineering.



J. J. Davidson and L. M. Krugman of Advanced Development Engineering, Radio and "Victrola" Division, Cherry Hill, leading the conference on transistors at the George Washington Hotel, Canonsburg, Pa.

RADIO & "VICTROLA" DIVISION CONDUCTS TRANSISTOR SYMPOSIUM . . . A symposium on transistors and their application in radio receiver design was held within the Radio and "Victrola" Division during the period from June to September. Mr. Paul R. Bennett, manager of engineering, initiated the program for the purpose of acquainting both engineering and the manufacturing plants with the problems and latest thinking in transistor circuit design and measuring techniques. The lectures were held at both the Cherry Hill and Canonsburg Pa. locations.

The following is the outline of the program.

Subject	*Lecturer*
Fundamentals of Transistor Physics	L. M. Krugman
Class A and B Audio Output and Driver Stage Considerations	W. Hasenberg
Detector-AGC Circuits	J. J. Davidson
Converter Circuits	L. M. Krugman
Intermediate Frequency Transformers and Circuits	J. B. Schultz
Temperature Stability Considerations	J. B. Schultz
Receiver Measuring Techniques and Description of 7BT9 and 7BT10	P. Gallo

RADIOMARINE NEWS

NEW COASTAL STATION . . . In September ground was broken for the erection of a new marine coastal station at West Creek, N. J. Unlike its predecessor, comprised of receiving and transmitting installations several miles apart, the new station will be a "unit" station with receiving and transmitting facilities housed in the same building.

In 1954 a similar "unit" station was built at Lantana, Florida. Through advances in engineering the maze of wires formerly associated with coastal radiotelegraph stations is conspicuously absent, as the picture of the operating-transmitter shows. The vertical radiator and the associated transmitting and receiving antenna are located within several hundred yards of the operating building.

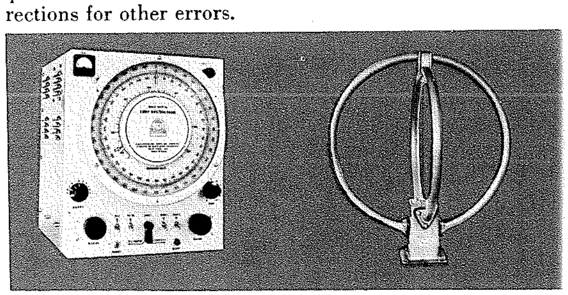
Power, coaxial cables, tuning controls, telegraph lines, etc. and all connections to the building itself have been placed underground.

Here, technical improvements combined with architectural simplicity to create a pleasing effect, which is the modern version of the busy coastal radio station.

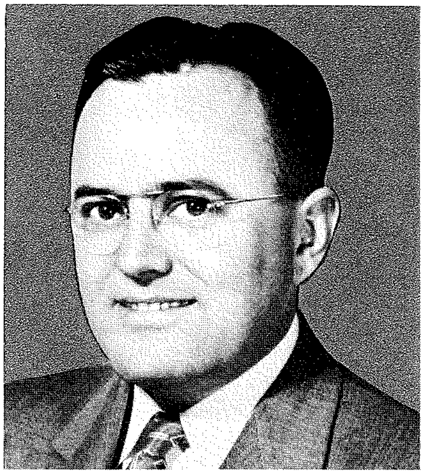
NEW FIXED-LOOP DIRECTION FINDER . . . Radiomarine has announced its new, compact, highly sensitive fixed-loop direction finder, Model AR-8714. It is designed primarily for shipboard application and to comply with the latest applicable rules and regulations of the Safety of Life at Sea Convention (London 1948), the U. S. Maritime Administration and the F.C.C.

With the modern AR-8714, a ship's position can be determined from a lighthouse or lightship beacon signal over relatively great distances through fog, darkness and other visual handicaps. The equipment consists of two basic units—a rugged fixed loop, and a sensitive radio receiver with null meter and peak tuning indicator. The receiver tuning range of 280-525 KC includes the international marine radio beacon band and other frequencies used by ships and stations.

The AR-8714 provides the user with simultaneous true and relative bearings. It features a gyro-repeater driven compass scale and automatic electrical correction for quadrantal error as well as mechanical corrections for other errors.



Engineering NEWS *and* HIGHLIGHTS *continued*



M. S. Corrington

REPORT WRITING COURSE COMPLETED AT CHERRY HILL . . . A 10-session course in technical report writing was completed September 15 at Cherry Hill. The course, conducted by M. S. Corrington, Advanced Development Engineering, Television Division, was designed as a practical course for men writing technical reports, for publications, and who will speak before technical societies.

Twenty-six engineers from the RCA Victor Radio and "Victrola" and Television Divisions, and RCA Service Company at the Cherry Hill location attended the one-evening-per-week course, which started June 21, 1955.

Among the texts used in the course was, "*Why Engineers should Write Technical Papers*," by M. S. Corrington, Vol. 1, No. 1, RCA ENGINEER.

RCA RELIABILITY CONFERENCE ON MILITARY ELECTRONICS HELD SEPT. 20 AT WRIGHT-PATTERSON USAF BASE . . . A reliability conference, co-sponsored by RCA and the U. S. Air Force, was attended by representatives of the Headquarters Air Research and Development Command, Wright Air Development Center, and Air Materiel Command's quality control, production and procurement, and maintenance engineering activities. More than 500 were present.

The reliability conference followed the pattern of a similar meeting conducted in Philadelphia in August by RCA and USAF for more than 300 designers, manufacturers, and users of military electronics.

The program dealt with advanced ideas and techniques for designing greater operating reliability into increasingly complex military electronic equipment.

RCA AWARDED CONTRACT FOR NON-ENTERTAINMENT COLOR TELEVISION SYSTEM . . . The nation's first installation of compatible color television for hospital use will be made by the RCA to serve three Government medical activities located at the Walter Reed Army Medical Center, Washington, D. C. The comprehensive installation will provide three complete color television systems for use by the Armed Forces Institute of Pathology, the Walter Reed Army Hospital, and Army Medical Service Graduate School. The installation represents the largest compatible color television system so far developed for non-entertainment applications. Installation, now underway is scheduled for completion early next year. The system will be operated by the Army Signal Corps.

The installation will include the three separate and complete color television broadcast studios which can be operated independently, or joined for operation as a combined network. Each will be equipped for closed-circuit TV operation and for direct transmission to commercial television network lines.

One system will be installed in the new building of the Armed Forces Institute of Pathology, central laboratory for the U. S. Army, Navy, and Air Forces, as well as other Government agencies. The color system will be utilized to further its research, teaching, and consultation services.

A second system will be installed at the Walter Reed Army Hospital for primary use in the teaching and demonstration of surgical procedures.

The third system will be at the Army Medical Service Graduate School, which provides military medical personnel with instructions in latest medical, dental, and veterinary techniques.

Thirty RCA Victor 21-inch color television receivers, distributed among the three locations, will be utilized for viewing the pictured transmitter from the three broadcast studios.

RADIO AND "VICTROLA" DIVISION FORMS 'ENGINEERING SERVICES' SECTION . . . The formation of an Engineering Services section in the Radio and "Victrola" Division's Engineering department has been announced by Mr. J. L. Franke, Chief Engineer of the Radio and "Victrola" Division. Mr. Franke is acting manager of the section.

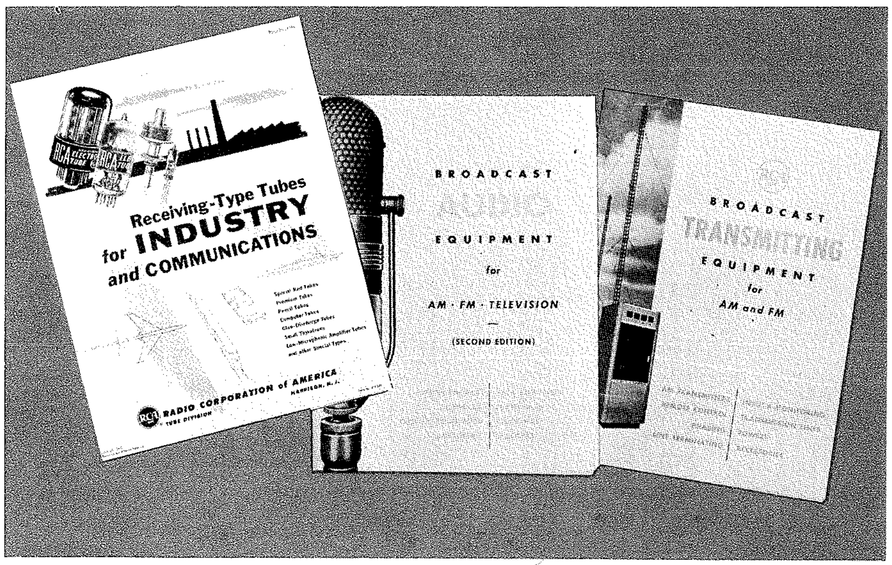
The new service is intended to reduce the number of tasks performed by individual engineers that are not considered a part of normal design work. The personnel of the section are: D. A. Baskin, leader; J. W. Sadlier, packing design; and J. A. Keliner, procurement clerk.

RCA-CHERRY HILL HOLDS OPEN HOUSE FOR PHILA. SECTION OF IRE . . . All members of the Philadelphia Section of the IRE were invited to an Open House at Cherry Hill on Wednesday evening, Oct. 5, 1955, it was announced by M. S. Corrington, Vice Chairman, Philadelphia Section, IRE and member of the RCA Victor Television Division.

A steak dinner was served at Cherry Hill, followed by a talk by Mr. R. F. McCaw on the construction of the Cherry Hill Plant. In the evening there was a guided tour of the Engineering Building, Model Shop and Hall of Progress, with ten exhibits set up in the Engineering Building. The exhibits were explained by RCA engineers during the course of the tour.

Mr. David Carlson was Chairman of the Exhibits Committee and Mr. E. O. Johnson arranged for the guides.

ENGINEERING DATA AND CATALOGUES



TUBE DIVISION ANNOUNCES BOOKLET ON RECEIVING-TYPE TUBES FOR INDUSTRY AND COMMUNICATIONS . . . This 20-page technical booklet (Form No. RIT-104) contains technical data on 130 small industrial tubes including Special Red tubes, premium-tubes, pencil-type tubes, computer tubes, glow-discharge tubes, small thyratrons, low-microphonic amplifier tubes, and other special types.

Each tube type except those in the latter group is covered by a text description, tabular data, and a base or envelope connection diagram. In addition, representative tube types are illustrated.

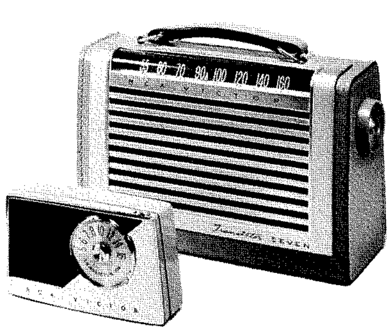
BROADCAST AND AUDIO TRANSMITTING CATALOGUES ANNOUNCED . . . Broadcast Marketing of Engineering Products Division has announced two technical catalogues: "Broadcast Transmitting Equipment for AM and FM" and "Broadcast Audio Equipment for AM-FM-Television" (second Edition). Each contains complete technical details, including specifications, curves, photos and data on transmitters, remote control, phasing line terminating, input and monitoring, transmission lines, towers and accessories; microphones, consoles, custom equipment amplifiers, rack equipment, turntables, recorders and speakers.

NEW PRODUCTS

The **RCA-200** is a new projector designed to replace the RCA-100 for both indoor and drive-in-theater use. Water-cooled aperture-unit mechanisms are available for increased illumination without undue heat, and other features include: main and reverse shutters housed together in a single rear casing, but with the reverse shutter independently driven; 4-in. lens mount; sealed ball bearings; simplified film-threading; and automatic loop-setting pad rollers.

BATTERY - OPERATED PORTABLE RADIO - PHONOGRAPH COMBINATION ANNOUNCED . . . The RCA Victor Radio and "Victrola" Division has announced a battery-operated portable radio-phonograph combination (Model 6BY4) with an optional powerpack for a-c power operation. The new combination—the first to be marketed by a major manufacturer—operates from its own self-contained batteries, using an A/B pack and four smaller batteries. The unit is housed in a compact plastic cabinet, and contains a single-play 45 turntable powered by a constant-speed motor than assures the proper speed throughout the life of the batteries.

The lid is styled so it covers only the record player, permitting the radio to be tuned with the lid closed. The optional external powerpack for a-c operation will be available.



ALL-TRANSISTOR PORTABLE RADIOS ANNOUNCED . . . Two all-transistor portable radios—one in the miniature size with six transistors and the other featuring a larger loudspeaker and case with seven transistors—were announced by the RCA Victor Radio and "Victrola" Division, for introduction during the fourth quarter. Both the six-transistor set (Model 7BT9) and the seven-transistor set (Model 7BT10) will be nationally announced at $79.95. The Model 7BT9 will come in a plastic case measuring 5½" x 3¼" x 1½". The Model 7BT10 will be in a size comparable to the present RCA Victor "Personal" conventional portable radio, 10" x 6-9/10" x 3½".

NEW PRODUCT INSTALLATIONS

ITV EQUIPMENT INSTALLED AT STEVENS COLLEGE . . . J. H. Greene, RCA Service Company's ITV specialist, has completed the installation of a three-camera chain ITV equipment to be used for educational purposes at the Stevens College, Columbia, Missouri.

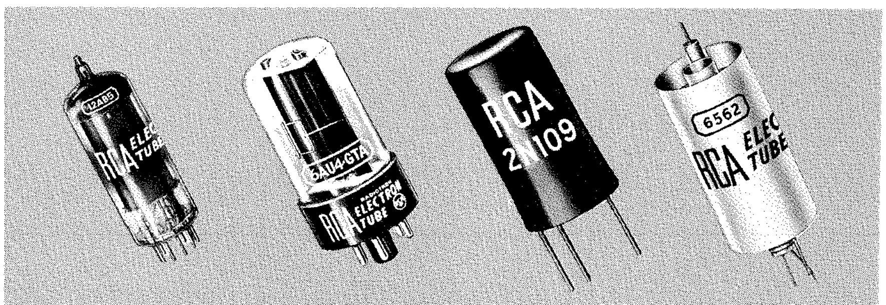
'RECTANGULAR SLOT' VHF ANTENNA INSTALLED BY RCA AT TV STATION KCOP . . . A high-band VHF television transmitting antenna which obviates need for conventional diplexing equipment and techniques has been installed by the RCA at station KCOP-TV, atop Mt. Wilson near Los Angeles.

The RCA-developed antenna, named the 'Rectangular Slot', eliminates diplexing by means of separate visual and sound sections which are fed by individual power lines. Designed for operation on high-band VHF channels, from 7 to 13, the new antenna is particularly adaptable for installations with special gain or pattern-shaping requirements, or with multiple-antenna and antenna-stacking problems.

THE UNION OIL COMPANY of California has installed a three-station microwave system using RCA MM-26A 2700 mc Multi-channel transmitting and receiving equipment, and extending from Santa Paula through Torrey Hill to Mulholland, Cal. The overall length of 35 miles provides three trunkline telephone circuits and five telemetering channels for observation of conditions at the Mulholland pressure regulating station.

AKERS MOTOR LINES, INC. TO INSTALL RCA VHF COMMUNICATIONS SYSTEM . . . Akers Motor Lines, one of the nation's largest motor transport firms, has contracted for installation of RCA two-way radio communications equipment. The radio installations will provide RCA Fleetfone mobile radios in 220 local pickup and delivery vehicles in 24 key terminals of the Akers system. Each of the 24 terminals, extending from Boston, Mass. to Albany, Ga., will be equipped as Fleetfone base stations.

The Akers firm operates more than 1,000 vehicles over an 11-state area of the Eastern Seaboard, with a total of 52 terminals and call-stations strategically located from Massachusetts to South Georgia.



NEW RCA TUBE TYPES

RCA-6AU4-GTA is a half-wave glass-octal type vacuum rectifier particularly suited for use as a damper diode in both color and black and white television receivers. The tube is rated to withstand a maximum peak inverse plate voltage of 4500 volts (absolute), a maximum peak plate current of 1150 ma.

RCA-12AB5 is a 9-pin miniature type beam power tube designed for use in the output stage of an automobile radio receiver operating from a 12-volt storage battery. Design features which particularly suit the 12AB5 to automobile receiver use include (1) a large plate structure to allow for improved heat dissipation, (2) a heater specially processed to withstand the severe operating conditions encountered during battery charging and discharging, and (3) double base-pin connections for grid No. 1 and grid No. 2 to provide for cooler grid operation and greater flexibility of circuit connections.

RCA-6562 is a fixed-tuned uhf oscillator "pencil type" triode for radiosonde applications similar to the 5794, but having its cathode externally connected to one of the heater leads to simplify circuit connections. The design of the 6562 incorporates a pencil-type construction with two integral resonators of the cavity type. One of the resonators is fixed tuned and is connected between grid and cathode. The other, which is connected between grid and plate, is tuneable over a narrow range centering at 1680 mc and is loop-coupled to an r-f coaxial output terminal. Features contributing to the usefulness of the 6562 in radiosonde service include high efficiency, small frequency drift, low battery drain, and small size.

RCA-2N109 is a new, alloy-junction transistor of the p-n-p type intended especially for use in large-signal applications such as class B audio service, and as a high-gain class A driver device. The 2N109 has characteristics which permit the design of amplifiers requiring high power sensitivity, low distortion, high power efficiency, and low battery drain. This transistor, therefore, is particularly applicable to the design of battery-operated portable radio receivers having a transistorized output stage. Use of the 2N109 in such receivers will result in power sensitivities closely approaching those of portable radio receivers employing electron tubes in the output stage.

RCA-3BZ6 is a semiremote-cutoff pentode of the 7-pin miniature type intended for use particularly in the gain-controlled picture i-f stages of television receivers. This tube is designed with a 600-ma heater having a controlled warm-up time to insure dependable performance in television receivers employing series-heater string arrangement. The semiremote cutoff of the 3BZ6 reduces cross-modulation effects in the picture i-f stages, and minimizes distortion resulting from high signal levels and automatic gain control time delay. In addition, the high transconductance of 6100 micromhos contributes to high gain per stage. The 3BZ6 envelope is the same as the 6BZ6.

Engineering
NEWS and HIGHLIGHTS
continued

RCA SHOWS WEATHER RADAR AND OTHER PRODUCTS AT WESCON . . . Weather-detection radar equipment having a range of 150 miles was the feature exhibit of the Engineering Products Division during the Western Electronics Show and Convention, August 24-26, in San Francisco's Civic Auditorium. The RCA weather-detection radar will be placed into passenger service this fall by several commercial airlines.

Other highlights of the RCA display included a recently announced transistorized adapter amplifier (see *RCA Engineers Design First Air Force Equipment Using Transitors*, RCA ENGINEER, Vol. I No. 2), and a Loran receiver for use in long-range navigation in long-distance aircraft.

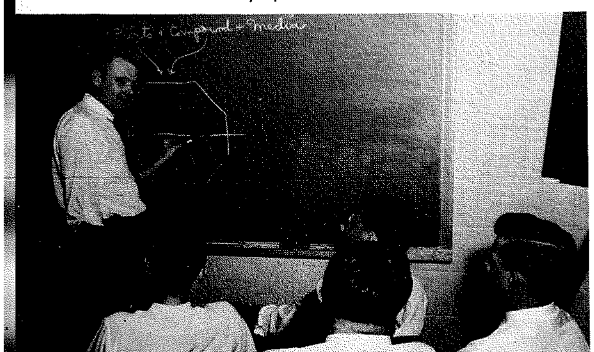
Tubes and components for color television receivers, a complete set of color test equipment, and a plastic-encased chassis of a color receiver highlighted the display of the Tube Division. This exhibit also included ten types of power tubes; four multiplier phototubes; three types for microwave transmission; four "Special Red" tubes designed for long life and durability; seven "pencil" types; seven tubes for use in computers; and fifteen "premium" types. The Tube Division also displayed three Geiger counters; four commercially available transistors and six crystal diodes; a selection of batteries for industrial use and new types recently developed for transistorized battery-operated radio receivers.

SYMPOSIUM ON PARTS MAKING EQUIPMENT AND PROCESSES CONDUCTED AT MARION . . . Marion Parts Plant Engineering of the Tube Division has been conducting a Symposium on Parts Making Equipment and Processes. The Symposium began May 5, 1955, and meets approximately twice a month. The meetings are scheduled to continue to October 24, 1955.

The speakers and subjects are:

J. Beuoy	Grinding
W. M. Neale	Cataphoretic Coating
J. C. Dobie	Four-slide Operation
H. P. Horwitz	Coil Winding
P. L. Hinton	Eyelet Machines
T. J. Morris	Drawing Dies
S. B. Wielgolinski	Stud Welding
J. DeGraad	Barrel Finishing
T. C. Hudgins	Standard Costs
H. Larivey	Forming and Embossing Dies

J. DeGraad speaking on Barrel Finishing at the Marion Symposium



ENGINEERING MEETINGS AND CONVENTIONS

October-December, 1955

OCTOBER 3-5
National Electronics Conference
Hotel Sherman
Chicago, Ill.

OCTOBER 3-7
AIEE Fall General Meeting
Morrison Hotel, Chicago, Ill.

OCTOBER 3-7
78th Convention of SMPTE
Lake Placid Club
Essex County, New York

OCTOBER 10-12
AMA Conference on Automatic Production
Hotel Roosevelt
New York, N. Y.

OCTOBER 11-13
AIEE Aircraft Electronics Equipment Conference
Los Angeles, Calif.

OCTOBER 12-15
1955 Convention of the Audio Engineering Society concurrent with the Audio Fair
Hotel New Yorker
New York, N. Y.

OCTOBER 17-19
RETMA Fall Meeting
Hotel Syracuse
Syracuse, N. Y.

OCTOBER 20-22
Eighth Annual Gaseous Electronics Conference
GE Research Lab
The Knolls
Schenectady, N. Y.

OCTOBER 21-23
New England Hi-Fi Show
Hotel Touraine, Boston, Mass.

OCTOBER 24-25
First Annual Technical Meeting
IRE Professional Group On Electron Devices
Shoreham Hotel
Washington, D. C.

OCTOBER 24-26
Sixth National Conference on Standards (ASA and NBS)
Sheraton Park Hotel
Washington, D. C.

OCTOBER 25-27
International Conference on Electronic Digital Computers and Information Processing
Darmstadt, Germany

OCTOBER 26-28
Fourth Annual Conference Atomic Energy In Industry, NICB
Waldorf-Astoria Hotel
New York, N. Y.

OCTOBER 27-28
Aircraft Electrical Society 12th Annual display of aircraft equipment
Pan-Pacific Auditorium
Los Angeles, Calif.

OCTOBER 28-29
1955 Symposium of Philadelphia ISA
Penn Sherwood Hotel
Philadelphia, Pa.

OCTOBER 31-NOVEMBER 1
1955 East Coast Conference on Aeronautical and Navigational Electronics, IRE
Lord Baltimore Hotel,
Baltimore, Md.

OCTOBER 31-NOVEMBER 1
International Conference on Scientific Basis of Applied Solar Energy
University of Arizona
Tucson, Ariz.

OCTOBER 31-NOVEMBER 4
East Coast Conference on Acronautical and Navigation Electronics
Baltimore, Md.

NOVEMBER 1-5
World Symposium on Applied Solar Energy Sponsored by AASE
Stanford Research Institute and University of Arizona
Phoenix, Ariz.

NOVEMBER 3-4
Eighth Annual Electronics Conference
Kansas City IRE
Town House
Kansas City, Kan.

NOVEMBER 7-9
IRE, AIEE, ACM Eastern Joint Computer Conference
Hotel Statler
Boston, Mass.

NOVEMBER 14-15
IRE Symposium on Communication by Scatter Techniques
Lisner Hall of George Washington Univ.
Washington, D. C.

NOVEMBER 14-16
IRE, AIEE, ISA Electrical Technology in Biology & Medicine
Shoreham Hotel
Washington, D. C.

NOVEMBER 15-17
Second International Automation Exposition
Navy Pier
Chicago, Ill.

NOVEMBER 21-22
IRE Aeronautical Communications Symposium
Hotel Utica
Utica, N. Y.

NOVEMBER 28-30
IRE Instrument Conference & Exhibit
Hotel Biltmore
Atlanta, Ga.

DECEMBER 10-16
International Atomic Exposition
Cleveland Public Audtiorium
Cleveland, Ohio

DECEMBER 12-16
Nuclear Engineering and Science Congress coordinated by Engineers Joint Council
Cleveland, Ohio

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