**VOL. 1, NO. 2 AUG.-SEPT., 1955**

# RCA ENGINEER

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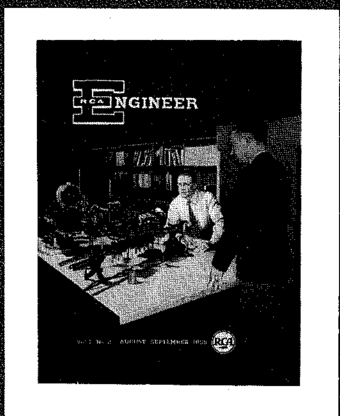
## CONTENTS





JOHN D. ASHWURTH

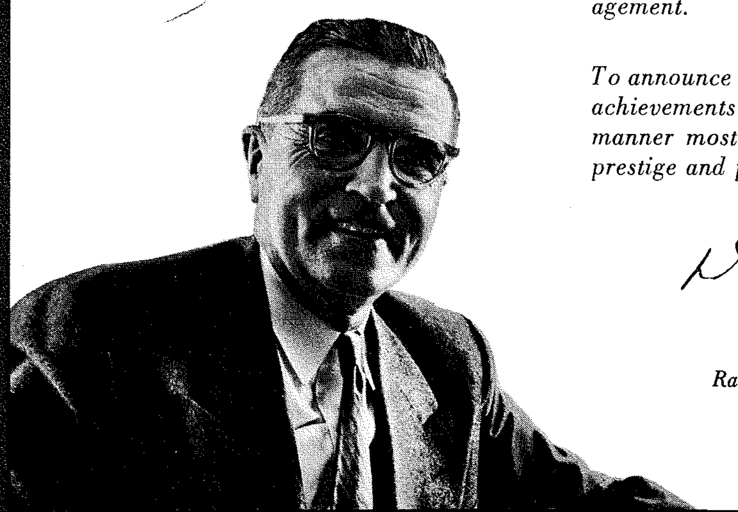
# OBJECTIVES OF THE RCA ENGINEER




Sound and practical *objectives* are the underlying, motivating forces of every worthwhile endeavor . . . whether it be simply the completion of a straightforward product design or the tackling of a complex engineering project. With this thought in mind, the choice of objectives for the RCA ENGINEER was made!

During the course of organizing our groups of Editorial Representatives—reactions and opinions were solicited at all locations. The *seven major objectives,* finally selected as guideposts for preparing material to be published in the RCA ENGINEER, are a direct result of the many helpful suggestions received from engineers throughout RCA.

Since each one of these seven is considered essentially equal in value—no attempt will be made to establish an order of importance. In order to portray adequately these objectives, it is our plan to repeat them in each issue of the RCA ENGINEER.



**OBJECTIVES**

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

•

*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.*

•

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

•

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

*Vice President*
*Product Engineering*
*Radio Corporation of America*

# THE ENGINEER AND HIS PROFESSIONAL SOCIETY

*by* **BENJAMIN E. SHACKELFORD**
*RCA International Division*
*New York City*

THE ENGINEER lives in a competitive and challenging world. He must consistently rise above the obstacles he encounters daily and seek to take advantage of every opportunity, particularly those offered by the Professional Engineering Society. These organizations extend to the engineer several outstanding benefits: They provide the engineer a closeup view of industry and the problems posed by competition. They give the engineer the opportunity of meeting with other engineers and of exchanging views and experiences. They help him to meet the challenge of competition.

#### THE DEMANDS ARE MANY

Every engineer must satisfy both the demands of his profession and of his specific engineering and non-engineering problems. He is also in a continual struggle to improve his work performance and to develop his own capabilities to the fullest. Often there is pressure to be satisfied with less than the best possible, either as to compromise in the direction of effort or in the strength of the effort itself. Likewise, every engineer is in competition with other engineers and with individuals in other departments. In spite of this competition, he and his associates and his company can develop properly only when cooperation is predominant.

#### A "COMMUNITY" APPROACH

In tackling and solving his problems, the engineer can rely on the Professional Society for much assistance.

During society activities, the engineer deals neither with "superiors" nor with "inferiors," but with his peers. He is a member of his own town meeting. In technical sessions, committee meetings, and in rubbing elbows with his fellows, the engineer learns to live; that is, to broaden his point of view, enlarge his interests, become more tolerant, and improve his capabilities.

#### INTERCHANGE OF CHALLENGING IDEAS

During the technical sessions of his society, the engineer encounters new points of view and learns to think on his feet and to discuss new ideas. From the presentation of his own papers, he discovers that he must be prepared for and welcome challenging points of view. The powerful stimulation which comes from the interchange of new ideas and the opportunity to interject one's own thoughts increases enthusiasm and spurs the individual to renewed activity in his chosen field.

In the early days of this country, individuals such as Benjamin Franklin and other scientists and engineers met together to discuss the latest discoveries, experiments, and theories. In these sessions they discovered that the personal touch, added to a discussion of a technical subject, brought life to what might otherwise be a colorless report. An enduring result of these meetings was the founding of several professional societies of varying scope which accelerated the development of science and of engineering in this country.

#### COOPERATION AND COMPROMISE

One of the more satisfying aspects of professional society activity is committee work. Here cooperation and proper compromise are joined with leadership to advance the common good. Those who have participated in committee meetings know the lasting value that is derived from sessions with individuals who possess both ideas and the power to stimulate other ideas, and who can inspire the group to strive for a common goal. Conversely, we are quick to recognize those individuals who seek to advance merely their own selfish interests.

#### A BROADENED OUTLOOK

Another rewarding aspect of the meetings of professional societies is the opportunity they offer to assist those who are younger or less outspoken. A few words of merited praise or of encouragement when an idea is advanced or a paper presented may have untold value in stimulating the creative mind.

The professional society thus offers the individual engineer a unique opportunity to broaden his horizons in a variety of ways, and it better equips him to meet the demands of his professional world. It gives him the benefits and training derived from both competition and cooperation, and gives him experience in balancing these forces.

**BENJAMIN E. SHACKELFORD**—Dr. Shackelford received the A.B. and A.M. degrees from the University of Missouri. In 1916 he received the PhD degree from the University of Chicago. He joined Westinghouse in 1916 where his activities included work in illumination and incandescent lamp physics. In 1918 he undertook engineering development of radio tubes and became manager of Radio Engineering in 1925. Dr. Shackelford joined the Radiotron Division of RCA at Harrison, N. J., in 1930. He was appointed manager of the Patent Department in 1934. After serving as manager of the company's foreign licensee service, Dr. Shackelford transferred to New York where he became assistant to the Director of Research and later to the Chief Engineer. In 1942 he was appointed engineer-in-charge of RCA's Frequency Bureau. In 1944 he was made assistant to the Vice President in charge of RCA Laboratories, and in 1945, Director of the License Department of the RCA International Division. Dr. Shackelford is a Fellow of IRE, AIEE, and American Association for the Advancement of Science. He is a member of the American Physical Society, the Franklin Institute, Sigma Xi, Gamma Alpha, and Alpha Chi Sigma. He was president of IRE in 1948, and a member of the Board of Directors 1945-50, 1953-55.

# GRAPHICAL REPRODUCTION OF FLUX PATTERNS

*by*

**BERNARD J. McHUGH**
**AND DANIEL J. COYLE**

*Electronic Components Engineering*
*Tube Division, Camden, N. J.*

Fig. 1—Relationship between direction of beam current (forefinger), which is opposite to that of electron travel, horizontal-coil flux (middle finger), and resulting deflecting force (thumb) as illustrated by the "right-hand screw" rule.

***summary***

This article describes two new methods for the graphic recording of the fields of flux generators. The first system provides for accurate reproduction of two-dimensional field plots formed by powdered iron on a plane surface. The second method produces permanent three-dimensional field plots formed by powdered iron suspended in resin. Although this paper refers specifically to television deflecting-yoke fields, other applications are equally practical.

Despite a high degree of practical development, there is a definite lack of catalogued information on commercial television deflecting yokes, particularly concerning their magnetic fields. One reason for this lack is the constant pressure to produce less expensive working units, which has forced theoretical work into the background. Another factor has been the lack of an efficient system of obtaining and recording such information. The systems described in this article approach this problem from the standpoint of graphic reproduction.

The principle on which magnetic deflecting yokes operate can be stated as follows: An electron moving in a magnetic field in any direction other than parallel to the lines of flux is acted upon by a force. This force is perpendicular to the plane formed by the velocity vector of the electron and the flux lines which it crosses. Whether this force is up or down depends upon the relative directions of the velocity and flux. The magnitude of the force (F) is proportional to the charge of the electron (e), the velocity (v), the density of the flux (B), and sin θ, where θ is the angle between (v) and (B). This information can be expressed as a vector (cross) product equation, as follows:

$$\mathbf{F} = e(\mathbf{V} \times \mathbf{B})$$

which is equivalent in magnitude to

$$F = evB \sin \theta$$

Although no graphic method can provide all the essential information about a magnetic field, the systems described produce a geometric representation of the field which provides some information about the relative strength of the field at various points.

The photograph shown in Fig. 1 illustrates the "right-hand screw" rule which is used in conjunction with the

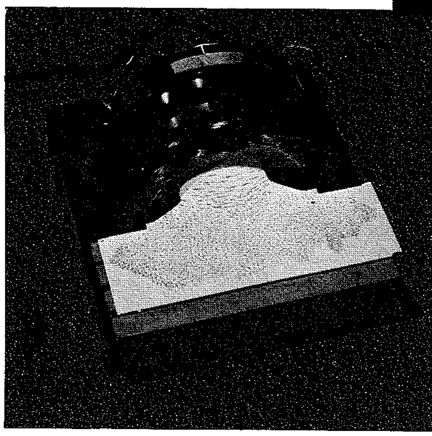


Fig. 2—Preparation for plane flux plot of deflecting yoke.

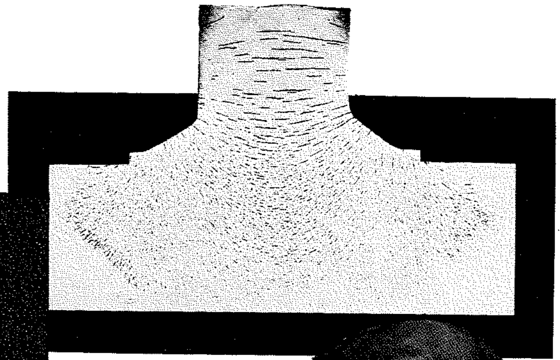


Fig. 3—Plane flux plot of color-television deflecting yoke.

Fig. 4—Rubber molds used in preparation for three-dimensional flux plots.

vector (cross) product equation. The forefinger represents positive current v, which is opposite in direction to electron travel, while the middle finger represents the horizontal-coil flux direction B. The resultant force vector, F, causing beam deflection is in the direction indicated by the thumb.

#### TWO-DIMENSION FLUX PLOTS

The two-dimensional system of field plotting utilizes Ozalid*-sensitized paper to reproduce permanently the pattern obtained with powdered iron in a magnetic field. Ozalid paper is exposed by the use of ultra-violet light and developed with ammonia gas.

1. *Procedure.* When a plot of a yoke field is to be obtained, the Ozalid paper is first cut to fit the interior of the yoke. The paper is then placed on the yoke and supported in the desired position as shown in Fig. 2. A smooth rigid sheet of material such as plastic is desirable for support because any unevenness in this sheet may distort the pattern.

When the paper is in position, it is covered with a light, uniform layer of powdered iron. For this application, best results are obtained with small particle sizes—150 mesh has proved satisfactory. A uniform coating may be produced by holding the powder on a sheet above the Ozalid paper, blowing it off, and allowing it to settle onto the lower sheet. The coils of the yoke are then energized with dc, and the iron particles are vibrated. Vibration can be accomplished effectively by means of a radio speaker driven at low audio frequency (60 to 80 cps). The speaker frame may also be held in contact with the supporting material to transmit the vibrations to the powder, or sound waves may be utilized if the speaker is held several inches above the Ozalid sheet. After the pattern has formed and, if possible, while the field is still present, the Ozalid paper is exposed to ultra-violet light. Although sunlight can be used as the source, the inconvenience involved in its use results in a need for an ultra-violet lamp.

When the color of the paper changes from pale yellow to white, the processing is complete. The light and current are then cut off, and the powder is removed. The exposed paper is run through the developing section of the Ozalid machine to develop the pattern.

2. *Interpretation of Pattern.* Accurate values for field strength can be obtained only by direct measurements. However, flux plots such as those shown in Fig. 3 can be used to determine relative intensities. General rules which can be used in the interpretation of field plots are:

1. The area of greatest flux density is indicated by fewer, though longer and thicker, lines.
2. Where the field is weaker, the lines become more numerous, but decrease in length and thickness. These characteristics vary in direct proportion to field strength.
3. The lines of the pattern should flow smoothly except where there is a flux generator or conductor to account for nonuniformities.

#### THREE-DIMENSIONAL FLUX PLOTS

Because electron deflection in television is a three-dimensional problem, the second method of field plotting to be described is of more practical interest. A good casting produced by this method enables the engineer to determine the direction of the force acting on an electron at every point along its path.

To be of any value, the plastic used in this process must possess the following qualities:

1. It must be transparent.
2. The initial viscosity of the material must be low enough to

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* *Trade Mark of the General Aniline and Film Corp.*

permit uniform dispersion of the powdered iron.

3. It must gel quickly.

4. It should not require heat for the gelling process. A distinction is made between "gelling," whereby the liquid becomes immobile, and the final hardening, after which the casting can be handled.

A commercial product which meets these requirements is "Castolite,"† when used with its hardener and promoter. The promoter is the catalyst which causes rapid gelling.

1. *Rubber Mold.* A preliminary step in the making of a casting is to obtain a suitable container for the plastic. Because of the odd shape of the yoke field space, the most practical choice is a rubber mold. This mold is made from liquid mold rubber, which is available from art-supply dealers. A yoke "plug" is coated with several layers of the rubber, which is peeled off when it sets. When such a mold is coated with a lubricant, the casting can be removed without difficulty. A typical rubber mold for deflection yokes is shown in Fig. 4.

2. *Procedure.* In the casting operation, the plastic is first poured into a suitable mixing container, and the hardener and promoter are added and thoroughly mixed in. From this point on, the time element is extremely important. Powdered iron is added and thoroughly dispersed. Best results have been obtained with —60 mesh iron flakes. These flakes are easy to see in the plastic because they have flat surfaces which reflect light. The usual time lapse between the addition of the promoter and the gelling of the plastic is eight minutes. The critical initial rise in viscosity occurs in less than thirty seconds.

The plastic mixture is then poured into the mold which has been set in the yoke and the chosen coils of the yoke are energized with d-c. The flux pattern forms almost immediately. This step should be completed within four minutes after the promoter is added because of the uncertainty concerning "gel" time. If the d-c field is applied continuously, the magnetic force may begin to draw the iron flakes out to the sides of the casting. Current is applied intermittently, therefore, at intervals sufficient to keep the pattern well defined.

The rapid hardening process is accompanied by the generation of a large amount of heat. In large castings (greater than one pound) where there is a high mass-to-surface-area ratio, this heat may cause sufficient expansion of the interior material to crack the casting. The small castings use a proportion of one unit each of the catalysts to one pound of Castolite. When an attempt is made to cast larger pieces, a reduction in the amounts of the catalysts used is necessary. Such a reduction, which may exceed fifty per cent, results in much longer gel time (more than fifteen minutes). The gelling process becomes less pronounced and thus requires considerably more time. Casting under these conditions requires closer observation of the process because the problems of settling and magnetic "pull out" are aggravated. Another approach to the problem of large castings is to cast them in parts.

3. *Preparation of Castings.* The surface of the casting requires machining and polishing before the pattern can be seen clearly. The amount of polishing necessary can be greatly reduced by coating the casting with laquer. The finished casting may be cut in a variety of ways to emphasize particular aspects of the field to facilitate study of the pattern. Typical cross sections of such castings are shown in Fig. 5.

4. *Interpretation.* The general rules given for the interpretation of plane flux plots can also be applied to the patterns observed in casting. When both horizontal and vertical coils are energized, the pattern produced is the plot of a field which is the vector sum of the two fields. When the casting is cut parallel to the fields of the individual coils, the pattern observed is that of these component fields.

Although this article describes a yoke-field plotting method, the processes are applicable to the fields of most flux generators. The only difficulties which may arise will be in the use of these systems to plot the fields of permanent magnets. The greatest problem will be experiencd in the use of the casting method on such magnets. Unless gelling occurs almost immediately after the plastic is poured into the field space, the iron will move toward the magnet. A suggested possible solution is to vary the amount of catalysts used so that the plastic has a higher viscosity at the time it is poured.

Ref: M. J. Obert. "Deflection and Convergence of the RCA 21-Inch Color Kinescope." RCA REVIEW. March 1955.

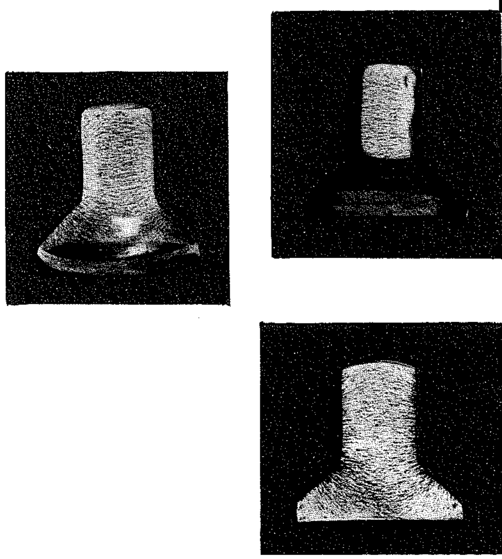
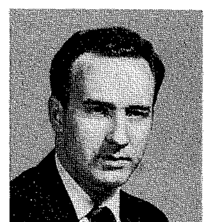
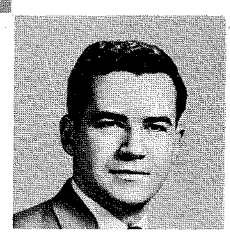


Fig. 5—Cross sections of castings showing three-dimensional flux plots of color-television deflecting yoke.



BERNARD J. McHUGH



DANIEL J. COYLE

**BERNARD J. McHUGH** and **DANIEL J. COYLE** are co-op students attending St. Joseph's College, Philadelphia, where they are majoring in Electronic Physics. They first joined the RCA Tube Division in Camden, N. J., at the end of their sophomore year in 1953. Mr. Coyle started in June of that year with the Transformer Development Group, while Mr. McHugh remained in school during the summer. In September they exchanged positions, and have repeated the change at the end of each of the three semesters of the school year since then. They will complete their studies this summer, and hope to return to RCA as engineers in the fall.

† *Trade Mark of the Castolite Company.*

# OPTICAL ENGINEERING AT RCA

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*Engineering Products Division*
*Camden, N. J.*

"ELECTRONICS" and "Optics" are fields of engineering that have become constant partners—a fact highlighted by the laboratory scene pictured on the front cover of this issue. Since the importance of the part being played by optics and optical engineers in the design of electronic products has not been as widely publicized as many other engineering activities—it is the purpose here to better acquaint the reader with the scope of this engineering function by briefly reviewing the story of optical engineering as applied to electronics in RCA. This story will also provide background for the technical paper in this issue entitled, "Transmission of Radiant Power" by L. T. Sachtleben.

#### EARLY HISTORY

In the late 1920's RCA entered the sound motion picture field in which techniques for recording sound photographically and reproducing it photographically were being developed. These techniques involved the use of complex optical systems and called for optical engineering activity within the company, which extended to the design of appropriate phototubes. Competence developed as experience grew, and in addition to commercial sound recording and reproducing optical systems, an optical printer was developed to transfer sound records from commercial 35mm motion picture film to 16mm film for home projectors. Picture optics as well as sound optics were included in RCA's activity when the company entered the 16mm projector and camera fields. The need to record sound in newsreel cameras presented challenging problems in optical system design because of the need for compactness and light weight. Near the start of World War II, optics were designed for a special multitrack sound printer, and reproducers to present Walt Disney's "Fantasia" in "Fanta-Sound."

It was inevitable that this accumulated experience should lead outside the field of sound movies, and in 1935 RCA solved the optical problems of a new system of bottled beverage inspection and entered the beverage inspection equipment field, where its activity has expanded steadily. In 1936 a need developed to project television pictures on a large screen. The optics of the Schmidt astronomical camera were adapted to that purpose for the first time by RCA, and were utilized with high-intensity projection kinescopes developed by the Tube Division in order to produce a practical large-screen projection system. From this grew the activity in theater television in both color and monochrome.

#### OPTICAL ENGINEERING DURING WORLD WAR II

During the war much optical sound equipment was furnished the armed forces from a commercial line that had become highly important to the company. RCA's experience with the Schmidt camera system was turned to development and production of infra-red signal receivers and viewing telescopes for the military. Products of this type were under continuing development at the close of the war, and in addition an infra-red telephone for two-way conversation between ships was under development. Optics also were developed for tape and page facsimile systems for transmission of typed or written messages, and line or half tone information. Since the war, RCA's work in military optics has continued along many other lines, new impetus having been acquired during the Korean campaign.

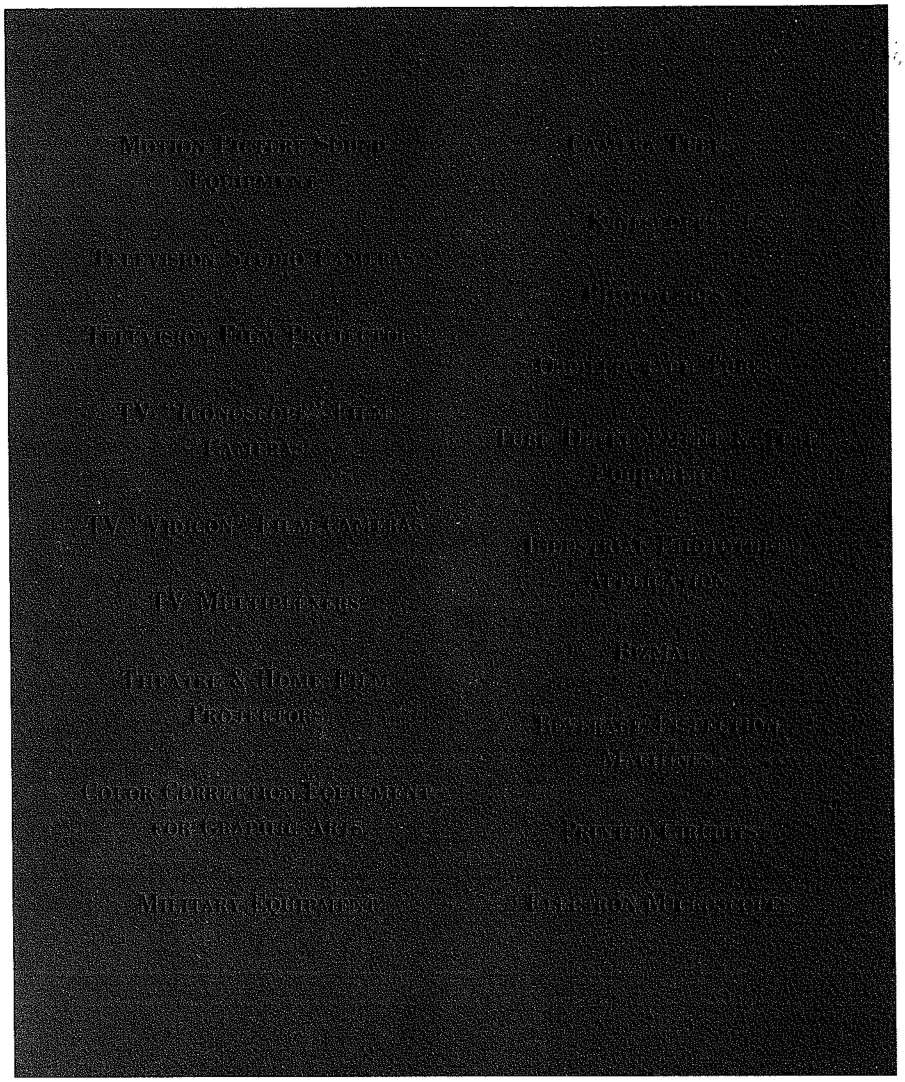
#### COMMERCIAL AND INDUSTRIAL ASPECTS

Optical engineering in the commercial field expanded rapidly at RCA after 1946, particularly in television where both color and monochrome optics were developed for studio cameras, for film playbacks, for multiplexers which permit a number of motion picture and slide projectors to work in a prearranged order into a TV camera, for continuous movie projectors and high-speed pull-down projectors, and for kinescope recorders. Similarly, the application of electron optics contributed to the development of monochrome and tricolor kinescopes, vidicons and image orthicons.

Dichroic mirrors, developed by RCA in 1939, proved invaluable in color TV cameras where available light must be divided into primary colors without absorption losses. The "magicote C" high-efficiency coating, developed by RCA Laboratories, is important in suppressing objectionable reflections from the backs of the mirrors. Methods for reducing reflections from kinescope screens, and tinting of kinescope faceplates to increase contrast were developed and employed by the Tube Division.

Optical means are used in the output of the Bizmac System to return information from its coded form on magnetic tape to a legible form on film and paper. The color correction project for the graphic arts field, and other similar projects, have depended materially upon RCA's optical engineering resources. These resources, furthermore, include electron optics, which is a basic science in the electron tube field.

Listed here as a convenient review for the reader are a few of RCA's electronic products which draw upon the abilities of the company's Optical Engineering Groups.




#### SPECIALISTS ARE REQUIRED

Optical engineering at RCA is carried out by specialists who are well qualified by training and experience in the field. The work ranges from research to construction of production models and includes conception and design of systems; design of corrected lenses and mirrors; design of electron tubes and luminescent phosphors; establishment of assembly, lineup, and test procedures; specification writing and commercial procurement; photometric evaluation; production of surface coatings; colorimetry; photography and photographic sensitometry in both color and monochrome; contributions to technical literature; and, where it has been necessary, actual fabrication of optical surfaces.

#### OPTICAL ENGINEERING AT SEVERAL LOCATIONS

The General Engineering Development group in Camden is equipped to handle many of RCA's optical and photographic engineering problems. In addition, optical work is proceeding at a number of other locations within the company. For example, at the David Sarnoff Research Center in Princeton, N. J., Dr. D. W. Epstein and his associates have made many important contributions to electron tube optics. Television engineering needs have also led to the development by Dr. Otto Schade in the Tube Division at Harrison, N. J., of a new electronic system of lens evaluation in terms of signal amplitudes. This is a basic contribution in the optical field where evaluation of lens quality has never been on a firm quantitative basis.

The foregoing is intended to broadly record the story of Optical Engineering at RCA and to indicate the extent of its importance to the company. The General Engineering Development group provides consultation service not only on the problems of optics and photography, but on a wide range of other problems in the Electronics Engineering field.

# PROJECTION OF RADIANT POWER BY OPTICAL SYSTEMS

*by* **L. T. SACHTLEBEN**
*General Engineering Development*
*Engineering Product Division*
*Camden, N. J.*

OPTICAL SYSTEMS are not usually thought of as power transmitting devices because of their predominantly visual interest. Yet their visual effects are directly dependent upon their peculiar power transmitting properties. Although the visible spectrum is a very small portion of the entire electromagnetic spectrum, much of the spectrum outside the visible can be projected and imaged by optical means just like visible radiation. In many cases where the images are not of visual or photographic interest, attention may center exclusively on the number of watts of radiant power in the image or on the watts per unit of area in the image. It is therefore desirable to understand the factors that determine power or power density in an image and how they enter into computations of those quantities.

#### POWER DENSITY AND CONVERGENCE LIMITING FACTORS

Where radiant power originates at the surface of a uniform radiator, and is caused to converge in a right-circular cone toward a point, the maximum possible power density that can be developed at that point depends only upon the power density at the surface of the radiator and the angle of the cone of convergence. These two factors set a physical limit that cannot be avoided, and may not be exceeded by any stratagem of invention or design in any optical system which does not increase the surface power density, or the cone angle, or both. The foregoing facts are generally not well understood, the reason being that optical systems are

## SCALE DIAGRAM OF ARRANGEMENT USED TO DEMONSTRATE TRANSMISSION OF RADIANT POWER BY AN OPTICAL SYSTEM

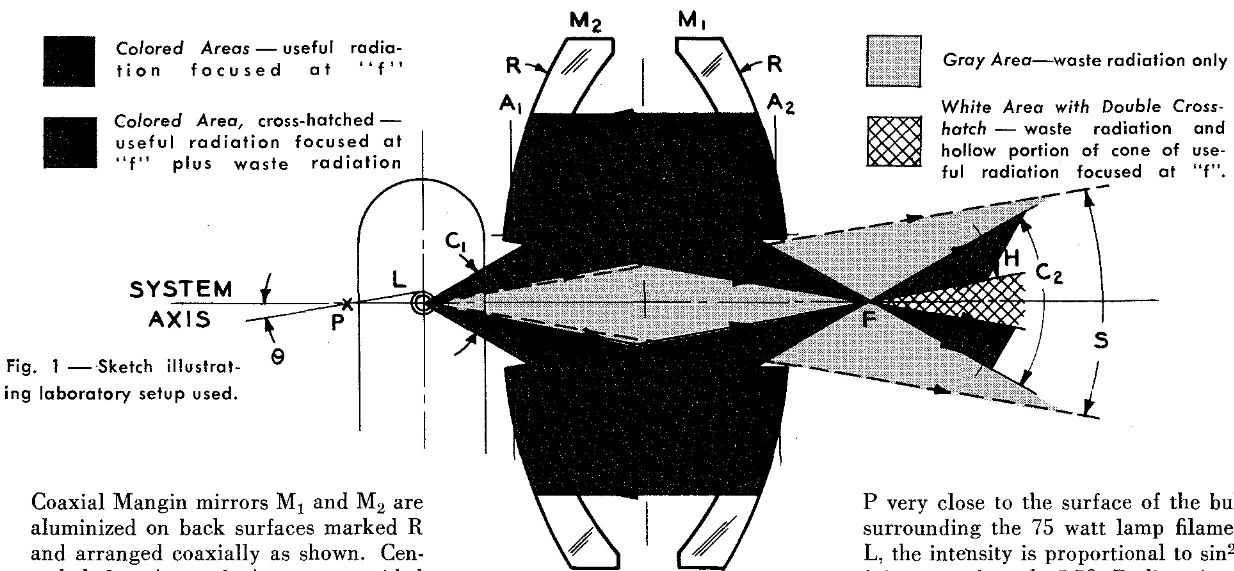



Fig. 1 — Sketch illustrating laboratory setup used.

Coaxial Mangin mirrors $M_1$ and $M_2$ are aluminized on back surfaces marked R and arranged coaxially as shown. Central holes $A_1$ and $A_2$ are provided through which radiation from source L respectively enters and leaves the space between the mirrors. A circular cone of radiation of vertex angle $C_1$ is admitted to the system, of which a central coaxial portion having vertex angle S escapes through opening $A_2$. The balance of cone $C_1$ is reflected parallel to the axis of the system by mirror $M_1$, at whose principal focus source L is located. Mirror $M_2$ in turn reflects this hollow cylinder of parallel radiation, and converges it in a hollow cone $C_2$ to its principal focal point F. The hollow portion H represents the lost light that originally escaped from the optical system in the cone S. The intensity at F is proportional to $(\sin^2 \frac{1}{2}C_2 - \sin^2 \frac{1}{2}H)$. In the demonstration $C_2$ is approximately 63°, and H approximately 19.8°. At a point P very close to the surface of the bulb surrounding the 75 watt lamp filament L, the intensity is proportional to $\sin^2\theta$. $\theta$ is approximately 5.7°. Radiant intensity in the image at F can therefore be approximately 24 times greater than at P near the outside surface of the lamp envelope. This factor is reduced some 30% by absorption of infra red radiation in the glass of the mirrors, which present an equivalent glass thickness approximating one inch, and make the actual gain factor about 17. The focus F is approximately $3\frac{11}{16}''$ from source L, and point P is $\frac{1}{2}''$ from L.

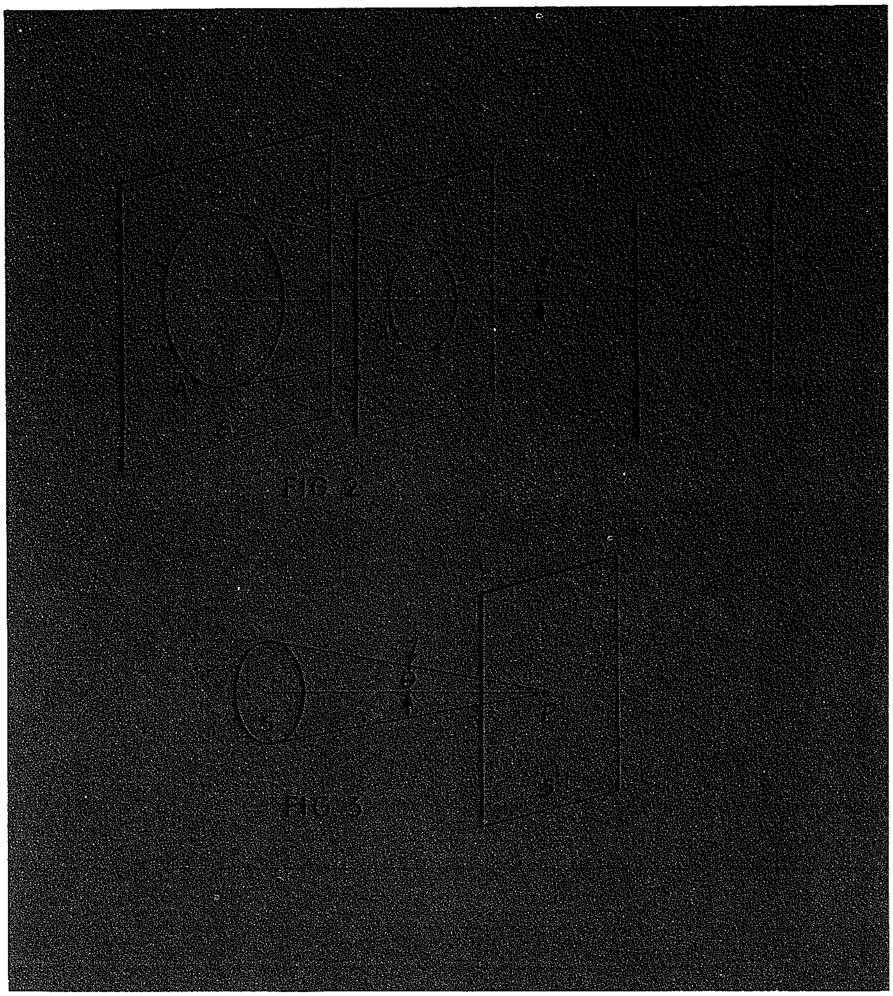


Fig. 2—Uniform radiator defined by constancy of apertured cone's effect at "P".

Fig. 3—Effect at "P" depends on power density of radiator and convergence angle ().

not ordinarily one of the tools of the power transmission engineer, and their theory is usually cast in visual terms rather than physical terms.

#### PROBLEMS OF PROJECTING RADIANT POWER

The general problem of projecting radiant power is very complex, and does not necessarily involve an optical system or any image forming elements. Simply stated, it is the problem of finding the distribution of radiant power over a given surface as receiver, when the surface distribution and directional distribution of radiant power emission from a second surface as source are known. The problem involves the geometry of the two surfaces, their relative positions, and the nature, geometry, position, and orientation of all physical media that can receive power from the radiator and by any process deliver all or a fraction of it to the receiving surface. The wave length of the radiation is a factor that must be taken into account where the projection process is selective with respect to that variable.

Only a few very simple aspects of the general problem will be discussed here. The purpose will be to point out the relationships that determine certain ideal upper limits to the quantity and intensity of radiant power that may be developed at a receiving surface when the radiation is projected by an optical system that forms a geometric image of the source. The problem, limited to light, is treated in the discussion of the photometry of optical systems in a few of the more specialized texts on optics. The arguments found there apply as well to radiation that does not produce visual effects. In optical system photometry, radiant power is the primary entity that is being projected and measured; the fact that we may or may not happen to call it light has nothing to do with the relationships that describe the quantity of radiant power that is handled, or its intensity at specified locations.

Beyond the above statement this discussion will not become further involved in developing the analogy with photometry, nor will it concern itself with proofs in the field of photometry. These may be examined by consulting, "The Principles of Optics," Ch. XIX, by Hardy and Perrin; "An Introduction to Applied Optics," Vol. II, Ch. VI, by L. C. Martin; "Principles of Physics III—Optics," 3rd Ed., Ch. 13, by F. W. Sears; or "Laboratory Instruments," Ch. 15, by Elliott and Dickson. Discussion will here be limited to pointing out the significance of the photometric relationships in the projection of radiant power by optical systems that are capable of producing geometric images.

#### POWER PROJECTED RELATED TO AREA

The first simplifying assumption has to do with the radiator itself. Suppose in Fig. 2, there is a radiating surface S with an emission density of Q watts of radiant power per square unit everywhere upon it.* Suppose a barrier with a hole A to be placed between an observation point P and the surface. If the radiation received at P through hole A is independent of the orientation and position of the surface, as long as projection A′ of A lies wholly on it, the surface is said to be a uniform or diffuse radiator. It is a property of a uniform radiator that the total power projected by it in a given direction is proportional to the area of the radiator projected in the given direction. Radiators having this property are said to obey Lambert's cosine law. It is a further property that the power projected in any direction is independent of the contour configuration of the surface, providing that no radiation in the given direction be reflected from any point of the radiator by virtue of the shape of the sur-

**Radiant power emission density is directly analogous to photometric brightness or luminance in Lambert units measured by the number of lumens emitted or reflected per square centimeter of a uniform radiator.*

face. For every point P on a surface S′ which may be projected upon a uniform radiator S through all points in A, the opening A may be said to have the properties of a uniform radiator.

The second simplifying assumption will limit the receiving surface S′ to a plane in air or vacuum, and will limit the region of space from which radiation may approach the point P to a right circular cone with axis normal to the plane of the receiver. The generating angle of the cone will be designated $\theta$.

#### APPLICATION OF INVERSE SQUARE LAW

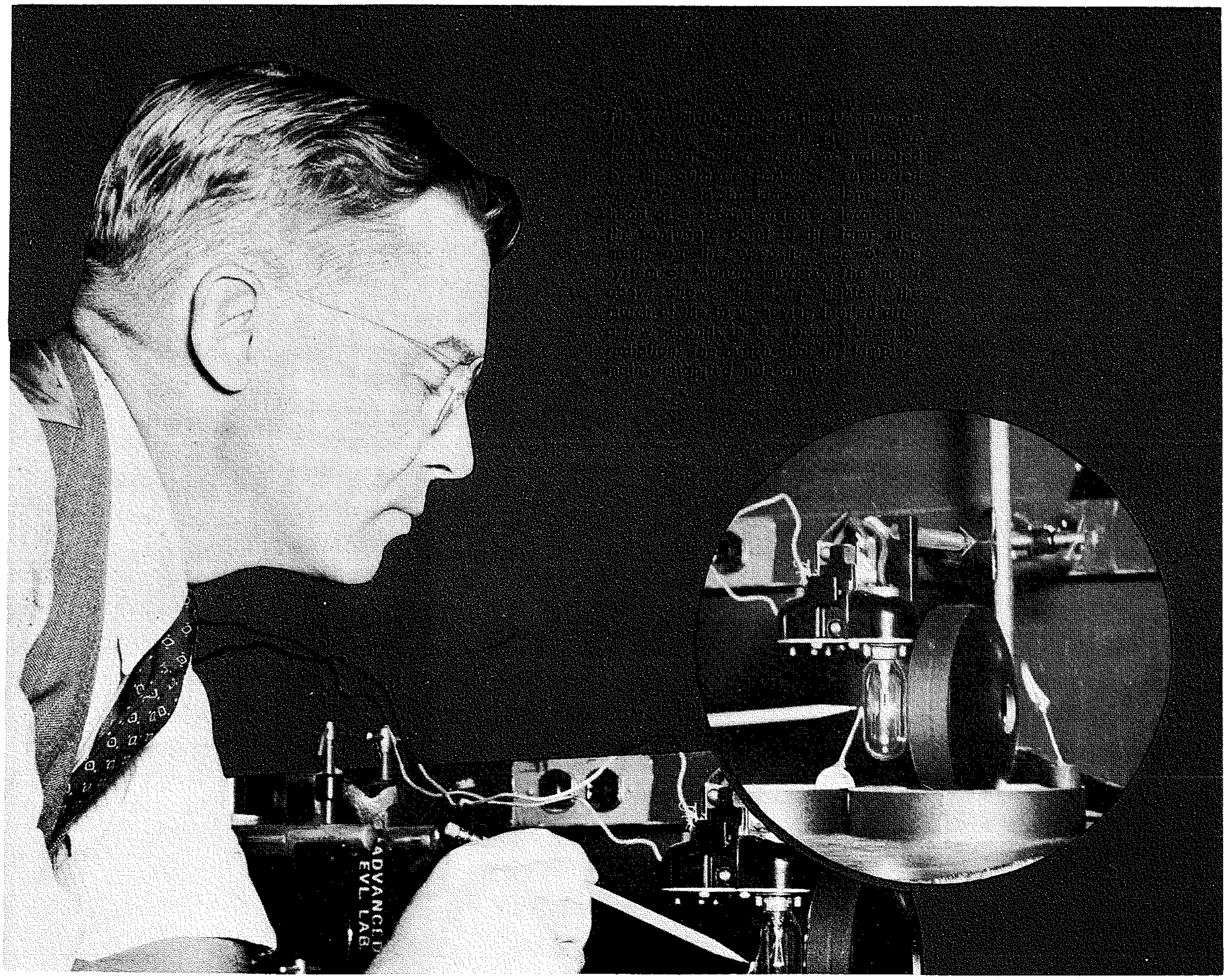
From these two simplifying assumptions, and application of the inverse square law according to the scheme of reasoning in photometry, a uniform circular radiator S in Fig. 3 will produce a radiation intensity Q′ at P on surface S′ such that $Q' = Q \sin^2\theta$ watts per square unit. If P is brought in contact with S, or if S becomes infinitely large, $\theta$ will reach 90° and Q′ will equal Q, as might be expected.

If the right-circular cone is limited by the circular hole A of Fig. 2, instead of by the boundary of the radiator, the intensity Q′ will still depend upon Q and the cone angle $\theta$ as expressed above. If the hole A be elliptical and the barrier so oriented that a right-circular cone of radiation converges upon P, the law of dependence remains unchanged. If the hole A have any shape and the barrier any contour such that a right-circular cone converges toward P the relationship is unaffected.

Furthermore, if an ideal no-loss optical system, capable of forming a geometric image, intervene between the source S and the surface S′ such that a right-circular cone of radiation converges upon the point P, the maximum possible intensity at P remains $Q' = Q \sin^2\theta$ watts per square unit. Usually the purpose of the optical system is to produce a geometric image of S upon S′, but whether P be in the plane of such an image or not the maximum possible Q′ at P depends upon Q and $\theta$ as before. The optical system may be a lens, or a mirror, or a combination of lenses and mirrors. Its construction is immaterial from the standpoint of the maximum possible Q′ at P, except insofar as it may limit the cone angle $\theta$.

#### REFLECTING RADIATION

Where the power does not originate at a surface, as in the case of a glow



discharge, it may be possible by optical means to build up the intensity of the source by reflecting radiation through it toward the point of projection or toward the optical system that is delivering radiation to such a point.

In the case of a radiating surface, if the environment of the surface and the power that can be supplied to it are at one's disposal, it can be made to approach the efficiency of a black body radiator and thus have the effective power density at its surface built up to a higher value than determined by its ordinary emissivity, without increase in operating temperature. In most cases, however, it is not possible to control the radiating surface to get such effects.

#### IRREGULAR RADIATING SURFACES

When a radiator is not a continuous surface, all the space in the cone of convergence may not be occupied by radiation that is traveling toward the vertex of the cone. If this is due to holes in the radiator, the deficiency may be partly remedied by placing a reflector back of it, as is commonly practiced in projection optical systems. A radiator may also exhibit temperature gradients or may have local emissivity variations. All such effects will influence the effective value of Q.

#### MAXIMUM POWER DENSITY

It should be noted that the foregoing has to do with the maximum possible power density that can be developed at the focal point P of an optical system that forms a geometric image. This maximum is a superior limit that cannot be exceeded by any optical or projection means whatsoever that does not increase Q, $\theta$, or both. It is not intended to imply that such a limit can actually be reached by a practical optical system, for such is not the case. All optical systems have absorption and reflection losses which reduce their efficiency below the ideal limit, and these must be taken into account in calculating the practical performance of a system. Also the absorption effects of surrounding media such as air or water are important factors that must be considered. These effects may be represented by a transmission factor, $k<1$, and the practical form of the equation is then $Q' = kQ\sin^2\theta$ watts per square unit. After all practical measures have been taken to increase the factor k as much as possible, any further increases in $Q'$ must result from increases in the angle $\theta$, assuming Q fixed.

#### IMPORTANCE OF CONVERGENCE

The curve of Fig. 5 shows the behavior of $\sin^2\theta$ as a function of the cone angle $\theta$. Fig. 6 shows it as a function of the solid angle $\omega$ of the cone where $\omega = 2\pi(1\text{-}\cos\theta)$ steradians. The curve of Fig. 7 is plotted to show dependence of $\sin^2\theta$ on another function of $\theta$, called the aperture ratio, which is equal to $2\sin\theta$. This is done in order that $\sin^2\theta$ may be easily computed for an optical system having P at its principal focus. The aperture ratio is equal to the reciprocal of the f/number or focal ratio of the system.

Fig. 5 shows clearly that, over the range $30° < \theta < 60°$, a substantially linear relation exists between $\sin^2\theta$ and $\theta$. It also shows that the contributions to $\sin^2\theta$ are small for the first 10° of $\theta$ at the low end of the angle scale, and for the last 10° of $\theta$ at the high end of the scale. Thus in a system for which $\theta = 30°$ a central portion of the cone for which $\theta = 10°$ may be blocked off at the expense of only about 12% of the available intensity at P.

Where critical image forming qualities are not an important consideration, systems are readily constructed for which $\theta$ is 45°, and this can no doubt be exceeded without great difficulty. The gain to be had from attempting to increase $\theta$ beyond 60° or 65°, however, might not be commensurate with the difficulty and cost involved, particularly in systems of long focal length.

While the value of $\theta$ determines the upper limit of the power *density* that can be developed at the focus of the optical system for a uniform radiator of given radiation emission density Q, the total *power* will be proportional to the area $S'$ of the image of the radiator which appears at P. This assumes that $Q'$ is substantially constant in the neighborhood of P; an assumption that is reasonable if the radiator does not subtend an angle of more than a few degrees measured at the optical system.

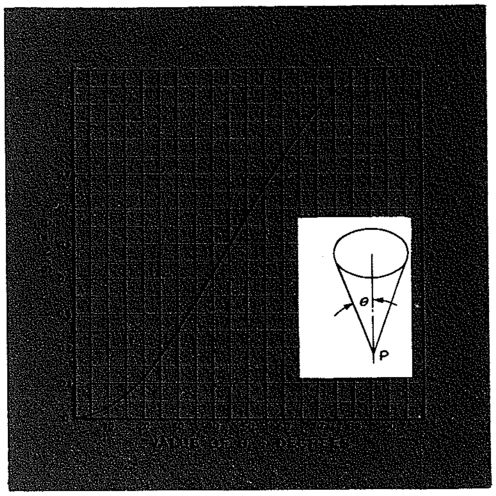



Fig. 5—Dependence of radiation intensity on convergence angle in degrees.

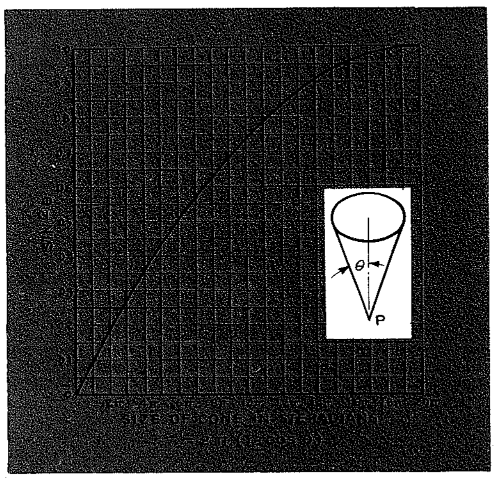



Fig. 6—Dependence of radiation intensity on solid angle of convergent cone.

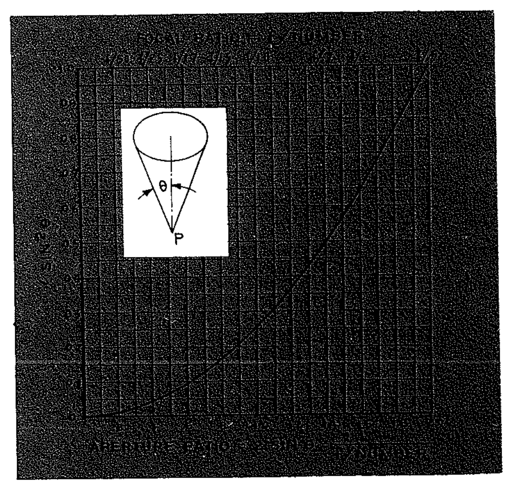



Fig. 7—Dependence of radiation intensity on speed of an imaging system.

#### RADIATOR IMAGE AREA RELATED TO FOCAL LENGTH

For distant sources the area of the image of a given radiator is proportional to the square of the focal length of the optical system. Where the source is circular and of angular diameter B, considered small, the diameter of the image is fB, and its area $\frac{\pi f^2 B^2}{4}$, f being the focal length of the optical system. The maximum power that can possibly be delivered by the optical system is therefore

$$W = Q' \times \frac{\pi f^2 B^2}{4} = \frac{\pi Q}{4} (fB\sin\theta)^2.$$

Suppose it be assumed that the sun is the source ($B = \frac{1}{2}°$), the focal length is ten feet, and $\theta = 30°$. According to Gamow, in "The Birth and Death of the Sun," the effective value of Q for the sun's surface, after deducting losses due to earth's atmosphere, calculates to be about 4.95 x $10^4$ watts per square inch. There is therefore at the focus a potential intensity

$$Q' = 4.95 \times 10^4 \times \sin^2 30° \text{ watts/in.}^2$$
$$= 12{,}400 \text{ watts/in}^2$$

and a potential total power of

$$W = \frac{\pi}{4} \times 4.95 \times 10^4 \times (120 \times .00875 \times .50)^2 \text{ watts}$$
$$= 10{,}700 \text{ watts.}$$

#### TOTAL POWER CAPACITY

By using this result, together with the curves of Figs. 5, 6, and 7, and the squared focal length relation, the potential capacity of any solar powered optical system may be quickly calculated. The practical capacity will, of course, always be less for the transmission factor of any real optical system is $k<1$.

When the problem is to find the total power intercepted by an optical system of given diameter, where the radiator subtends a small angle and the system subtends a right circular cone of generating angle θ measured at the radiator, the power is $W = kQ \sin^2\theta$ x area of the radiator. As before, Q is the emission density of the radiator in watts per square unit, the radiator being assumed to obey Lambert's law. k is the transmission factor for the medium between radiator and optical system.

#### EFFECT OF DIFFUSING SCREEN

An interesting case arises when radiation is first focused on a diffusing screen by one optical system, and an image of the screen is then formed by a second optical system. It is assumed the screen reflects 100% of the incident radiation, and diffuses it perfectly according to Lambert's Cosine Law. Transmission factors are assumed $k = 1$. For the first optical system $Q'_1 = Q_1 \sin^2\theta_1$, and for the second $Q'_2 = Q_2 \sin^2\theta_2$. But since the watts ($Q'_1$) received by the screen per unit area of the image is equal to the watts ($Q_2$) given off diffusely per unit of the same area, the result of this particular kind of cascade operation is that $Q'_2 = Q'_1 \sin^2\theta_2 = Q_1 \sin^2\theta_1 \times \sin^2\theta_2$ and if $\theta_1 = \theta_2 = \theta$, the result is $Q'_2 = Q_1 \sin^4\theta$.

If we now think of Q as representing luminous watts (or lumens) per square unit, and assume θ as great as 10°, it is seen that the cascading operation results in a final luminous intensity that is only 3% as great as that at the intermediate screen. In order to increase this figure to only 50%, by boosting the intensity at the intermediate screen, $\sin^2\theta_1$ must be increased by a factor of nearly 17. Fig. 5 shows that this will require $\theta_1$ to be made approximately 50°. These relationships serve to indicate the reason why it is difficult to project a brightly illuminated image of an opaque object such as the page of a book. It is much more satisfactory to project a transparent photograph of the page, for then, if the optical system is properly constructed the attenuating effect of the $\sin^2\theta_1$ term does not appear, and the final image intensity limit is represented by $Q'_2 = Q_1 \sin^2\theta_2$.

#### GENERAL APPLICATION OF THEORY

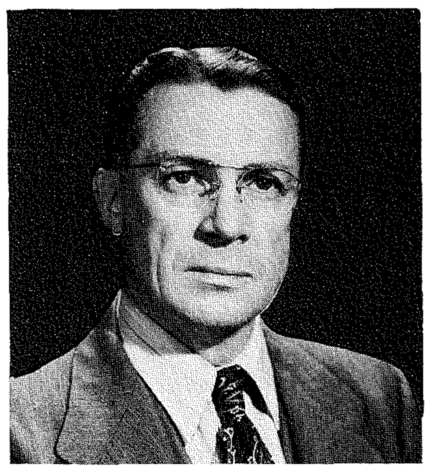
All of the foregoing is perfectly general, and Q may represent total watts, luminous watts (or lumens), or the watts that are effective in stimulating or energizing any type of receptor such as a photoelectric device or photographic film. Where Q is taken as the luminous emission density of the radiator in lumens per square unit, the surface luminance is simply $L = \frac{Q}{\pi}$ candles per square unit. The transformation from Q in watts to Q in lumens may be performed as described in Elliott and Dickson (referenced above), by taking into account the spectral response characteristic or luminosity function of the standard observer.

Regardless of how Q may be limited, the form of the formulas of projection is unaffected.

**LAWRENCE T. SACHTLEBEN** graduated with a BS degree in Physics from Antioch College in 1928. After a year of teaching and graduate study at the University of Minnesota, he joined the Photophone Department of General Electric in Schenectady. He came to RCA in 1930 and has been engaged in the development and design of all types of optical systems and components, both in Camden and Indianapolis.

He is a member of the Optical Society of America, and a Fellow of the Society of Motion Picture and Television Engineers.

Mr. Sachtleben has 44 U. S. patents to his credit as well as a number of foreign patents, and has had 16 or more of his technical papers published.



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**RICHARD H. WRIGHT** obtained the B.S. in E.E. Degree from Lafayette College in 1943 and then joined RCA. He did development and design work on high power filter networks and on Superturnstile and Supergain antennas such as those used on the Empire State antenna system. He is presently a group leader on the Television Transmitting Antenna Engineering Section.

**JOHN V. HYDE** graduated from the University of Maine with the A.B. degree in Mathematics in 1952, and shortly thereafter joined RCA. For the past three years Mr. Hyde has been a Design Engineer for Special Antennas, working in the Television Transmitting Antenna Engineering Section.

# HILL TOWER MULTIPLE ANTENNA SYSTEM

*by*
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*Engineering Products Dept.*
*Camden, N. J.*

RCA ENGINEERS have custom designed a number of multiple-antenna systems for television broadcast stations—the most widely known being on the Empire State Building with five antennas vertically stacked. Others include the Foshay tower in Minneapolis with three antennas, and Oklahoma City and Tulsa each with two antennas. All of these installations have utilized antennas that were *vertically* stacked.

### MULTIPLE SYSTEMS REQUIRE SPECIAL CONSIDERATION

Multiple antenna systems pose problems that are not encountered in installations having a single transmitter and antenna. For instance the question of cross-coupling between antennas is important because of the possibility of cross-modulation between transmitters. The possibility that each antenna will shield the other must also be investigated, as neither station could tolerate a dead spot in the service area due to the presence of the antenna for the other station. The requirements of television service also create a problem that would not exist in other types of broadcast service; for example the received picture from each station might have an echo due to reflections from the other antenna. This phenomena could occur if sufficient energy from station A were reflected back from the antenna of station B to enter antenna A, proceed to the A transmitter over the transmission line, be reflected, and reradiated from antenna A. The time delay of this reradiation would cause an echo which would seriously impair the picture quality of station A. Other problems of a similar nature must be investigated before RCA can take responsibility for the design of a multiple antenna system.

### NEW CHALLENGE IN CUSTOM ENGINEERING

Hill Tower, Inc. of Dallas and Fort Worth, Texas, presented RCA with a new and challenging problem: that a tower be erected between the two cities for television stations KRLD and WFAA *and that the two antennas must be mounted side-by-side* to show no favoritism of height or coverage of one over the other.

A preliminary study indicated that the radiating elements were to be mounted on a triangular platform approximately eighty feet on a side, atop a 1462-ft. supported tower. The triangular platform shape was chosen because of the practicability of a triangular tower-guying pattern. The antennas were to occupy two corners of the platform, and the third corner was to be counterbalanced with weights. The total height of the structure including the antennas would be 1521 feet, the maximum allowable under CAA regulations.

RCA Superturnstile antennas were chosen; these consist of a TF-6BM six-section antenna for channel 4 and a TF-12AH twelve-section antenna for channel 8. (For those unfamiliar with the Superturnstile, it is an antenna in which two crossed half-wave dipoles are energized with currents of equal magnitude, but in phase quadrature. In order to obtain a low V.S.W.R. over a considerable bandwidth the simple dipole elements of the turnstile are replaced by the equivalent of flat vertical sheets.)

### PROJECT DESIGN SPECIFICATIONS

The specifications or design goals were set up for the project by the consultants of the participating stations. These target specifications were as follows:

1. The radiation pattern, in the horizontal plane or at the vertical angle of the beam maximum of each antenna in the presence of the other shall not deviate from the average power radiation by more than $\pm 3$ db.
2. The power gain of each antenna, in the presence of the other, shall differ from the published power gain of each antenna by no more than 0.5 db.
3. The cross coupling between the north-south and east-west radiators on one antenna, in the presence of the other, shall be better than $-26$ db.
4. The cross coupling between the two antennas shall be better than $-26$ db.
5. The input impedance of each antenna, in the presence of the other is to be such that the V.S.W.R. shall not exceed 1.1 when connected to the 51.5 ohm line used on the tower.

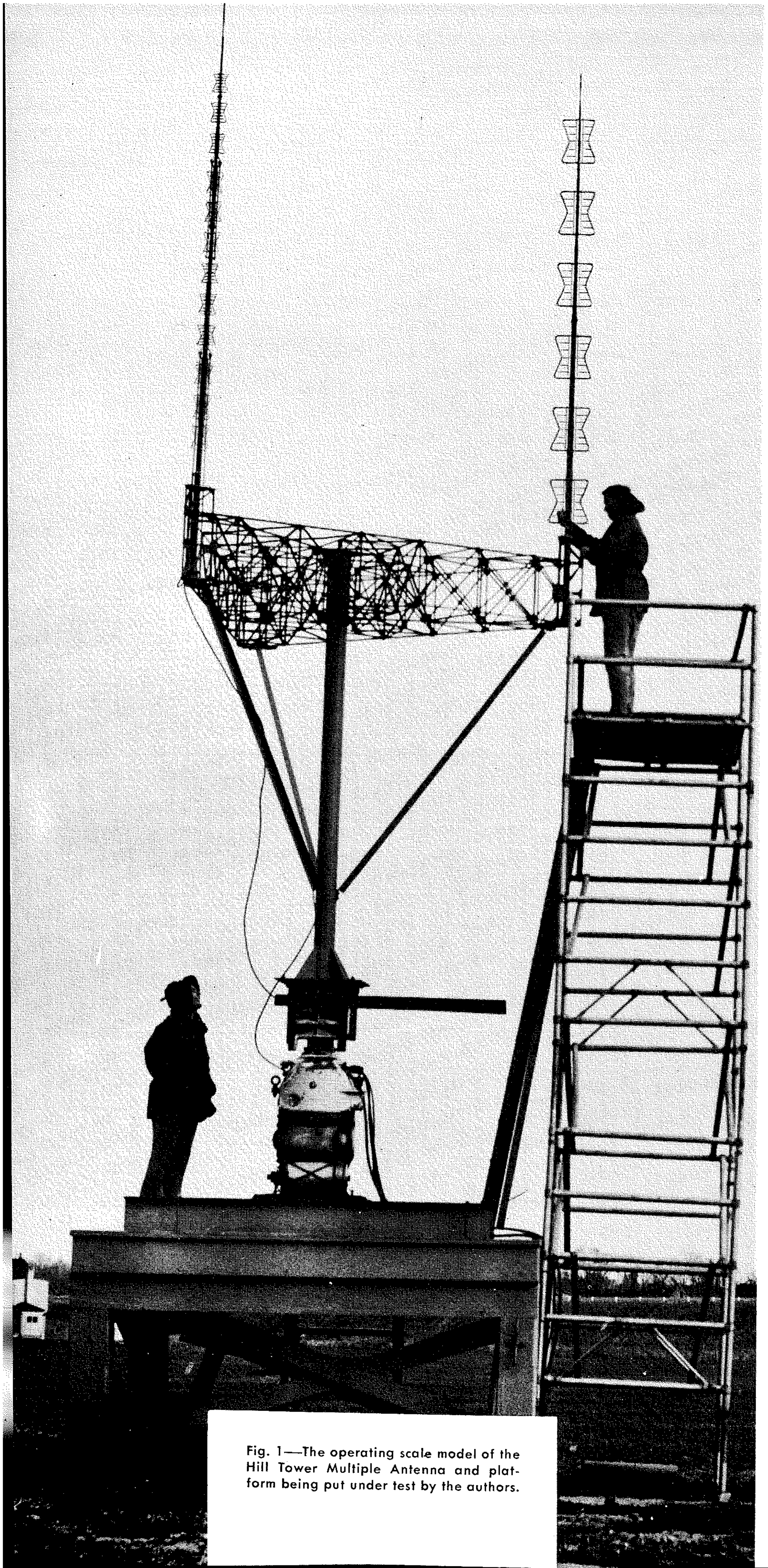


Fig. 1—The operating scale model of the Hill Tower Multiple Antenna and platform being put under test by the authors.

6. The tops of both antennas and their electrical centers shall be the same height above ground.

#### SCALE MODELS HELP DETERMINE MINIMUM SPACING

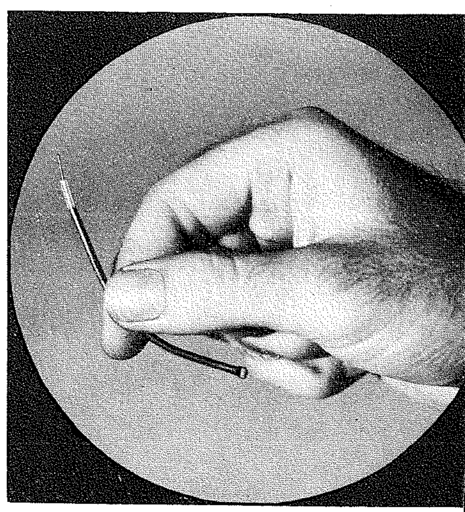
The overall project was assigned to the Broadcast VHF Antenna Engineering Group of Engineering Products Dept., under the supervision of L. J. Wolf. The co-authors of this article were specifically assigned to determine the minimum spacing between antennas that could be used without affecting the impedance, cross-coupling, and pattern characteristics beyond the limits of the customer's specifications.

Because of the impracticability of using full-scale antennas, it was decided to fabricate operating scale models of the platform and the antennas, using a scale of 8:1. This gave scale operating frequencies of 1464 mc for the channel 8 antenna (8 $\times$ midband frequency of channel 8 (183 mc) $=$ 1464 mc) and 552 mc for the channel 4 antenna (8 $\times$ 69 mc $=$ 552 mc). Using this scale, the physical height of the antenna was reduced from 99′2″ to 12′5″.

#### ACCURATE MINIATURE REPLICAS

The scale models were constructed accurately, and with the exception of some accessories that do not affect the electrical operation, duplicated the commercial antennas down to the minutest detail. The pole dimensions were scaled as closely as possible, utilizing standard copper pipe sizes. Wiring of the individual radiators followed the same procedure as the

Fig. 2—A sample of the scale coaxial feed lines used in the model antennas.



full scale antenna. The coaxial feed lines used to feed the radiators were composed of a .010″ silver coated copper-weld inner wire conductor covered with a Teflon* dielectric and encased in a .090″ copper tube outer conductor. The impedance of these lines was 77.5 ohms, corresponding to those of the full scale antenna. A sample is shown in Fig. 2.

A special junction box for the antenna feed lines was used, since it was felt unnecessary to scale this equipment in order to complete the tests.

#### EARLY IMPEDANCE CHECKS

Before the assembly of the antennas the accessories were impedance checked. As one example, the junction box was checked by having its feed line connections terminated in 77.5 ohms. The result of this check is shown in the Fig. 3 Impedance Chart.

During the impedance check on the antennas, however, difficulties were encountered. The 6-section model radiators had to be moved away from the pole and spacers added to decrease the slot length. The input impedance of this check are shown in the Fig. 4 Impedance Chart. This procedure was also followed in tuning the 12-section model.

The Impedance Chart in Fig. 5 show the North-South system of the channel 8 lower six sections at the junction box input.

#### FIELD TESTS

The field investigation was set up at the Moorestown Plant antenna site. The model platform and antennas were mounted on a rotatable pedestal as shown in Fig. 1. In order to reduce ground reflections the platform was raised 21 feet above ground by a length of pipe.

The receiving antenna was located on a tower 1400 feet from the pedestal, across a small valley as depicted in Fig. 6. The receiving antenna was a half-wave dipole mounted in a 4-foot parabolic reflector. This was first placed about 40 feet above ground, but was brought to ground level after it was found that this further reduced ground reflections.

Once the transmitter and receiver locations were established, work proceeded on impedance checks and pattern measurement. Several problems were encountered before and during these investigations. It was proposed at first to use the pedestal in conjunction with a Training Control Amplifier. This, however, was not practical as the controlled speed of rotation of the pedestal was too great to record the vertical patterns of the 12-bay channel 8 model, so during the test the pedestal was rotated manually.

#### ANTENNA FEED ATTENUATION PROBLEMS

In order to provide calibrated polar patterns at various power inputs to the antenna, an adjustable attenuator was required that would withstand five watts dissipation. Available carbon resistor pads proved unsatisfactory, and an alternate method had to be devised. The first design consisted of two hybrid rings in conjunction with a "line stretcher," as diagrammed in Fig. 7. In theory this would have provided the necessary 0 to 30 db attenuation range, but it was found that a range of only 15 to 20 db was attained. It was assumed that the assembly of this laboratory unit, using RG-8/U cable and split ¼ inch copper pipe fittings as "tee" junctions was not held to sufficiently close tolerances, for the high frequencies involved, to give the correct phasing within the individual hybrid rings for the required 30 db rejection. The design finally decided upon was a combination of dummy load, line stretcher and triple-stub tuner, as shown in Fig. 8.

A method for obtaining angular measurements was devised so that portions of the pattern could be analyzed. This was done with a relay that drove a separate pen on the automatic chart recorder which marked the chart every degree of rotation, and with a double mark every 10 degrees.

#### VERTICAL PATTERN MEASUREMENTS

To obtain vertical patterns of the models that would be comparable to the full scale antennas, each one was measured individually. To do this, they were mounted horizontally on a T-shaped mount (Fig. 9) and rotated through 360°, while a graph was made of the field strength at the fixed receiving location. The patterns recorded by this method compared quite favorably with the required full-scale antenna patterns. Individual measurements were also obtained for a comparison with the patterns expected from the antennas when mounted on

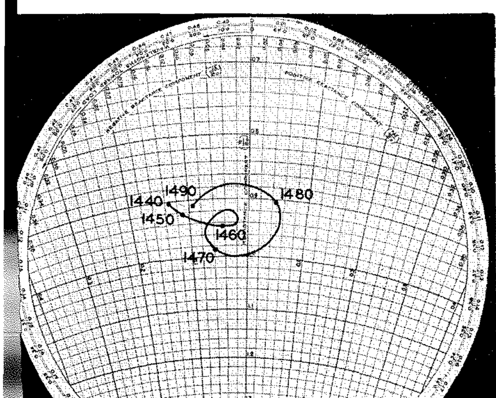



Fig. 3—Impedance Chart plotted at the antenna junction box.

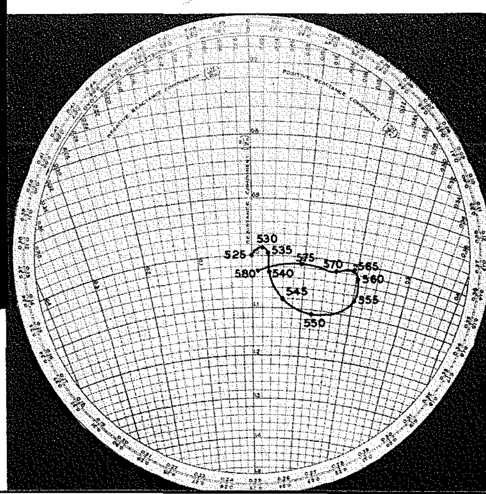



Fig. 4—Impedance Chart of the initial tests on the 6-section antenna.

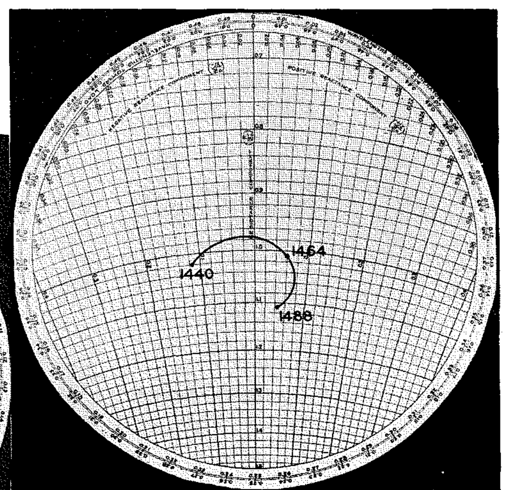



Fig. 5—Impedance Chart of the N-S system channel 8 lower six sections.

*Reg. T.M. of Dupont for tetrafluroethelyne resin.

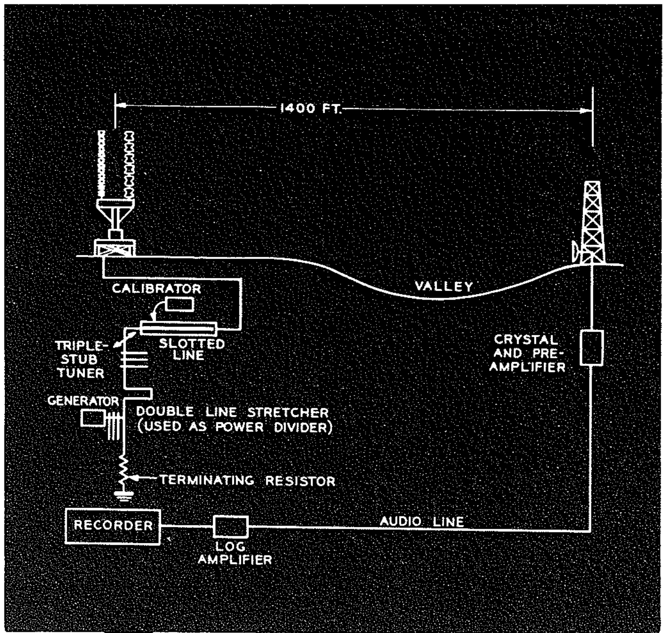



Fig. 6—Operational test setup at the Moorestown test site.

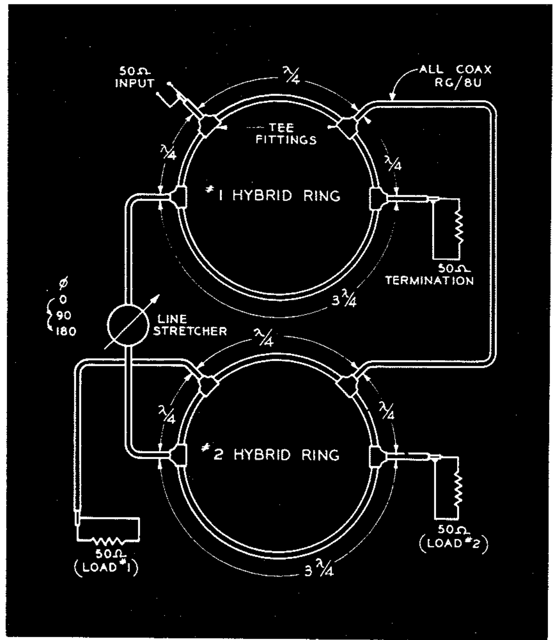



Fig. 7—Original hybrid ring attenuator design.

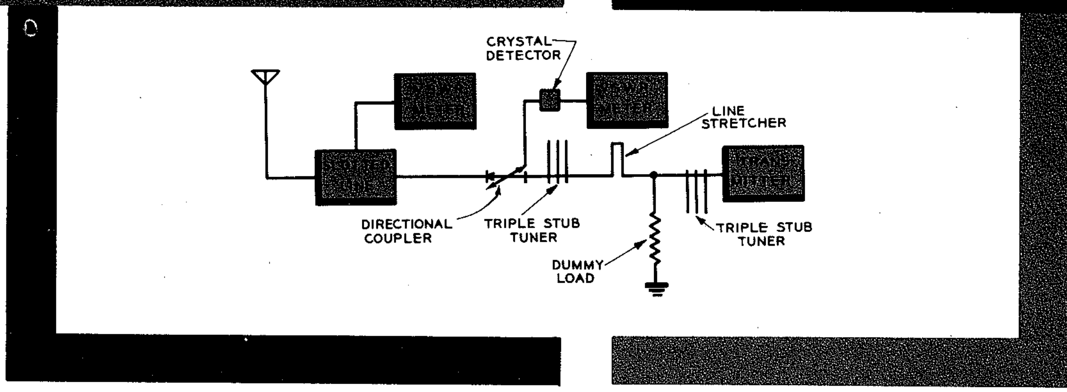



Fig. 8—Final design of the power input attenuator for the scale antennas.

the model platform. In order to check the vertical pattern for discontinuities, a method was devised which measured the horizontal patterns in cones instead of a single azimuth plane. For this test the axis of the rotating pedestal was tipped in successive one-half degree steps from the vertical, with pattern measurements taken through 360 degrees at each step. These so-called conical patterns were repeated with the model separated at various distances on the triangular platform to make sure no detrimental effects due to the platform were occurring. The optimum antenna spacing was found to be 112½″; at this point no great discrepancies were found in either vertical patterns.

From the research conducted on vertical patterns, the actual antennas would be spaced 75′ apart. It then remained to validate this figure with the results of the horizontal patterns.

#### HORIZONTAL PATTERN MEASUREMENTS

Work then proceeded on the next phase of the project: the horizontal pattern measurements. This area was of prime importance to both the customer and RCA, as outlined in the target specifications earlier in this article. Because of the close proximity of the antennas in the same plane, it was anticipated that cross coupling and phase cancellations might conceivably prove insurmountable obstacles.

As in the vertical pattern measurements, individual horizontal patterns were taken for a comparison with full scale antennas, and also with the anticipated patterns from the side-by-side mounting. In taking the measurements, it was found that the circularity differed by approximately 1 db from the measured circularity of the full scale antenna. This difference was partially due to the slightly larger pole dimensions of the model and partially to the increased tip-to-tip dimensions of the radiators. The side-by-side horizontal patterns were undertaken with the triangular platform atop the pedestal and pedestal extension. Patterns were first taken with just the 12-section, channel 8 antenna in place, in order to have a comparison with patterns taken with both antennas in place on the model.

A series of horizontal patterns was recorded with different spacings between the two antennas to determine the least deviation from average power radiation of each antenna in the other's presence. Fig. 10 illustrates a series of these patterns. Notice the changes in the horizontal pattern with distance where the antennas are in line (front to back) and also the region where they are approximately broadside to the receiving direction. The nearly sinusoidal variation in the broadside direction is very nearly proportional to the antenna separation in wavelengths. Also, notice that this variation increased in amplitude with a decrease in the antenna separation.

#### 75-FOOT SPACING CONFIRMED AS IDEAL

The horizontal patterns were made by rotating the entire model platform on its turntable base. Before the resulting patterns could be accepted, a problem had to be investigated. As the platform is rotated, the distance between the antennas and the receiving location will vary, because the antennas are offset from the center of rotation of the platform. In the actual tests, the effect of this "offset" appeared as a slight oscillation on the recorded pattern in the region of maximum change in separation between the receiving and transmitting locations. This was attributed to the changing relative phase between the direct and ground reflected wave as the antenna was revolved.

Measurements taken on the horizontal patterns were studied, and it was found that 112½″ spacing between antennas on the model proved to coincide with the target specifications. According to the horizontal measurements the antennas should be spaced 75′ apart—the same distance calculated from the vertical measurements!

**CROSS COUPLING AND IMPEDANCE TESTS**

While the antennas were mounted on the platform, cross coupling and impedance tests were made. The input impedance of each antenna was taken at spacings from 112½″ apart to 12″ apart, with the radiators of each antenna 45° to each other. A chart of the resulting input V.S.W.R. is shown in Fig. 11. Additional input impedance measurements were taken for the two antennas at various angular positions with respect to one another. In making the tests for effect on standing wave ratio each antenna was rotated with respect to the other and data was taken at a series of angular positions. For each position at which data was taken, the adjacent antenna was successively open circuited, short circuited, and terminated in the characteristic impedance of 51½ ohms, thus covering the complete range of impedance variations.

The cross coupling measurements were also made at each of a series of angular positions. Hence the resulting data were complete and applicable to any arrangement of the antennas that might be chosen from reasons of coverage.

All facts of the investigation were considered and compared against the target specifications. It was concluded that these specifications could be met, and that two transmitting antennas could be mounted side-by-side, spaced 75′ apart, and provide adequate coverage of the two station areas.

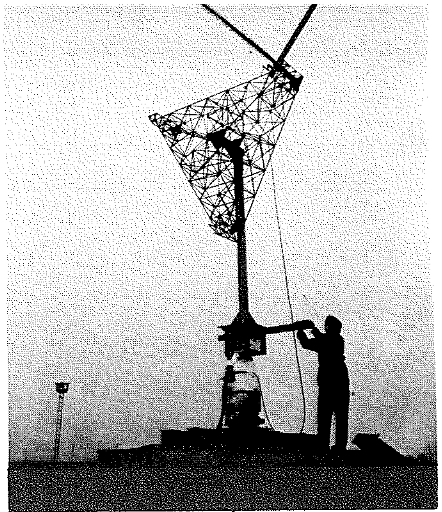
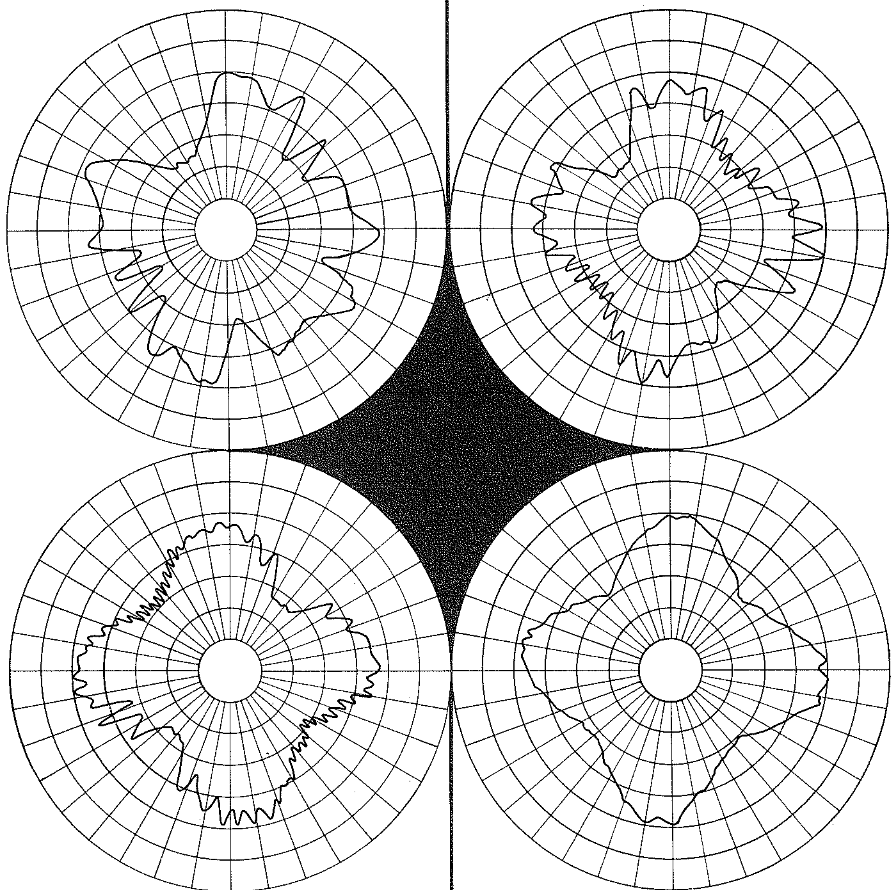


Fig. 9—The platform is tilted to obtain vertical pattern measurements.

10a—28″ 10b—58″



10c—112½″ 10d—12-section alone

Fig. 10—Horizontal patterns for various spacings between antennas.

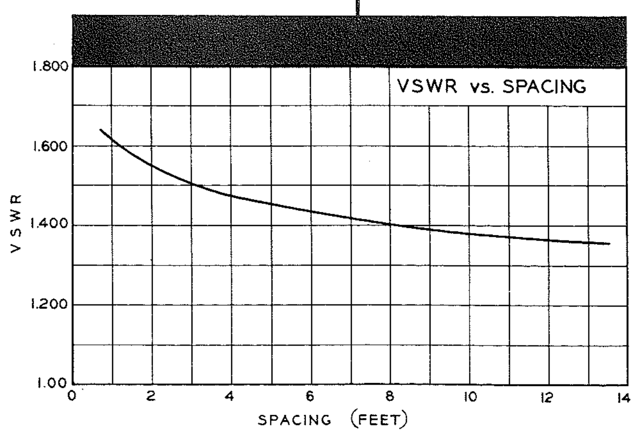
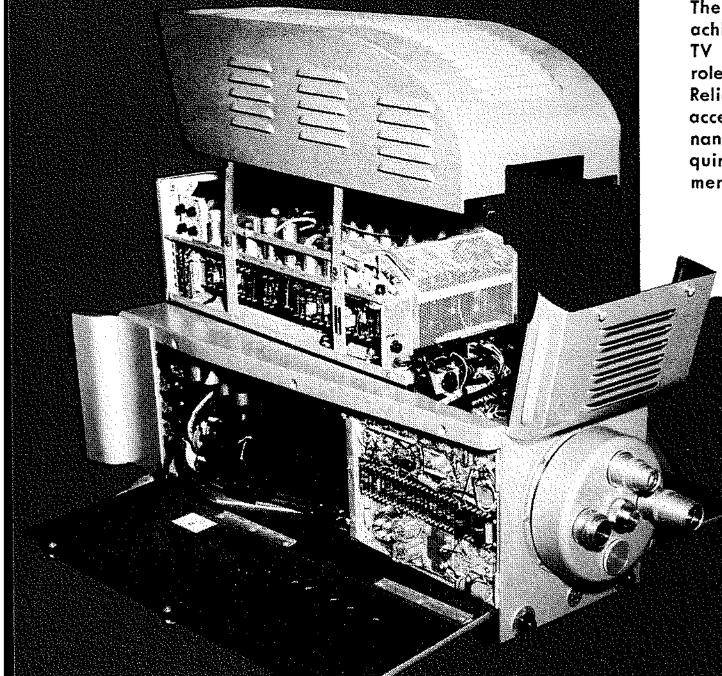
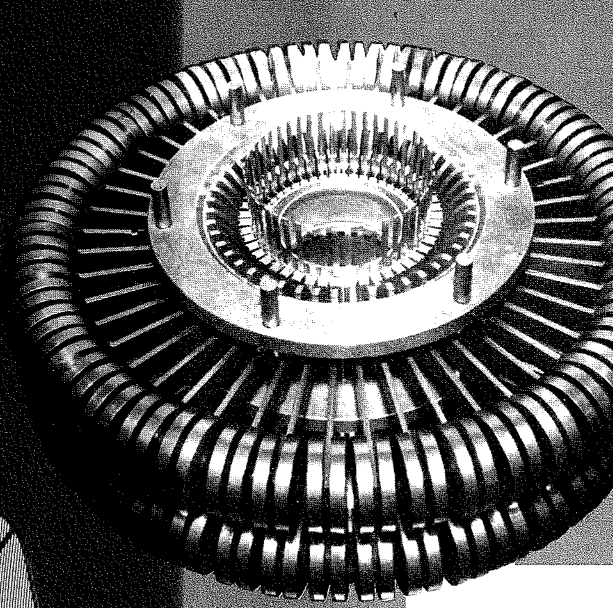


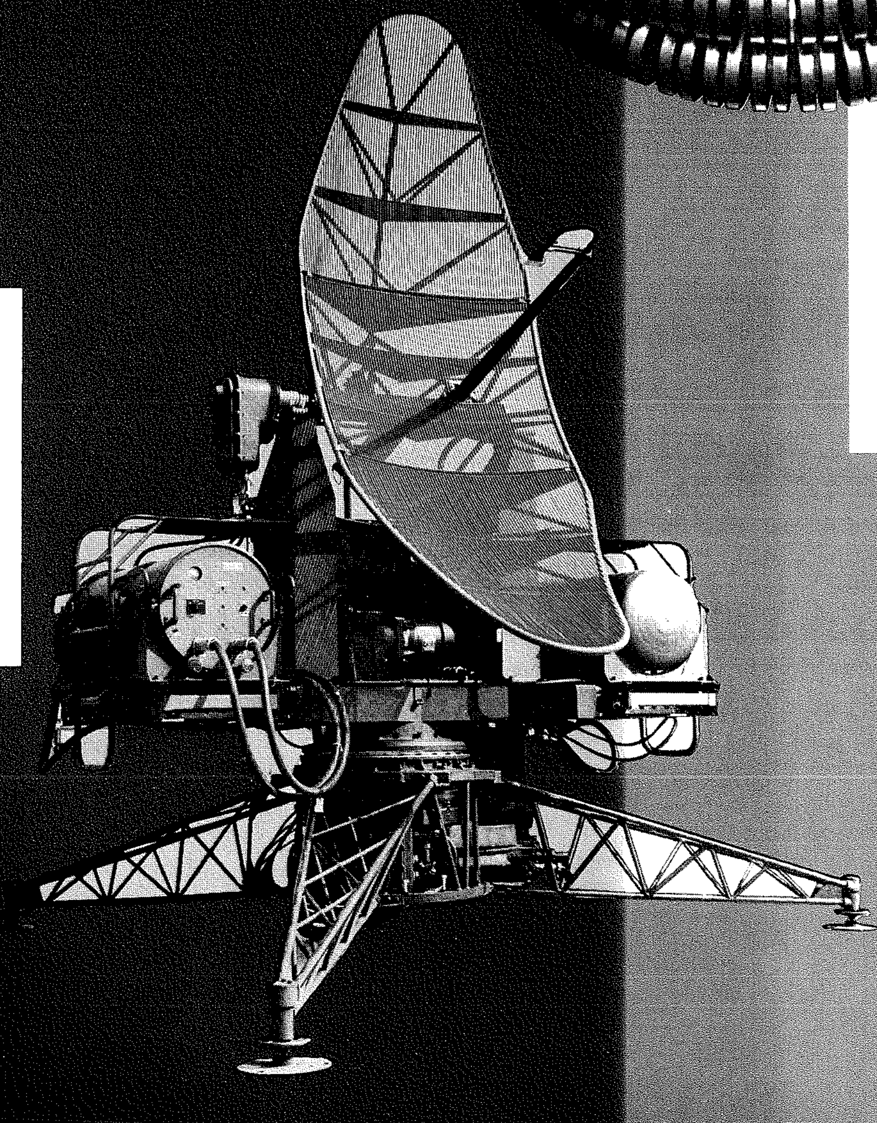

Fig. 11—V.S.W.R. vs. Spacing in feet



The "inside-out" accessibility achieved in the design of this TV Studio Camera typifies the role of the mechanical engineer. Reliability, mobility, complete accessibility and rapid maintenance are inportant design requirements for telecasting equipment.

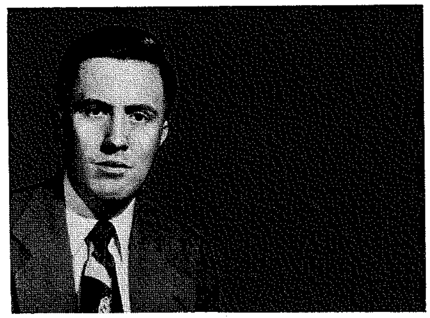


Design of this T-Bone brazing fixture is the job of the mechanical engineer at the Tube Division. This complex array of bars and discs attached to the tube structure is necessary to prevent distortion of the copper internal structure during brazing.



This height-finding radar pedestal illustrates many mechanical design features. The precision antenna, waveguide rotary joints, balanced mount for the pressurized electronic units, and the rugged but lightweight base structure are indicative of problems to be solved by the mechanical engineer in Electronics.

# THE ROLE OF THE MECHANICAL ENGINEER IN ELECTRONIC EQUIPMENT DESIGN



*by*
**T. G. GREENE**
*Missile and Radar Engineering*
*Engineering Products Division*

*and*

**P. C. HARRISON**
*TV Terminal Equipment Engineering*
*Engineering Products Division*

**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 B.S. 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 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 the General Electrical Engineering Unit.

**PAUL C. HARRISON** received his B.S. degree in Mechanical Engineering from the University of Delaware in 1948. Previous to that he spent one year in Arms and Ammunition Design at the Aberdeen Proving Grounds, Maryland and two years in the Army Airways Communication Service as a sergeant in Radio, Tower, and Direction Finding Apparatus Operation.

Mr. Harrison came to RCA in 1948 and worked on the mechanical design of Television Camera equipment. He is presently a Leader of Design and Development in Broadcast Studio Engineering.

Mr. Harrison is a member of Tau Beta Pi and Phi Kappa Phi.

TECHNICAL PRODUCTS today are the result of the applied efforts of many individuals working as a team. This is particularly so in the electronics industry which, while still in its infancy, has grown so rapidly that its present needs and its future potentialities are beyond the scope of the individual. To meet these needs and to fully realize the potentialities, the industry must employ the combined services of many "specialist" engineers. The role of the electrical engineer is readily understood. The need for good circuit design is unquestioned. The role of the mechanical engineer, while equally important, is much less publicized and, therefore, not as easily recognized nor as completely understood. This and several future papers to appear in the RCA ENGINEER will apply primarily to the mechanical engineer's role in electronic equipment design. These articles will be written *about* the mechanical engineer rather than *for* him. They will delineate and describe the various techniques, materials and methods that he uses in solving the mechanical problems encountered in the design of electronic gear. These factors will be listed, outlined, and sufficiently well described to provide electronics engineers with a better appreciation of some of the problems on which they need mechanical engineering help.

#### EARLY ELECTRONICS ENGINEERING

Since we are concerned with how the mechanical engineer fits into the product team, let us start by reviewing a bit of the history of electronics engineering. The industry which we know today as "Electronics" owes its beginning primarily to three discoveries dating back over seventy years. The first, in 1883, was Edison's discovery of the "Edison Effect," the flow of current when a metal plate was enclosed with a heated filament in an incandescent bulb. Second, was the first possibility of useful application of the "Edison Effect" in the diode "valve" patented by Sir Ambrose Fleming in 1904. Third, was the work of Dr. Lee DeForest in 1906, which, with the introduction of the control grid, resulted in the first use of the electron tube for amplification.

In this "dawn of the era," the field of electronics was confined almost entirely to laboratory experiments and the construction of a few crude working models by the inventors themselves. The inventor, with perhaps an assistant, was his own engineering force, production force, and, when he could find a market, his own sales force. He was truly a "jack of all trades."

#### SIMPLE MECHANICAL DESIGNS

The next phase in the growth of electronics was the start of limited production, primarily restricted to the communications field, by organizations, rather than by individuals. As the mechanical design of this equipment was relatively simple, it became standard practice for the electrical engineer to assume responsibility for both the electrical and mechanical aspects of the product design. Indeed, since the "state of the art" was so meager, it didn't matter much what "specialty" the engineer had studied. The pioneering nature of the manufacturing processes permitted this practice.

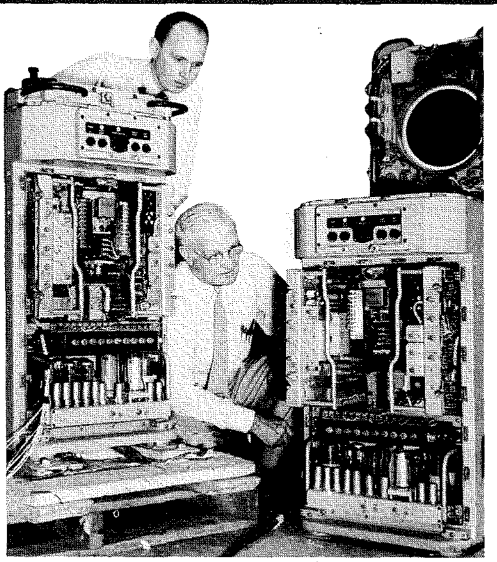


Fig. 1—Stew Arensberg, standing and Herb Greene, mechanical engineers responsible for the design of this equipment at Moorestown, N. J., examine samples of a very compact radar indicator. The model at right shows top cover raised and vertical electronic chassis partially withdrawn.

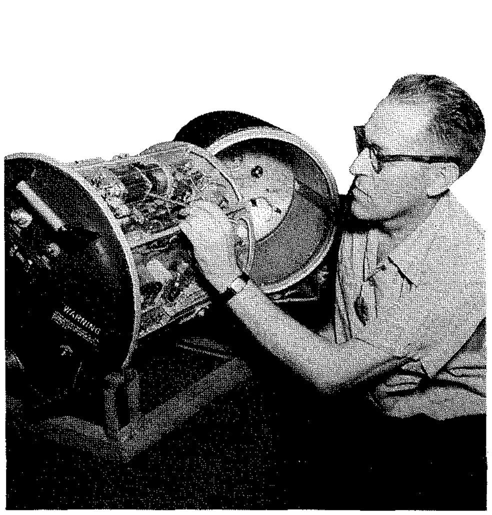


Fig. 2—Mechanical engineer, Ted Hecking, of "EPD," points out a precision oil-filled tuning mechanism in an extremely compact airborne transmitter-receiver. The unitized construction for ease of maintenance and the cylindrical shape to facilitate pressurization make the design unique.

Fig. 3—Mechanical engineer, Bob Schietinger, (l) of Missile and Radar engineering, checks an assembly tolerance in a unit of a radar precision pedestal with M. H. Betchen, general foreman. Note variety of precision drive gears, bearings, oil lines, and machined castings employed in this design.

#### COMPLEXITY INCREASES DURING WARTIME

With the coming of World War II, the electronics industry expanded rapidly. Radar, sonar, aviation equipment, and other wartime equipment needs resulted in engineering development and research exploring many hitherto unexplored phases of electronics. The increasing complexity of these products of the electronics industry, together with volume production requirements, opened up a field for skills other than those furnished by the electrical engineer. This same trend carried over into peacetime when engineering and production facilities were diverted to such fields as television, sound recordings, commercial aids to navigation, color correction equipment for the graphic arts, and electronic computers. The application of electronics to the solution of military problems also stimulated the further growth of such new developments as atomic energy devices, guided missiles, shoran, and miniaturized walkie-talkies.

#### MANY ENGINEERING TALENTS NEEDED

This new variety of applications, with their inherent complexities, has expanded the field of electronics to the extent that it would be virtually impossible for one individual to comprehend and cope with them all. The design of a single electronic product may, and quite frequently does, require the solution of problems in heat transfer, humidity, shock and vibration, precision instrument gearing and power drives, structural design, human engineering, production economics, and mass production techniques. Obviously, the electrical engineer cannot be expected to solve all these problems and also do circuit development and design.

The fundamental background of the mechanical engineer's education is such as to prepare him for the solving of these problems. His education has included the study of the principles of Thermodynamics, Vibration, Machine Design, Dynamics and Statics, Heating and Air Conditioning, Psychology, and Manufacturing Processes. In addition, he has completed enough basic courses in electrical engineering to be able to recognize the importance of the criteria imposed by the electrical aspects of the design.

The keen competition in the consumer goods field of the post war period has placed emphasis on reliability, ease of servicing, and low manufacturing cost. At the same time the armed forces, as customers of the industry, are insisting on improved mechanical design in their equipment. Every new contract for electronic military weapons, defense measures, and communications gear, reflects an attempt to extend the range, increase the accuracy, and improve the reliability of such equipment. The larger firms in the industry were first to recognize the growing need to employ many special skills and talents to meet this challenge. Such firms are employing more and more mechanical engineers to work on the development and design of their electronic products. Many of the small firms, whose engineering payrolls must of necessity be limited, are seeking engineers who can "double in brass," that is, electrical designers who can also handle the mechanical design of their equipment.

Increasing numbers of both graduate and future graduate mechanical engineers will be required to provide for the continued growth of the electronics industry. The challenge to the imaginative young engineer is too great to be ignored, for, in this industry more than in most any other, he will be called upon to use all of the talents which he has developed during the course of his education.

#### A TYPICAL MILITARY EQUIPMENT DESIGN PROBLEM

The mechanical engineer working in a radar pedestal design team for example, must face an entire gamut of problems before the complete design is accomplished. The overall system requirements and the environmental conditions of temperature, humidity, windload, and altitude encountered in the tactical use establish the parameters of design. Within the boundaries designated by these factors, mechanical engineers must begin to tackle individual design problems. The elevation and azimuth accuracy and the slewing speeds required will determine for him the techniques which must be used in designing his gear train. The choice of the proper material, manufacturing tolerances, the permissible backlash in the gear train, the torque required for supplying the surge load placed on the gears by varying wind loads, are all factors which he must consider in designing power gears for the complex system.

At the same time, within the pedestal, provisions may have to be made for precision-instrument gear trains to drive synchros, or precision potentiometers, providing data take-off. In this area he must work very closely with the electrical engineer.

In the antenna design, again the system requirements may specify an extremely narrow beam width and the mechanical engineer must become acquainted with microwave techniques, for he is responsible for the design and manufacture of the antenna structure itself. His knowledge of optics may be called upon if a parabolic reflector is required. Here he faces the problem of designing and having manufactured a large surface within extremely precise tolerances. The design of this "dish" will require careful stress analysis and a thorough knowledge of materials and manufacturing methods if a lightweight, low-inertia structure of high rigidity is to be achieved to maintain the beam precision.

The mechanical engineer is responsible for the structural design of the base, and the antenna mount as well, which frequently necessitate the use of a rigid but lightweight casting. Careful thought must be given to the method of construction, the choice of materials to be used, and the selection of the proper finish to protect the structure under varying environmental weather conditions.

The mechanical engineer and the electrical engineer together must solve the problem of designing slip-rings to provide connection for the various electrical signal and power circuits through the rotating mount. This problem alone can take many hours of design consideration.

The precision equipment and electronic gear must be housed within the pedestal. Heat will be generated internally by these equipments and careful consideration must be given to cooling these components. Care must be exercised in the design of moving parts and the selection of lubricants and means of lubricating, since inaccessibility under tactical conditions sometimes prohibits frequent maintenance. Occasionally, both heaters and cooling fans must be provided within the housing to maintain performance in either arctic or tropic environments.

The entire antenna pedestal may weigh several tons. High-speed rotation and rapid reversal of the mount may impose severe conditions of shock on the design. A further complication is that the antenna pedestal may be destined for shipboard installation where pitch, roll, and gun blast impose further conditions of shock and vibration.

Because of the obvious mechanical complexity of such an antenna-pedestal, project responsibility lies with the mechanical engineer. In addition to the usual estimating, scheduling and cost control, and design responsibility required of a project engineer, the mechanical engineer is frequently

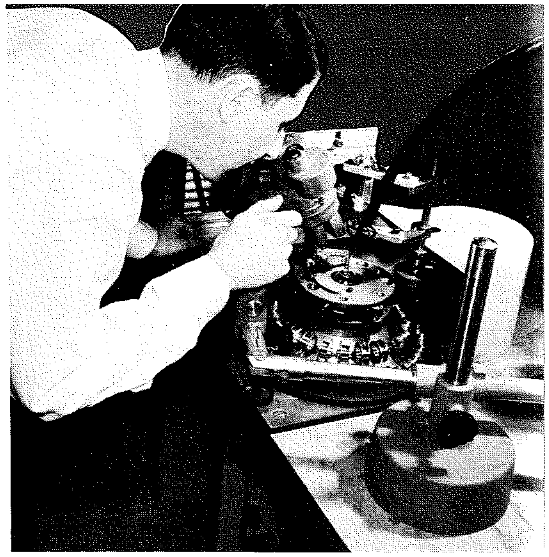


Fig. 4—H. J. Ackerman, Tube Division Mechanical Engineer, checks alignment of wires in Vertical Grid for Pencil Tubes. Machine automatically draws vertical wires from spools at bottom, winds a helix coil around them, and R-F brazes each cross-over point.

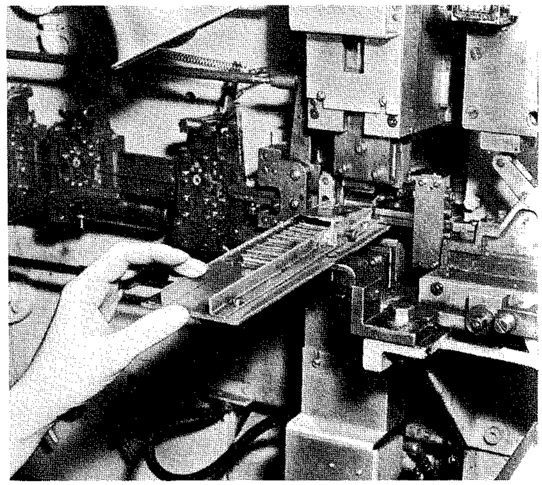


Fig. 5—Tube Division equipment development engineers are responsible for design of this automatic grid welder. It makes grids by welding grid wires to siderods. All wires required to form the specified number of turns are pulled over two side rods, a sizing mandrel forms the ovate grid shape, and wires are welded and cut. Grids emerge onto a tray.

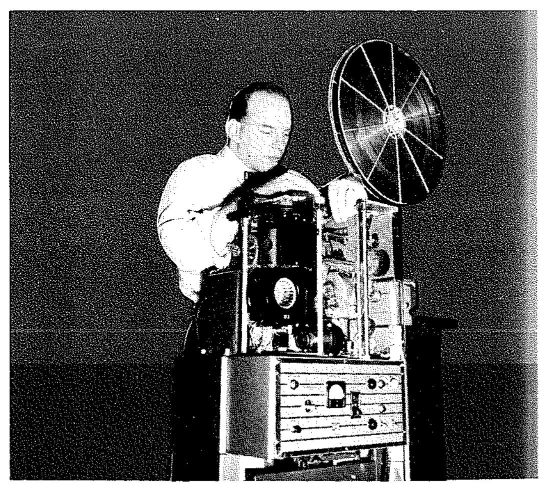


Fig. 6—H. G. Wright of "EPD," mechanical engineer, is adjusting tension on changeover shutter of Professional Projector for TV. Note cooling blowers and control-panel styling.

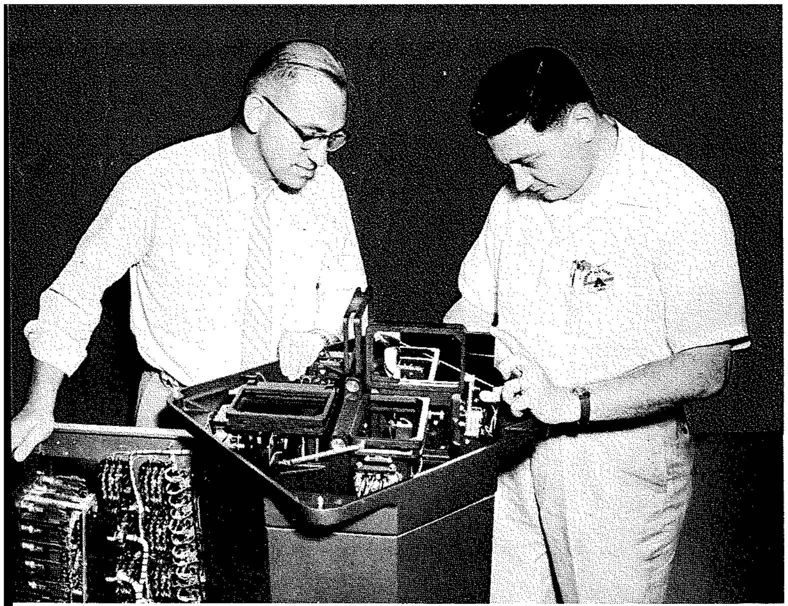


Fig. 7—M. H. Hutt and B. F. Melchionni, mechanical engineers from TV Terminal Equipment Engineering, "EPD," are inserting a mirror in a TV Film Multiplexer. Note cast base, and accessibility of control-panel components for servicing.

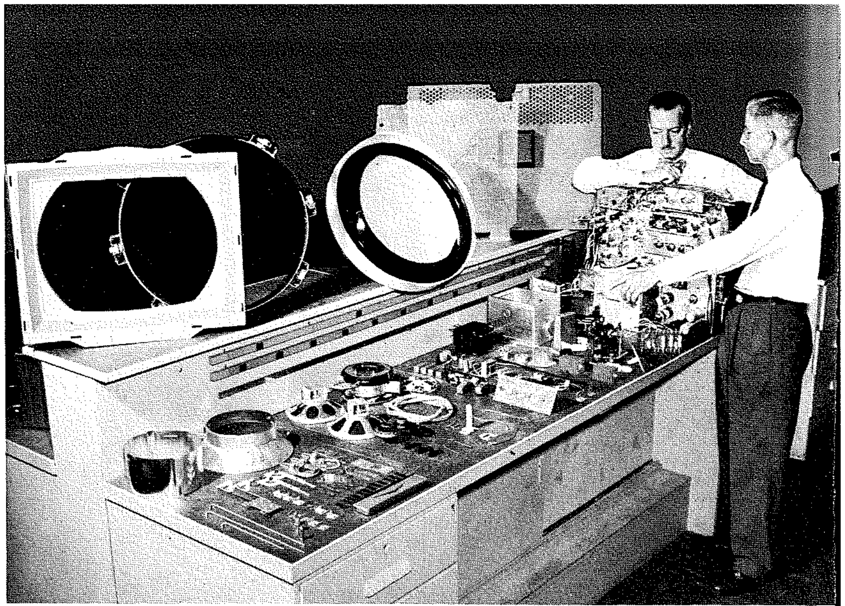


Fig. 8—Mechanical design and assembly of a color receiver involves many components requiring special attention, such as the high-voltage assembly, deflection yoke assembly, and color equalizer. Ernie Dawson (at far right) and Jack du Bois, mechanical engineers at Cherry Hill, N. J., have grouped together a typical instrument assembly for purposes of illustration.

also responsible for a major subcontract for the design and fabrication of such a pedestal.

#### MECHANICAL DESIGN OF AIRBORNE EQUIPMENT

A similar antenna mount for airborne use requires the same considerations but under altogether different design parameters. The equipment for installation in planes is subject to different conditions of shock and vibration. Size and weight must be kept to a minimum. The environmental conditions of temperature, humidity, and pressure may designate that entire units must be hermetically sealed and pressurized, further complicating the cooling problem. Such packaging requires a precision tuning device which may be remotely controlled. High-speed slewing of the antenna may impose altogether different requirements for the gear train. While solving these problems, the mechanical engineer must also design for ease of maintenance and repair.

#### TUBE DESIGN AND THE MECHANICAL ENGINEER

Mechanical engineers face an altogether different variety of problems in electron tube development and design. In the design of ultrahigh-frequency power tubes, for example, the mechanical engineer must not only become familiar with evacuating techniques, heat dissipation problems, and the characteristics of metal-to-glass seals, but must work very closely with the electrical engineer in designing very complicated cathode and anode structures. The material selected and the shape of a metal anode, for example, must provide structural strength, rigidity, and good heat dissipation, and it may also provide the resonant cavity which establishes the operating frequency. Careful selection of the cathode and grid materials, and the design of internal supporting structures is required to prevent vibration and prohibit mechanical resonances.

In the design of kinescopes and equipment for the manufacture of kinescopes, the mechanical engineer is again faced with the problem of metal-to-glass seals, the structural strength of the glass envelope or tube face, and the tremendous pressures caused by evacuation. He must become familiar with the principles of electron ballistics in determining the gun configuration and its tolerances. With the advent of color television, mechanical engineers face tremendous problems of designing and having constructed the screen structure which establishes the color dot pattern. Ruling engines, for example, find application in such precision problems.

The design and development of automatic machinery for winding grids, assembling, evacuating, and sealing electron tubes, offer tremendous challenges to the mechanical engineer. In this area, a knowledge of kinematics, cam design, gear and ratchet mechanisms, and Geneva movements, as well as fundamental machine design practices, is an essential requirement for the mechanical engineer.

#### MECHANICAL DESIGN OF TELECASTING EQUIPMENT

In the design of television broadcasting equipment, the mechanical engineer faces problems in styling, in serviceability, in manufacturing economy, and in systems compatibility considerations, as well as in specific technical design problems. As an example of the latter, the advent of television required a re-examination and further development in photographic film drives. In the design of studio equipment for kinescope recording and for televising films, both old and new, the mechanical engineer has been faced with the problem, among others, of synchronization between television scanning standards and standards earlier established by the film industry for film speed. Some very unique designs have been created to attain the rapid pull-down and stop and start requirements for movie film in television broadcasting.

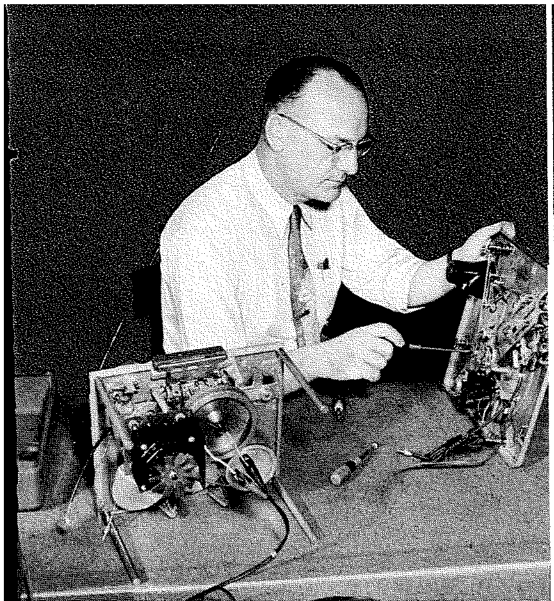


Fig. 9—Roland Di Sabatino, mechanical engineer of the Radio and "Victrola" Division is shown adjusting a three-speed automatic record-changer mechanism.

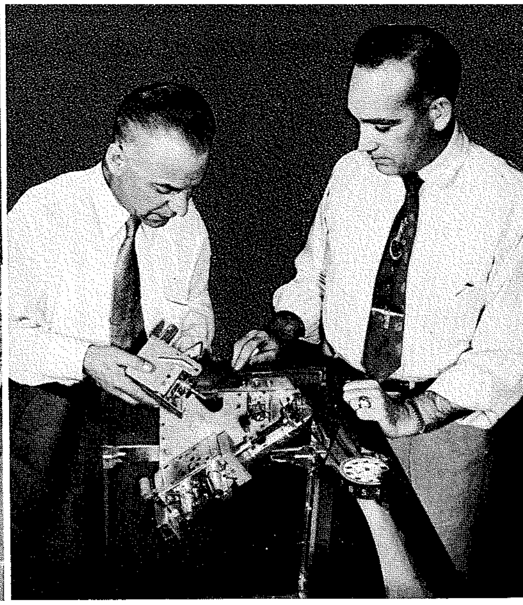


Fig. 10—E. J. Sperber (l) and C. Schlight, mechanical engineers in Television Receiver design, are inspecting mechanical assembly of a tri-axially operated TV tuner, featuring a belt-driven channel indicator.

Fig. 11—Robert D. Short (l), mechanical engineer and J. K. Forman, draftsman of the Radio and "Victrola" Division, checking a printed wiring circuit board for clearance between wiring points. On the table is the photomaster.

Television cameras must be designed with accessibility for ease of maintenance. Again the mechanical engineer must draw upon his knowledge of optics to provide focusing of the image upon the pickup tube. Vibration-free packaging of the image-orthicon tube must be attained in limited space in order to keep the camera small. Internal heat dissipation problems plague the mechanical engineer, and special quiet and efficient cooling techniques must be developed. The pedestal upon which the camera is mounted must be carefully designed, for here the goal is to move a large mass rapidly with practically fingertip control.

#### MAGNETIC TAPE DRIVES

The problems of advancing a film or tape posed in the design of computing machines, and audio and video tape mechanisms, differ from those of the television film drive design described above. In the storage devices, or memories, of large-scale computers, for example, long lengths of magnetic tape must be accelerated from rest to high-speed operation almost instantly, if the acquisition of the required data is to be attained rapidly. Whole new techniques of drives and mechanical servo systems have been developed, and stand as a monument to the ingenuity of the mechanical development engineer.

#### MECHANICAL DESIGN OF RECEIVERS

Teamwork is again the story when you consider the design of a home receiver. The mechanical engineer works with styling, drafting designers, and the electrical engineer to design a finished product which will catch the eye of the consumer with its beauty, quality, and utility.

The television receiver, comprised of electron tubes, including the kinescope, and a myriad of components, presents its own peculiar challenges to the mechanical engineer. The design of tuners and drives requires a high degree of skill and ingenuity. The usual glass kinescope does not require extensive shielding but the color television metal-shell kinescope, operating at high voltages, calls for the use of a protective plastic mask and shielding around voltage-carrying surfaces. The chassis, parts of which carry the same high voltages, requires a mechanical-electrical, voltage-capacitor discharge device, as well as the customary power-removing interlock, to protect the public from shock when the back cover is removed from the cabinet. Kinescopes, particularly color, are affected by external magnetic fields, such as the earth's, and at times call for the design of a magnet system to counteract such influences.

The design of AM & FM radio receivers and "Victrolas" from the smallest portable to the largest console offers the mechanical engineers many other intriguing problems. For instance, automatic record changers and the transport mechanisms for tape recorders are in themselves mechanical achievements. Many hours are spent designing the motor drive systems and automatic features.* The mechanical improvements in record players in general, from the old 78 rpm to today's precision microgroove instruments, are just as marvelous as the concurrent developments in electronic audio amplification techniques.

In addition to the problems of component design, chassis and component mounting, heat dissipation, vibration, accessibility for servicing, and protection of the public from electrical shock, the mechanical engineer has the problem of adapting his product to designs established by the stylist to appeal to the public taste. Liaison with vendors and purchasing and close production follow up, essential in all mechanical design effort, is mandatory in the high-quantity production of home-consumer goods. The mechanical engineer faces a constant request for a smaller, less expensive, more efficient product.

So it is evident that today's receiver demands much of the mechanical engineer and to meet these demands calls for the full use of his powers of

*See "Slide-O-Matic" Mechanical Design Article this issue thought, perseverance and, above all, imagination.

### MINIATURIZATION AND NEW PRODUCT DESIGN

Mechanical engineers are leading the way in opening new frontiers of knowledge in many areas. The advent of just one new item, such as the transistor or printed circuit, opens up a whole new field of endeavor in simplification, miniaturization, and subminiaturization. Considerable publicity has been given to the transistor, but little has been said of the companion circuit components that have been developed to go with transistors. The transistor as an amplifier brings into the realm of possibility many revolutionary products. An example is the hearing aid built into the arm of a pair of spectacles. Consider the problems the mechanical engineer encounters in miniaturizing the associated components in such an amplifier. And consider the "packaging" problem in putting all those parts in the arm of the glasses. The advent of this same transistor means that the first stage of amplification in a high-fidelity system can be built into the tone arm of the record player.

### AUTOMATION AND THE MECHANICAL ENGINEER

The emphasis on reliability, coupled with the developments in subminiaturization, leads quite naturally to printed wiring and printed-circuit techniques, and these are ideally suited to automation. The problems of printing, etching, plating, and dip soldering have been solved by the mechanical engineer. He is now confronted with the design details of automation. If he is to create an automatic factory in which, ideally, components and raw materials are fed in the supply end, machines do the assembly work, and the equipment comes out as "finished goods," he must solve many more problems. Materials for the printed boards must be selected; thickness, outside dimensions, and punched-hole standard dimensions must be agreed upon. Automatic machines for printing the wiring, for shearing the boards to size, for punching component insertion holes, for inserting the components, for soldering, and for testing the finished boards, must be designed. Compatible automation standards must be established throughout the industry so that component manufacturers and equipment manufacturers have a sound basis for production. These problems, of developing an automatic machine which rivals the combined complexity of a shoe machine, electron-tube assembling machine, and a high-speed printing press all rolled into one, are being solved today by mechanical engineers. In the future, automation will be essential for any electronics firm desiring to remain competitive. It demands that the best available talent be employed to develop the system standards and the production facilities. Moreover, electronic equipment design engineers must seriously consider that today's designs are tomorrow's production. Major responsibility lies with the mechanical engineer to see that today's designs make use of every possible technique of miniaturization, modularization, and automation.

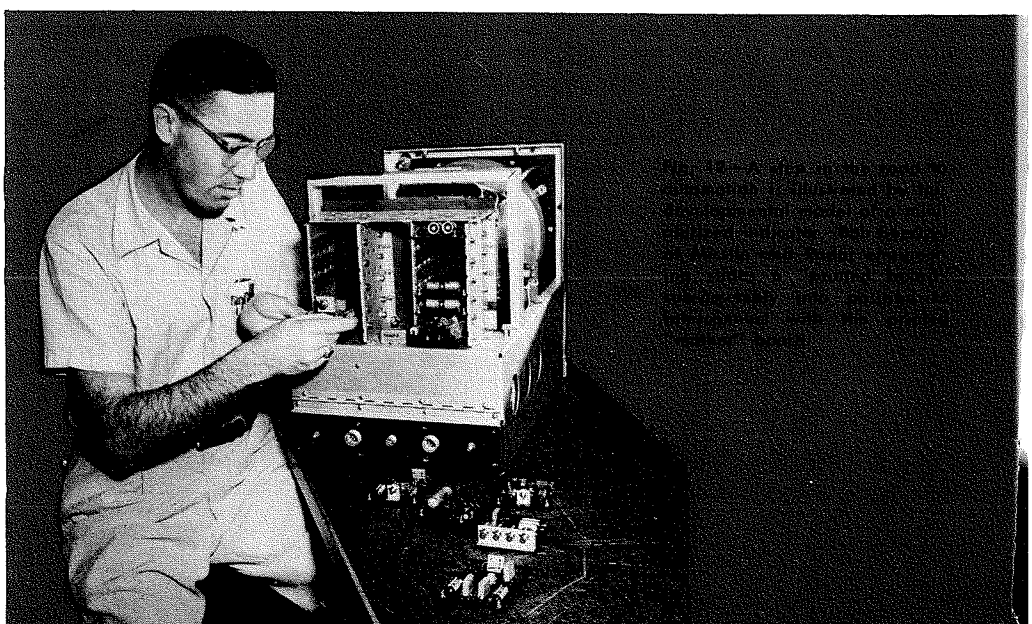
### THE MECHANICAL ENGINEER IN MANAGEMENT

Just as electronics firms are recognizing the importance of good mechanical product design, and as the mechanical engineer further mechanizes production, growing importance is placed on mechanical "know-how" in the planning and running of electronic businesses. As the days of the automatic factory approach, an engineering background becomes more and more desirable for the business manager, and mechanical engineers are facing expanded opportunities to move into management positions. Mechanical, electrical, chemical engineers, and physicists all will find their place in running the business of the future.

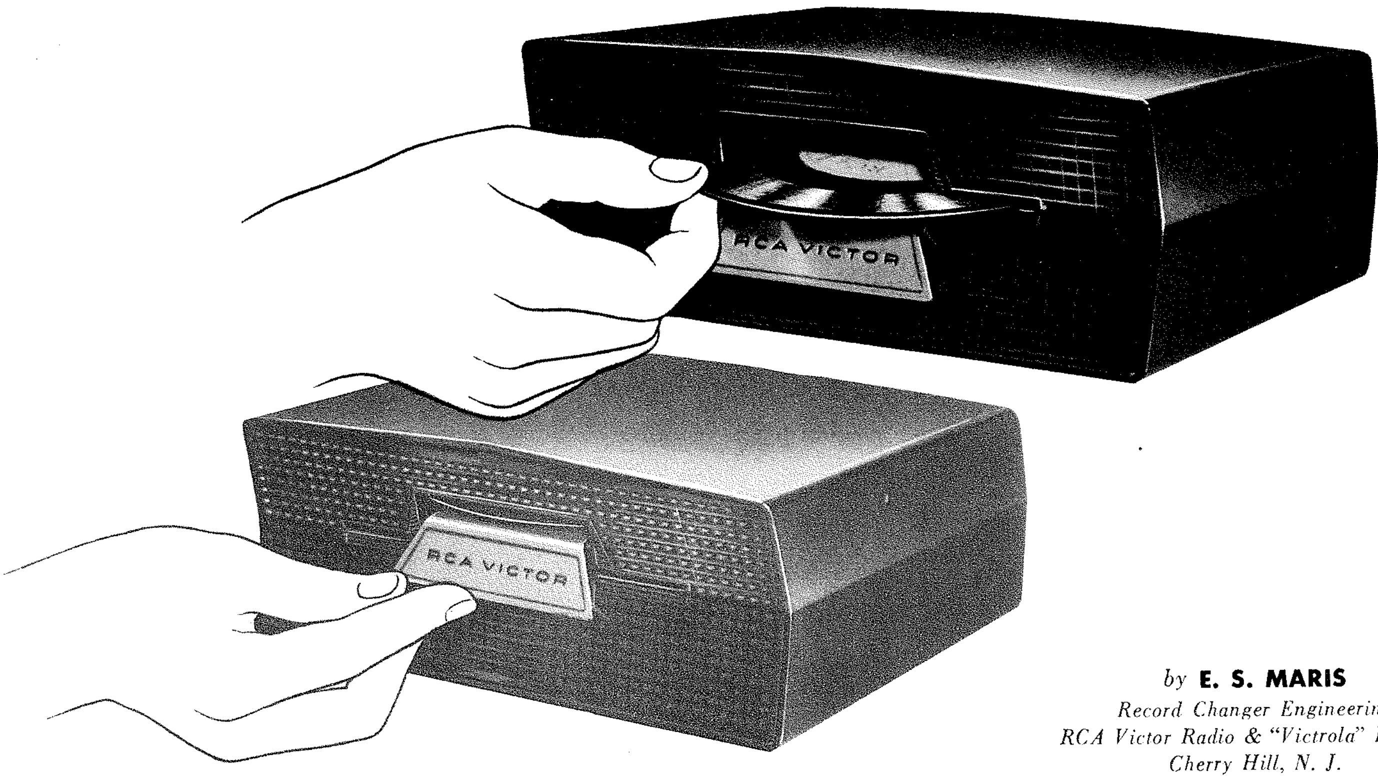
### CONCLUSION

Because of the importance of the role of the mechanical engineer in Electronics product design, the editors of the RCA ENGINEER are planning to publish a series of articles devoted to this subject. It is intended to illustrate, in greater detail, many of the specific mechanical engineering problems, and demonstrate many of the techniques and methods employed in their solution. Naturally, it is impossible to print in the space available every detailed solution to every problem encountered. Many topics to be covered in one or two paragraphs could be the subject of a complete text or handbook. Each article will be well annotated with references and a bibliography so that engineers can pursue any subject in greater detail.

It is hoped that the way to proper solution will be sufficiently well shown that the electrical engineer will be better able to discuss his problems with his fellow mechanical engineers, consultants, subcontractors, and vendors. We hope that the mechanical engineer in the electronics field will find in this series a systematic review of the problems he faces daily, and that he can draw upon these articles for guidance in tackling his problem. Finally, it is our hope that by promoting a better appreciation and understanding of their mutual problems, the electrical-mechanical design team will produce better electronic products.



# NEW SLIDE-O-MATIC "VICTROLA" ATTACHMENT




*by* **E. S. MARIS**
*Record Changer Engineering*
*RCA Victor Radio & "Victrola" Division*
*Cherry Hill, N. J.*

THE RCA SLIDE-O-MATIC is a semi-automatic single play record player attachment. It is designed to be operated with any radio or TV instrument equipment with phono jack utilizing the audio and speaker system of the same instrument. Playing mechanism, engineered from an original design submitted by B. R. Carson, consulting engineer, is completely enclosed in a two-piece molded cabinet and grille which offers maximum protection against accidental damage during operation, as well as flexibility in color combinations. Cabinet was styled by Henry Dreyfuss, industrial designer, for RCA.

The player is operated by first sliding a record through the slot in the grille to a position at rest against inner stops in the cabinet and then raising the play control upward to a latched position. This automatically switches on motor, places the record on the turntable, and also indexes the pickup arm and stylus to the correct landing area on the record.

The mechanism is automatically stopped after the selection is played or it may be manually stopped at any time by tripping the play control. Either of these operations causes the mechanism to be lowered to a position where the record can be removed through the slot in the grille, switches off the motor, and permits tone arm to return by gravity to the correct landing position for playing of the next record.

Consideration during layout was given to three applications of this mechanism; namely, the attachment is a self-contained phono with amplifiers and speaker, and a radio-phonograph combination. This mechanism which is designated as the RP-199 is shown in Fig. 3. As can be seen from the reference figures, the entire operating mechanism including the front grille is mounted on a sub-plate permitting complete testing before assembling in cabinet.

#### MECHANISM COMPONENT DESIGN

Various problems face the designer of record changers and players which can be attributed to the motor and drive system. Rumble, nominal speed variation, and wow are among the most important.

The relatively large motors used in the production of 45 rpm record changers have had many additional manufacturing processes in order to reduce rumble. Rotors have been dynamically balanced to extremely close limits. Motor shafts are being ground on the surface which drives the idler. The grinding operation is performed under conditions equivalent to the motor running in its bearings. Running in its bearings results in shafts having no more than .0001 inch run-out (eccentricity).

About three years ago, the motor supplier was approached on a project to miniaturize the motors used in 45 rpm record changers. As a result of an ensuing joint program between RCA and motor supplier, a motor was designed and tooled which resulted in a substantial reduction in size and cost. Representative figures on size reduction are as follows: laminations from 2½ inches square to 1½ inches square; rotor diameters from 1⅛ inches diameter to ⅝

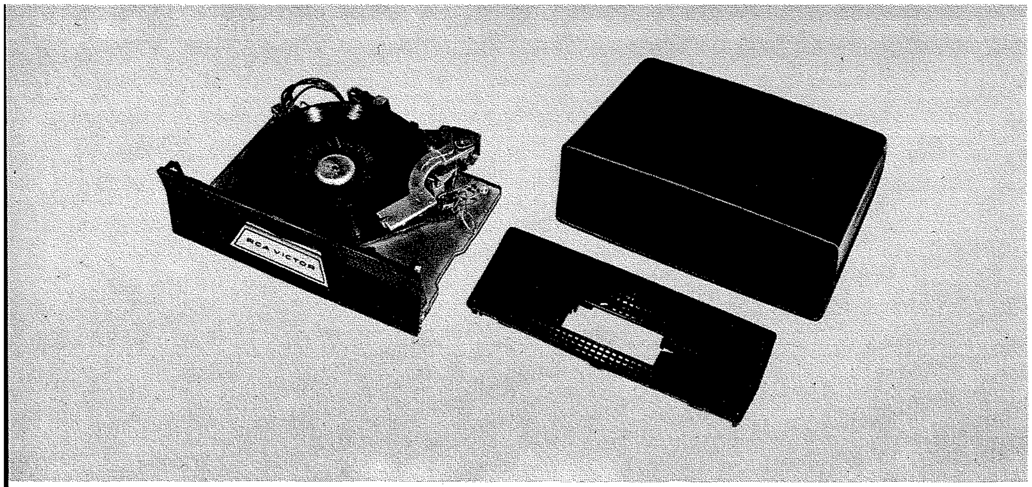



Fig. 1—Left: mechanism, sub-plate and grille assembly; Right: two-piece molded plastic cabinet.

Fig. 2—E. S. Maris (left) and J. A. Tourtellot taking response measurements of the RP-199

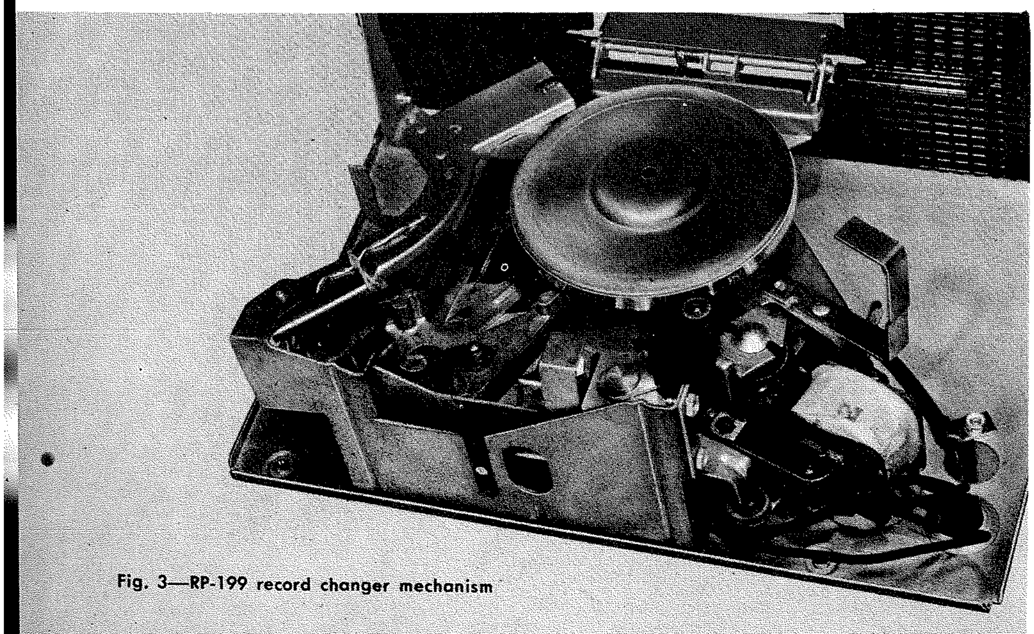


Fig. 3—RP-199 record changer mechanism

inches; bearings from .171 inches diameter to .125 inches. This motor was used on 45 rpm changers in limited quantities but its advantages were not fully made use of until the "Slide-O-Matic" model was developed. The dimensional area of the lamination was important to the reduction of cabinet size. The smaller rotor diameter resulted in commercially acceptable rumble figures without balancing, and the reduction of bearing friction due to smaller shaft diameters, in turn, reduced the excitation which had a further beneficial effect on rumble. These changes resulted in a sizeable reduction in cost which was necessary for successful marketing of this instrument.

Turntable speed is accomplished through a stepped idler of approximately $2\frac{1}{2}$ to 1 step-down ratio from motor shaft to the turntable diameter. The stepped idler was necessary because of the overall ratio of motor speed to turntable speed of approximately 75 to 1. This large ratio would have resulted in excessively large turntable diameter or impractically small motor shafts if a single idler was used. Turntable speeds of 45 rpm are kept within limits, for all reasons, to a total variation not to exceed $\pm 3\%$ which is considered to be commercially acceptable. It has been necessary to set up motor speed inspection limits which can be interpreted by the motor supplier and by incoming inspection at the RCA plant, and which will produce the end result of the aforementioned acceptable turntable speeds.

There are two motor variables which affect turntable speeds. These are the motor speed variation itself and the shaft diameter. We have added a factor to the motor specification which is the product of motor speed and shaft diameter. This product, with tolerances, is such that when converted through the drive ratios used will maintain turntable speeds within limits. The entire system is reasonably flexible in that as far as motor is concerned, motor speed or motor shaft diameters may be changed to satisfy this factor.

"Wow" is the direct result of eccentricity or "runout" of idler diameters with respect to their bearings, the turntable with its bearing, or the record center hole and recording. The worst offender is the idler diameter "runout." There has been considerable effort put into this problem to produce true running idlers. The idlers now in production are made with a metal insert, which has an integrally assembled oil-less bearing with rubber tires bounded to the inserts. The inserts are made with a minimum of "runout" and the rubber tires are ground to diameter on a true running mandrel. Total runout of assembly is limited to .001 inch. Turntables are zinc die castings which are turned true with respect to their shafts to within a .005 inch. The processing outlined has made major improvement in "wows" on 45 rpm record playing equipment.

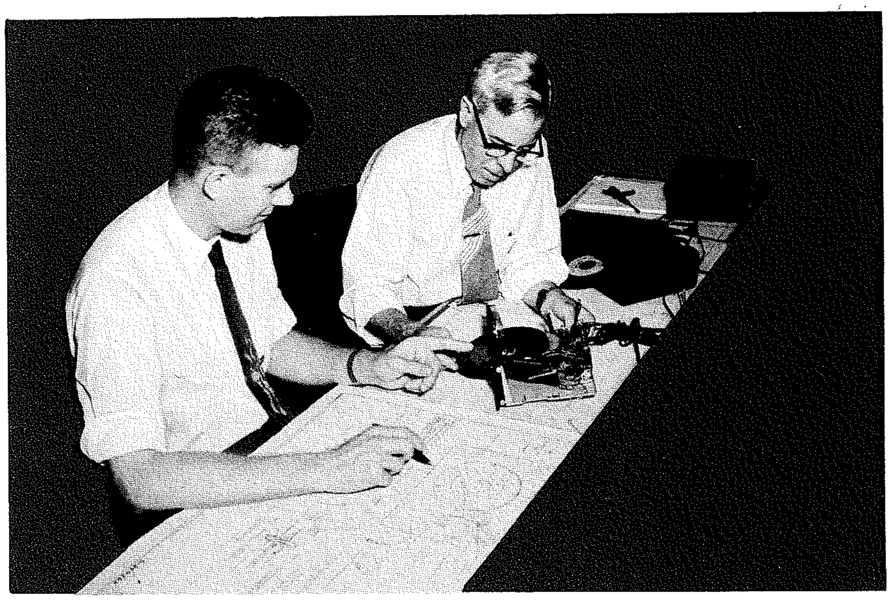


Fig. 4—J. A. Tourtellot (left) and E. S. Maris discuss production drawings

#### PICKUP ARM

The pickup used is the RMP-128-5. It is a crystal pickup with osmium type stylus having .001″ radius. The pickup arm is a formed stamping of steel. The pickup is inserted in a channel section and held in its operating position with a clamping spring. The normally vertical pivot for this arm is offset at an angle of approximately 4° from the vertical in such direction that when the pickup is not resting on the record, the arm will swing to the outside radius of the record where it is held by a stop position directly over the landing area of the record. The pickup arm also has a pivot in the horizontal direction with attachment means for a spring which controls the needle force. This arm is different from other pickup arms in two major respects: first, there were no decorative finishes required, and secondly, the gravity return to landing position contributed to tracking problems.

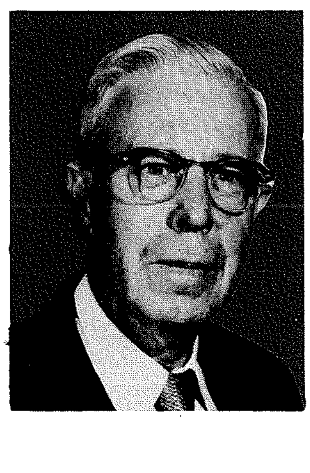
The first arm designed was an aluminum formed shape which had no provision for controlling the needle force other than the assembled weight of the arm and pickup. Tracking difficulty was encountered because of a pronounced peak in response in the region of 50 cycles. Increased stiffness was found necessary to improve the tracking. This was developed through several stages, one being an increased thickness of the aluminum, and a drawn construction rather than formed flanges. The drawn steel construction described with the vertical and horizontal pivots was the finally accepted method.

#### ADDITIONAL DESIGN DETAILS

The remaining design details of the mechanism include a mounting for turntable bearing, the hinging of the framework allowing the mechanism to be positioned for loading and discharging the record through the slot in the cabinet, the latching of the mechanism in the playing position, the switching of the power switch and the tripping of the mechanism after the record is finished playing.

Switching to start the motor is accomplished by raising the mechanism, which is hinged to the lower or fixed frame. The switch is attached to hinged member, with an actuating means as part of the fixed member. The motion resulting between the two members switches the power "on" or "off" as required.

The means of stopping, when a record has been played, is controlled by a trip lever which is actuated by the pickup arm as it moves to the concentric groove of the recording. The trip lever is moved until it engages a rotating lug on the turntable. A force supplied by the motor through the turntable causes a lever, which is connected to the latch at the front on the mechanism, to be disengaged. The mechanism is then lowered to the record discharge position and the power switch is moved to the "off" position.



**E. S. MARIS** graduated from Stevens Institute of Technology with a BS in ME in 1915. He worked in Civil Service as a Mechanical Engineer, and for a Detroit automobile manufacturer as a tool designer before joining the Victor Company in 1926. After a brief absence from RCA in 1930 to work at the Brown Instrument Company, he returned to RCA to work in the drafting section, and in 1936 was transferred to Engineering. Here, he worked on such things as dial drives and push-button tuning devices. Mr. Maris did engineering on altimeters during the war and since then has worked in record changer design. He is presently working on tape recorder transport mechanisms.

# THE SYNCHROGUIDE: A DESIGN HISTORY

*by* **SIMEON TOURSHOU**
*Black-and-White Television Engineering*
*RCA Victor Television Division*
*Cherry Hill, N. J.*

AMONG the many requirements of good design of television receivers is one of picture stability under various and adverse conditions of reception, including that of interference by electrical noise. The section of the receiver most vulnerable in this respect is the Line Scanning Oscillator, since its timing determines the precise positions of picture elements on the kinescope face. Adequate protection from electrical disturbances is obtained through a buffer circuit in a form of Automatic Frequency Control, and Synchroguide is the form used in the RCA receivers since 1947. While several modifications have been made since that time, the basic patterns of its operation have survived to this day essentially unchanged.

### EARLIER FORMS OF AUTOMATIC FREQUENCY CONTROL

Effects of electrical noise on television reception had been studied by K. R. Wendt and Dr. G. L. Fredendall before the war, and they arrived at the conclusion that the serious aspect of this interference was not in the dots and streaks appearing in the picture, but in the contamination of the synchronizing signal which caused erratic timing of scanning oscillators, resulting in scattering and scrambling of the elements of the picture in a manner illustrated in Fig. 1.

To counteract this effect they developed an "Automatic Frequency and Phase Control of Synchronization in Television Receivers," which, by averaging the timing information in large numbers of synchronizing pulses and thus filtering out their individual disturbances, prevented the misfiring on individual scanning lines. They used a blocking oscillator followed by a saw-tooth-forming discharge tube, and a push-pull phase detector followed by a d-c amplifier whose output was fed back to the oscillator to control its frequency and phase. With a total of five tube functions, these men achieved a noise immunity vastly greater than any obtainable heretofore by conventional "triggering" means.

A later form, by A. Wright and E. L. Clark, utilized a sine wave oscillator and a reactance tube across the tank for frequency control, followed by a saw-tooth-forming discharge tube and a push-pull phase detector controlling the bias of the reactance tube—a total of five tube functions in 3½ envelopes. This circuit, called "Synchrolock" by its inventors, achieved a high noise immunity and a high degree of frequency stability at the same time. "Synchrolock" was used commercially, for example, in the RCA 630-TS series television receivers and played a tremendous role in making the post-war "Eye-Witness Television" a success.

The drawbacks of Synchrolock, however, were its high cost, high power drain, and a relatively low phase sensitivity of sync riding the smooth slopes of the sine wave, and a tendency for the picture to shift rather excessively on the kinescope face.

The form of AFC known as Synchroguide, using only two tube functions in a single envelope, was developed by the author. Because of its low cost, low power drain, and good phase sensitivity, it replaced the Synchrolock beginning with the RCA 721-TS in 1947, and has been used in all RCA receivers built to this day.

**SIMEON TOURSHOU** received his B.S. in E.E. from Robert College, Istanbul, Turkey, in 1928, and his M.S. in E.E. from Michigan College of Mining and Technology in 1930. His experience covers, in main, seven years with Philco and nearly seventeen with RCA. The latter includes development of the second "Personal" radio, the BP-12, development and design work on pulse altimeters and airborne radar, and on television.

In the Black and White TV Engineering, he is the Manager of Product Development group which has been responsible for a number of RCA and industry "firsts," such as the receivers with metal kinescopes, receivers with "wide angle" deflection, 21-inch receivers, receivers with 90° deflection, as well as many deluxe, top of the line models. The group spearheads the continuous search for better and cheaper circuits, techniques and products.

#### THE PRINCIPLE OF SYNCHROGUIDE

The philosophy behind the development of Synchroguide was to control the oscillator by *guiding* it into a very nearly correct frequency with the information from a slow-changing averaging device. Then, accurate *synchronizing* occurs at the ends of individual scanning lines, with synchronizing pulses of a relatively low amplitude, thus reducing the effect of noise to a very low level. The reason for the very low level is that the effect of noise on picture stability varies as the square of sync amplitude*, since a reduction of the latter means (1) a reduction of the time range of possible misfires, and therefore of the amplitude of disturbance of scanning, and (2) a reduction of number of noise pulses occurring within this reduced-time range, and therefore of the number of disturbances of scanning-per-second. Guiding of the triode oscillator into a very nearly correct frequency was to be achieved with a minimum amount of circuitry, using the second triode of a dual-triode tube as a single-ended phase detector-amplifier. The triggering, of course, required no additional tubes.

While the idea was being proved in, it was found that a still greater noise immunity was obtained when the sync pulses were completely eliminated from the oscillator circuit, and replaced by information from a second averaging device that was fast enough and sensitive enough to detect any tendencies of the oscillator to deviate from its proper phase. Fig. 2 shows the two averaging devices in the cathode of the control tube: the large capacitor $C_1$, acting as a storage tank for pulses of current produced by the sync pulses on the grid, and the small resistor $R_2$ shunted by a small capacitor $C_2$ acting as a fast and sensitive indicator of any tendencies to deviate in phase. The combined

* The noise amplitude is held down to sync amplitude by the clipper action of the sync amplifier chain.

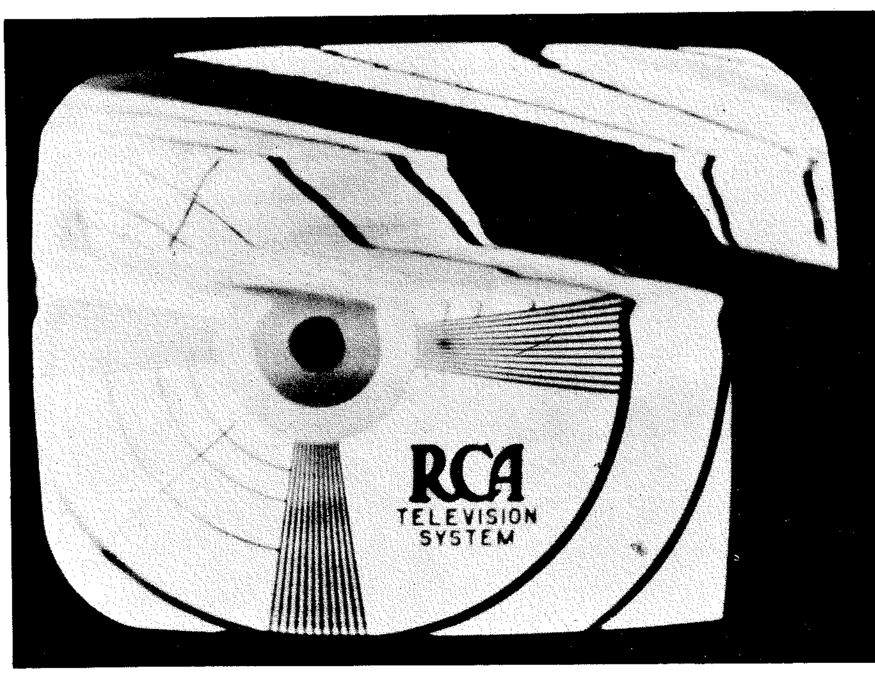



Fig. 1—The effect of electrical noise on early horizontal synchronization

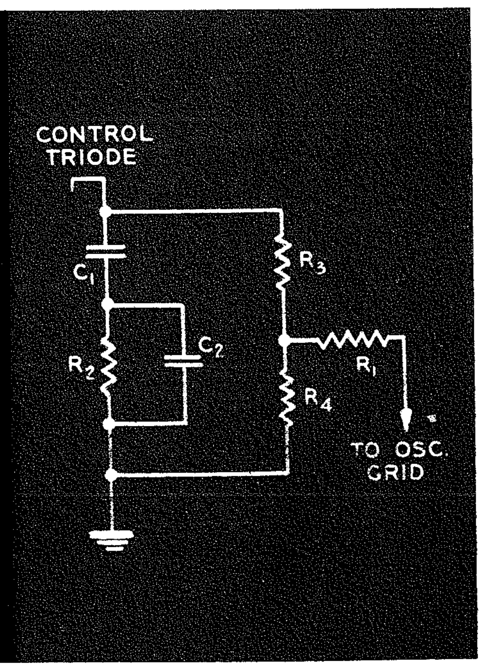



Fig. 2—Oscillator control tube averaging device

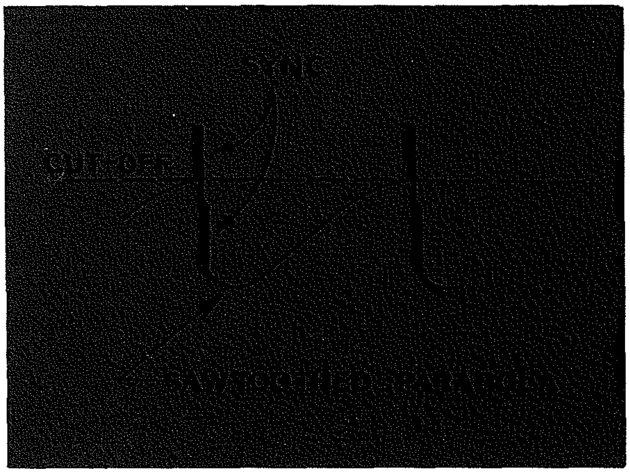


Fig. 3—Waveform at the control tube grid

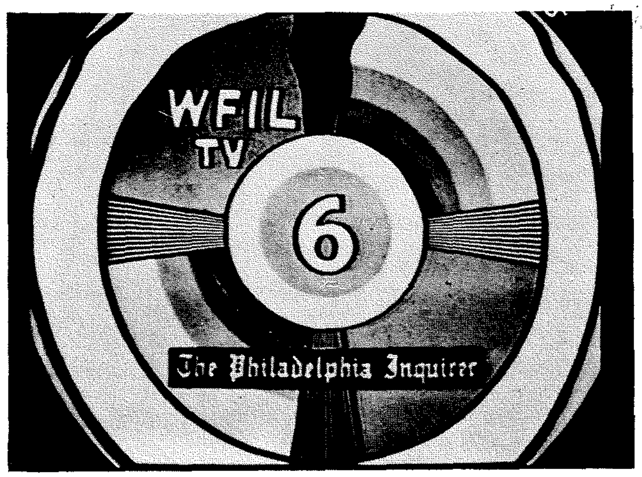



Fig. 4—"Hunting" due to improper control tube constants

voltages of $C_1$ and $R_2C_2$ are fed, through the divider $R_3R_4$, to the oscillator grid leak $R_1$ to vary its reference bias and frequency, as required.

#### CONTROL VOLTAGES AND THEIR SOURCE

The voltages of $C_1$ and $R_2C_2$ vary with phase between the oscillator wave (shaped into a saw-toothed parabola) and the synchronizing pulse on the grid of the control triode, as shown in Fig. 3. The synchronizing pulse rides partly atop the corner of the saw-toothed parabola derived from the oscillator and partly in the valley just beyond the corner. Since the triode is biased off except for the corner, the width of the triode current pulse is essentially the same as the portion of sync atop the corner. The wider this portion, the wider the pulse of current, and the greater the average control power delivered to the cathode circuit. Any tendency of the oscillator to slow down and fall behind in phase results in an immediate widening of the sync atop the corner and in an increase in the positive reference bias for the oscillator, which speeds it up to the correct rate. Similarly, any tendency of the oscillator to "speed up" results in a narrowing of sync atop the corner, and a decrease in the positive reference bias for the oscillator, which slows it down to maintain the precise synchronism with the transmitter*.

Since $C_1$ is made rather large to prevent the noise pulses from producing appreciable changes in its voltage level, its response to changes in the oscillator phase is rather slow. Were it not for the fast $R_2C_2$, which registers the slightest changes in phase and applies corrective voltages to the oscillator almost without delay, the latter would be swinging freely away from its correct position to one side, then to the other, in endless see-saw. See illustration (Fig. 4) where the $C_1$ voltage is always lagging behind, and never really able to catch up. Were $R_2$ made too large, the sensitivity of the oscillator to noise pulses would be high, and it would jitter almost as badly as was illustrated in Fig. 1. Thus there exists a balance between the $C_1$ and the $R_2C_2$ magnitudes, depending on the sensitivity of the control triode to changes in phase, and on the sensitivity of the oscillator to changes in control.

Such is the meaning of Synchroguide, and now a brief summary of the modifications made since its early inception.

#### THE FIRST PRODUCTION VERSION IN THE RCA 721-TS

The control-grid wave form of this version was a composite of a parabola derived from the saw-tooth, a

* This "width modulation" is also one of the characteristics of the Synchroguide that makes it different from other systems which depend on the amplitude modulation instead.

Fig. 5—The synchroguide in the RCA-721TS—First production in 1947

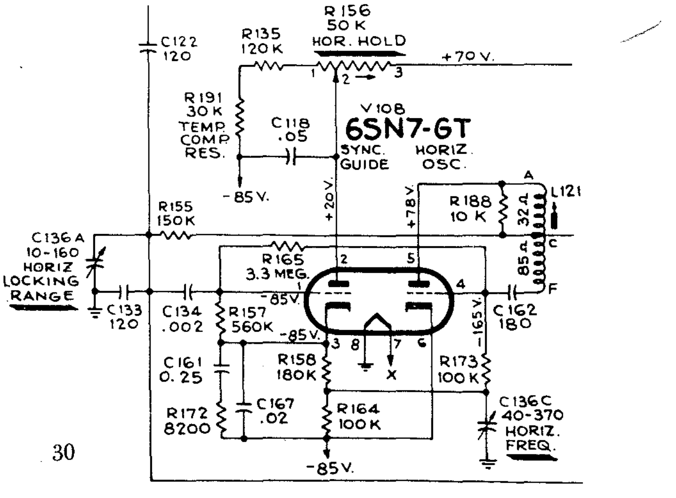
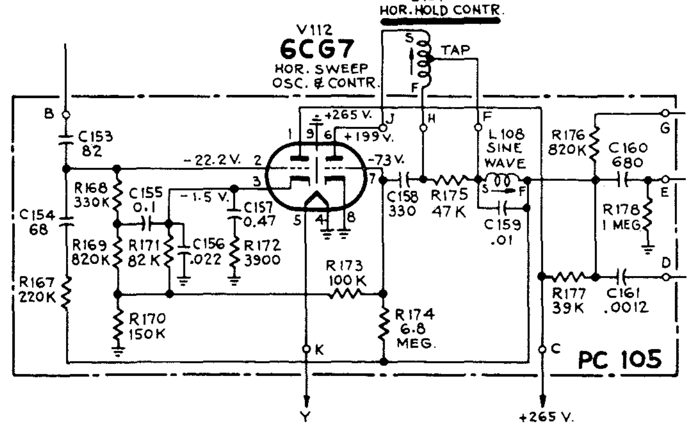



Fig. 6—The synchroguide in the RCA-21T641—First printed circuit production in 1955



negative kick-back pulse derived from the deflection yoke to produce the sharp drop in voltage following the "corner," and the synchronizing pulse. Bias for the control tube was derived from the bias developed by the oscillator. An oscillator grid leak resistor of a very stable carbo-film type was used, and except in a few cases where particles of dust had been trapped underneath the film resulting in instability and requiring replacement, it served the purpose. Microphonic instability of the blocking oscillator required rubber mounting of the socket. The Tube Division gave assistance by improving the mountings of the tube elements to make them more rigid. The hold control range had to be very considerable to accommodate the gradual shift in frequency with aging of the tube.

#### SECOND PRODUCTION VERSION BROUGHT OUT WITH METAL KINESCOPES IN 1949

Here a stabilizing sine wave tank was inserted in series with and just below the oscillator coil. The addition of the thus generated sine wave voltage to the exponential wave on the grid, and to the saw-tooth wave on the plate, "stiffened" the frequency characteristic by a factor of about three. It also gave some increase in noise immunity, since a basically more stable oscillator required less control. It allowed an ordinary carbon resistor to replace the carbo-film grid leak, and later to eliminate the rubber mounting of the socket.

#### INTRODUCED IN THE 21" SETS THE THIRD PRODUCTION VERSION

Biasing of the control stage from the oscillator bias was replaced by self-bias, which should have further reduced the effect of tube aging on frequency. The attained improvement, however, was masked by another factor, uncovered recently by RCA Laboratories and the Tube Division, namely the gradual formation within the tube of the "cathode interface resistance," which, by adding degeneration, weakened the oscillator and shortened the grid capacitor time of discharge.

#### THE PRESENT CIRCUIT VERSION STARTING WITH THE 1954 LINE

The advent of the controls compartment at the front of the set has made it possible for the oscillator coil to replace the potentiometer as a hold control, making a wide range of adjustment available to the user through an easy vernier action. Through the cooperation of the Tube Division and RCA Laboratories, steps were also taken to prevent the formation of the "cathode interface resistance," and it is believed that the field problems due to frequency shift are getting to be a thing of the past. This circuit version is shown in Fig. 5.

#### THE PRESENT PRODUCTION VERSION ON A PRINTED BOARD

Electrically this is the same as the previous version. Physically it is contained on one printed board, with the exception of the oscillator coil, which mounts at the front of the receiver to serve as a "hold control."

Although the development of the Synchroguide to its present state of refinement involved inherent frequency instability of blocking oscillators and the aging characteristics of the older type 6SN7GT tube, the high degree of the circuit phase stability afforded by Synchroguide, and its performance in the millions of sets in which it is used, have proven its value and acceptance over the years. Any further improvements in tubes toward better frequency stability will not only further minimize the long-term drift, but can also be translated into further increases in noise immunity by reduction in the amount of the needed control.

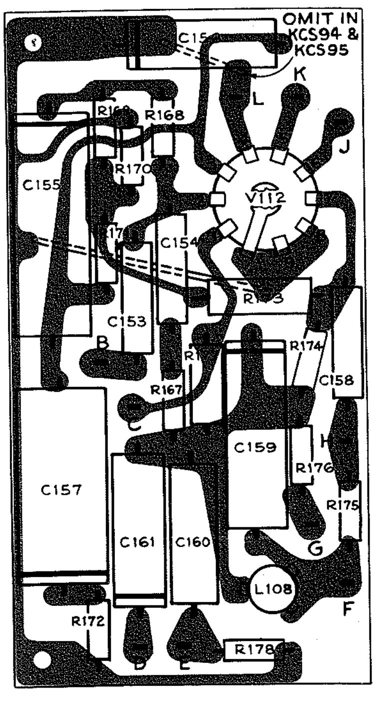



Fig. 7—The synchroguide as a printed circuit

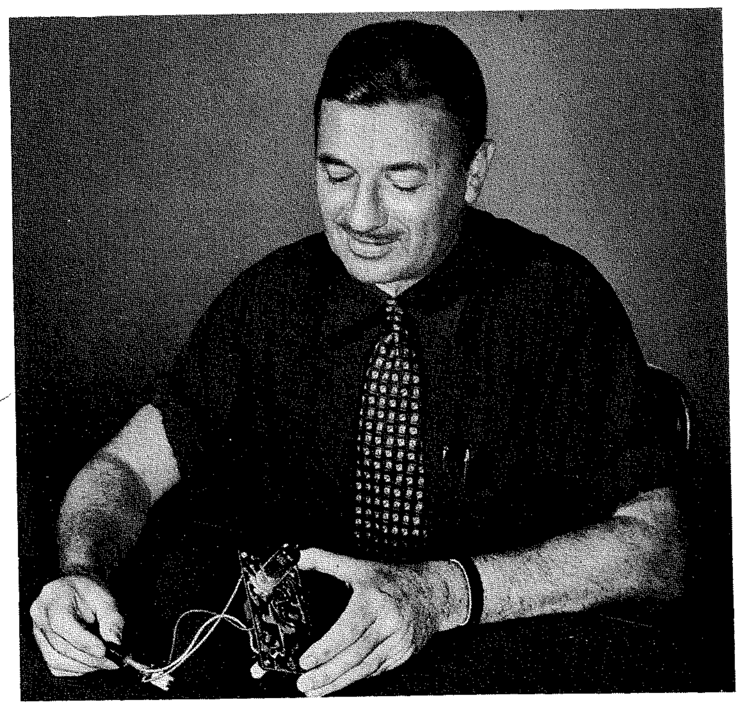


Fig. 8—The author examining a production version of the synchroguide on a printed board

# WHISKERS ON GANGS

## A METALLURGICAL MYSTERY

**DR. L. PESSEL**
*Components Engineering*
*Chemical-Physical Laboratory*
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About 10 years ago, the electroplating industry became aware of extremely thin, hair-like formations on cadmium plated surfaces which were termed "whiskers"(1). Soon it was determined that these filaments were metallic cadmium rather than a corrosion product, and that they were electrically conductive. This was rather alarming because it indicated at least the possibility of electrical difficulties due to shorts. These fears were indeed justified and a number of functional electrical disturbances could be attributed to the presence of whiskers. The first evidence of such failures was established in telephone, channel-frequency filters, but it was soon followed by other instances in radio and electronic fields, particularly in variable gang capacitors which proved to be inoperative until blown out with forced air. This, of course, removed the whiskers and restored performance.

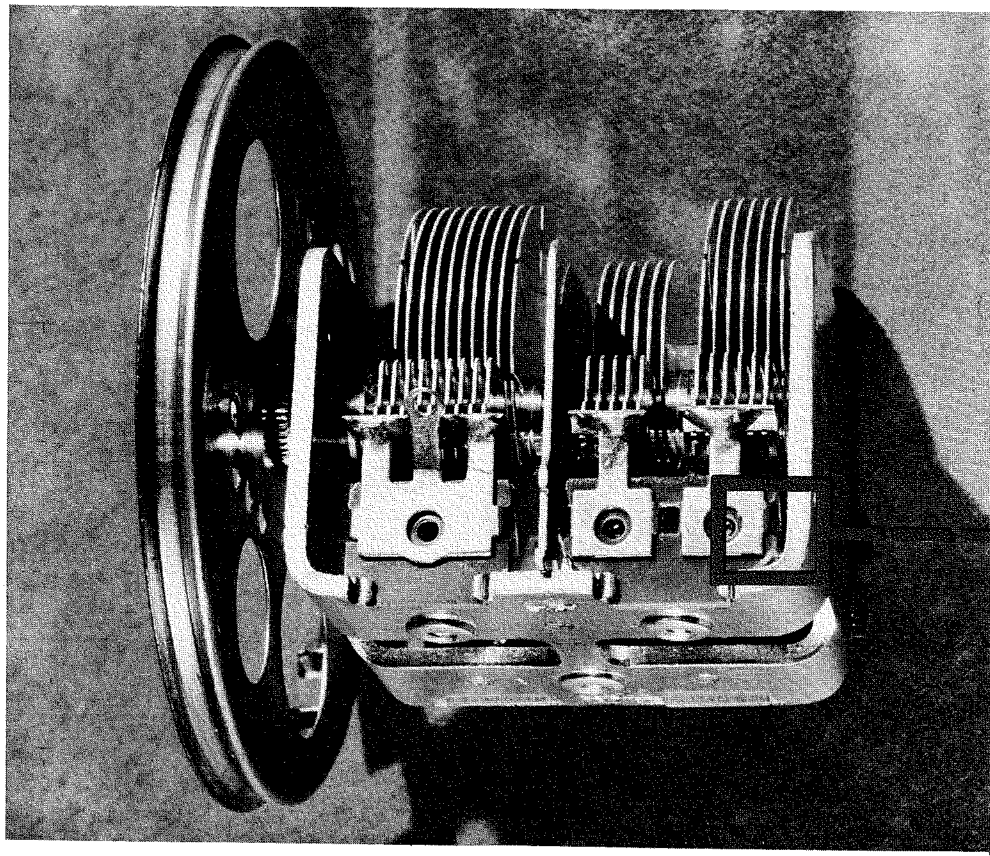

Fig. 1—Closeup view of a variable gang capacitor. Square indicates the general area where metal whisker growth occurred and caused a short.

#### IMPACT ON RADIO PRODUCTION

Although millions of radios have been manufactured in the past quarter of a century, metallic whiskers were not recognized as a source of trouble until late in 1953. At that time, inoperativeness of a number of sets could be traced to the formation of electrical shorts in the variable gang capacitors, and whiskers were identified as the cause. Furthermore, examination of variable gang capacitors held in stock revealed that 19% of the capacitors, which had been tested and shipped only 6 weeks before, had developed this growth during storage.

On a typical variable gang capacitor causing difficulty, the critical air gaps vary between 1/16 inch and 5/64 inch. For design considerations, the engineer can specify a larger gap, use other plating materials, or use an aluminum frame. As a temporary correction in devices other than gang capacitors, 0.15 x 2-inch fish-paper shields have been placed between controls and chassis. Directing an air blast (25 lbs./sq. inch) on the trouble areas to remove existing whiskers may also help because the secondary whisker growth is not so prolific. Low impedance circuits or current carrying circuits capable of producing 0.02 amperes at 10 volts are usually not affected with whisker growth.

#### SCOPE OF PRESENT KNOWLEDGE

While several papers have been published since 1951 in an attempt to explain these formations, the number of investigators has been surprisingly small in view of the potential seriousness of such metallic instability from the point of view of reliability of radio and TV receivers. In presenting the following review, it should be emphasized that these statements are "as of today" and will rapidly change as new facts are established. No satisfactory explanation of the mechanism of whisker growth on gang capacitors has been given as yet. Consequently, we are still justified in terming them as a mystery, although one of disturbing reality.

#### WHISKERS AND CHARACTERISTICS

Typical metal whiskers may be differentiated from dust or lint particles by their extreme thinness (averaging 1-2 microns or 40-80 millionths of an inch), by their straightness, the strong metallic light reflection from their surfaces and, of course, their electrical conductivity. Their length may vary from that of extremely short stubbles (one mill or less) to 0.25 inch or longer. Not infrequently, they are thicker than the indicated average and occasionally they are bent, kinked, or spiral-shaped. (See Fig. 3.)

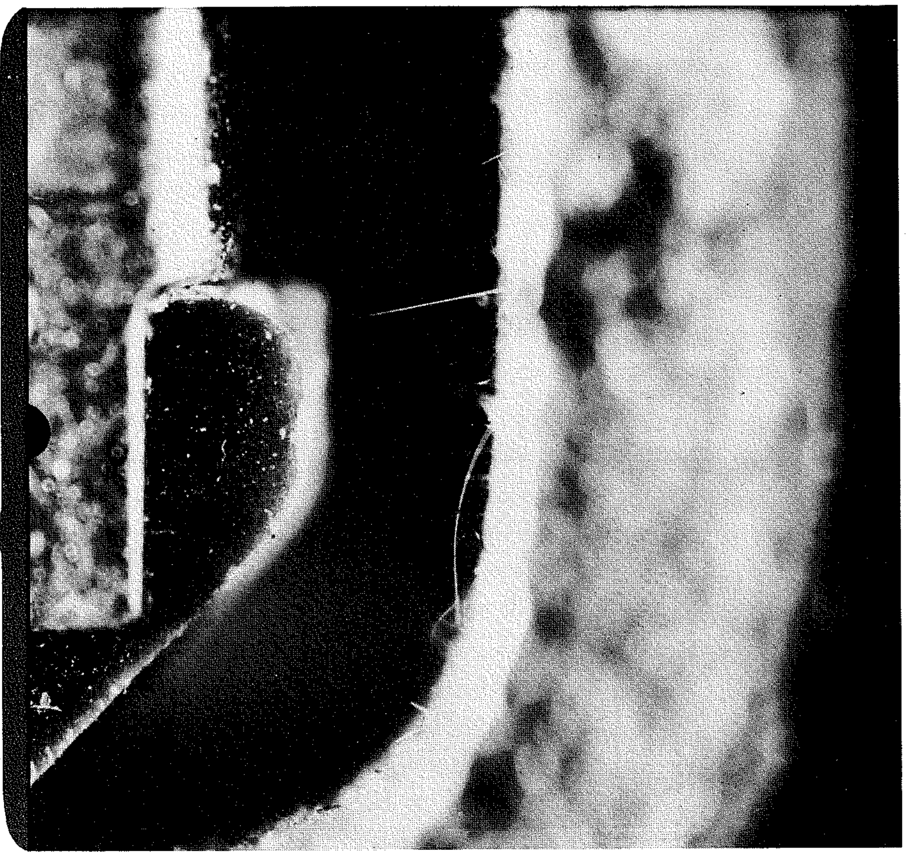

Fig. 2—A view (magnified 20 times) of the metal whisker shown bridging the gap between the chassis and a terminal.

#### GROWTH BY CHEMICAL ACTION

For practical purposes, a distinction should be drawn between such spontaneous growth and filament formation as a consequence of chemical action or in an artificial environment. Copper and silver surfaces will grow filaments composed of the sulfides of these metals in the presence of sulphur.

Chemical reaction is also involved in the formation of single-crystal silicon filaments (7). Formation of whiskers of metallic copper and silver has also been reported to take place under the influence of a d.c. potential, but the possible contributory influence of chemical action (corrosion) in these cases has not been clarified (8). Whisker growth should not be mistaken for silver "migration" which is an entirely different phenomenon and probably based upon a different mechanism. Whiskers of mercury have been grown on glass plates at $-63.5°C$ in mercury vapor of $6 \times 10^{-6}$ mm pressure (9). Production of whiskers of iron having tremendous mechanical strength has recently been reported but no details have been given (10, 16).

#### SPONTANEOUS WHISKER GROWTH

Spontaneous growth of whiskers under atmospheric conditions, without the apparent influence of any artificial or accelerating factor, has been observed predominantly on cadmium, tin, or zinc. Some growth has also been reported on combination plating, such as tin-lead, tin-zinc, cadmium-tin, on antimony, on some tin-lead and some tin-aluminum alloys. All of these metals are relatively soft and of low melting point. However, lead and indium, although having similar characteristics, appear to be immune.

Spontaneous growth has been observed not only on coatings formed by electro-deposition but also on those formed by hot-dipping, metal spraying, and evaporation onto a paper or mica base. It was also observed on cast metal ingots. Corrosion as a contributing factor has, if not ruled out, at least been minimized since metal whisker growth has been observed on test pieces when placed in a vacuum and under oil.

A possible influence of the substrate (underlying surface) may be indicated by the fact that, in the case of electro-deposited coatings at least, growth was much more pronounced on very thin coatings than on thicker ones. Iron as a substrate was found to encourage growth of tin and cadmium whiskers much more than copper, although the latter does not inhibit them completely.

#### PHYSICAL PROPERTIES

With respect to the physical properties, the outstanding quality of metal whiskers appears to be their mechanical strength. Strain characteristics indicate a strength approximately 100 times greater than that of the bulk metal (11). There is a general assumption that the inner structure must be that of a nearly perfect crystal which would explain the great strength. It is also assumed that the crystal is "built around" a screw dislocation, a Burgers vector being in the direction of filament growth. The sharp kinks, rather than gradual bends, which are often seen, may be due to twinning,* which, however, has not yet been proven. In spite of their great intrinsic strength, whiskers may

* Formation of crystal twins.

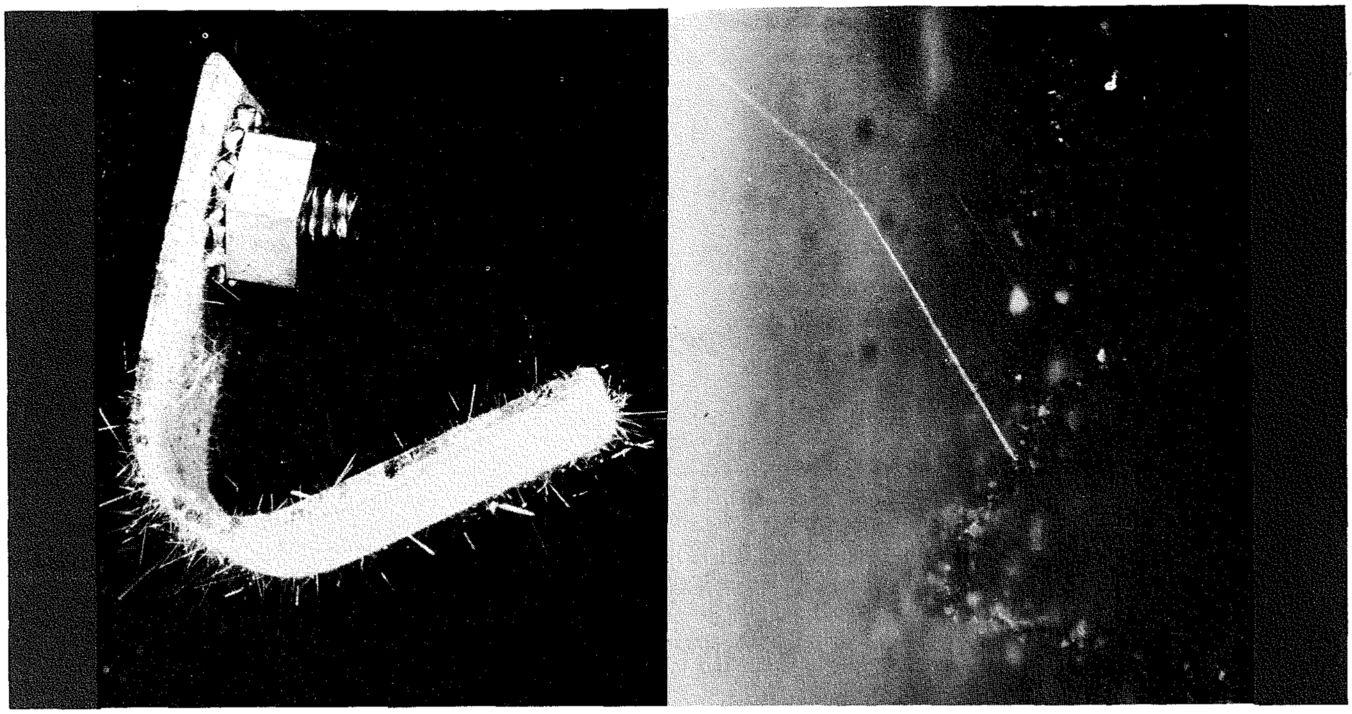

Fig. 3—View at left shows a growth of whiskers on tin-plated steel (Courtesy of Dr. S. M. Arnold). View at right (enlarged 100 times) shows a cadmium whisker with a characteristic kink due to twinning.

easily be broken off their base by slight mechanical shock or air currents. This is particularly true after they have grown long, which may be readily understood when considering that their diameter to length ratio may be 1/5000 or even less. A length of over 3/8 inch has been reported, but this may not be the ultimate limit but only the observable one due to the indicated mechanical sensitivity. As to the rate of growth, on some surfaces only traces of whiskers have been noted after years of storage, while in some extreme cases a rate of 25 microns or 1 mil per day was observed. There seems to be an optimum growth temperature of 125°F for tin whiskers. At 250°F there is a distinct decrease, and at 300°F there is no evidence of growth. At —40°F, growth is delayed but not prevented. By consecutive photographs of irregularities at the tip of whiskers, it has been proven that they grow from the bottom up, i.e., are virtually "pushed up."

#### ORIGIN OF WHISKERS

While the above just about summarizes present knowledge of the physical nature of whiskers, their origin and mechanism of growth is a subject of much guess and dispute.

The formation of these filaments has been explained entirely on the basis of lattice dislocations. The core of a dislocation is in a state characterized by high atomic disorder and high energy, thus approximating the molten state of metal. Atoms and vacancies can diffuse along the core with great facility and, as the atoms emanate from the dislocation core, parts of the spiral formed are favorably located to receive them and will grow into a whisker.

It has also been visualized that a mechanism in which localized surface tension forces exist will extrude or "wire-draw" a whisker. A surrounding restraining pressure, a catalytic effect of local lattice dislocations and an initial energy supplied by oxidation attack are also assumed.

The predominance of the phenomenon with low-melting metals would indicate an important role played by a high rate of self-diffusion. If this is so, whisker growth should be accelerated by the application of pressure. This has been accomplished indeed, at least with tin, and by the application of a pressure of 7500

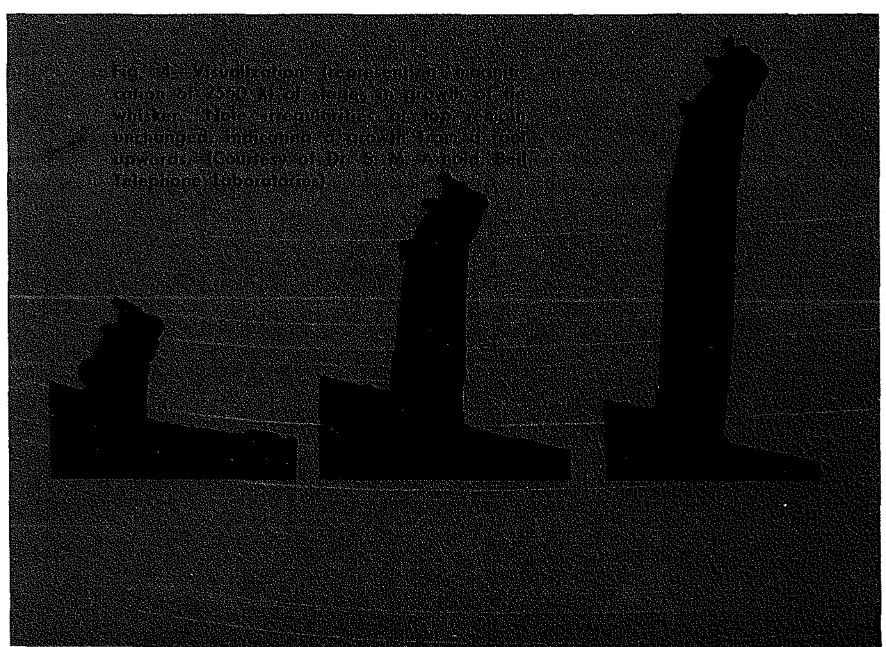

Fig. 4—Visualization (replica) at magnification of 2550 X of stages in growth of tin whisker. Note irregularities at top remain unchanged, indicating a growth from the root upwards. (Courtesy of Dr. S. M. Arnold, Bell Telephone Laboratories)

lbs/sq. in. a rate of growth of 1 mm in 16 minutes has been obtained which is $10^4$ times the rate to be expected under atmospheric pressure (15). Thus, local pressure factors should not be discounted. An existing dislocation, either in the substrate or due to some impurity, may provide the starting "step." Whether additional energy, supplied by oxidation or other chemical action, is needed must remain doubtful. The growth of mercury whiskers (9) should make such an assumption unnecessary.

#### PREVENTIVE MEASURES ATTEMPTED

In view of the wide-spread occurrence of lattice disorders, the possibility of whisker growth should be anticipated whenever low-melting point metals with a high rate of self-diffusion, such as cadmium, zinc, or tin, are used. Preventive measures based upon the use of coatings of wax or lacquer have not been successful. The whiskers penetrated them with ease. Hard, thermosetting coatings seemed to provide a more effective barrier, but, if fine cracks are present in such coatings, as is often the case at edges, the whiskers will grow through them. An undercoating of electro-deposited copper under cadmium plate seems to stunt and delay but not entirely prevent growth. Hard metallic coatings, such as those of nickel, seem to be immune but in electronic equipment their use is limited by their poor solderability. Recently, we have initiated tests with an electro-deposited coating containing 65% tin, 35% nickel, which has unusual hardness, tarnish resistance and good solderability. These tests are still in progress.

In the absence of preventive measures in the past, corrective steps have consisted in blowing out components with an air blast, dislodging whiskers by tapping, or burning them off by the application of voltage. The electric resistance of these filaments has been found to be of the order of 200-400 ohm and a potential of 10 volts is effective to burn them off, if a short or near-short has been established. This, of course, will not eliminate further growth of metallic whiskers which have not yet produced a short, and it will not prevent regrowth. Moreover, in many cases, the application of any corrective measures is altogether impractical. This holds true for fully sealed components such as crystal cases, potentiometers, channel-frequency filters, etc.

If the spacing is close, effective design precautions may comprise the use of impenetrable barriers or the use of metals assumed at present to be immune to whisker growth when properly protected, such as copper, silver, nickel, ferrous alloys, metals of the platinum group, etc. Such precautions may complicate the design and may cause increased costs and production difficulties. Yet these methods may be the lesser of two evils since the consequences of whisker-produced shorts might be intolerable as far as the customer or user is concerned.

The appended references, as far as writers' knowledge is concerned, constitute everything so far published with reference to metal whiskers.

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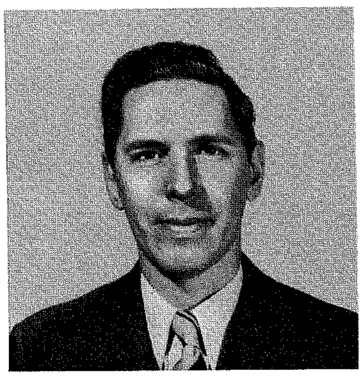
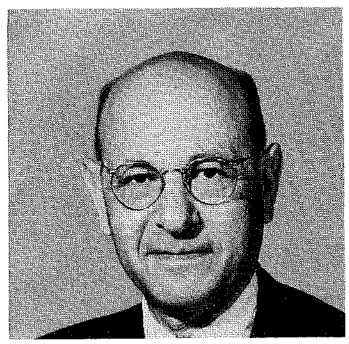


**WILBURT D. RHOADS.** Mr. Rhoads, who became Resident Engineer at the Canonsburg Radio Plant in 1950, has been active in various radio engineering and production capacities. Present duties include supervision of all manufacturing products from an engineering standpoint.

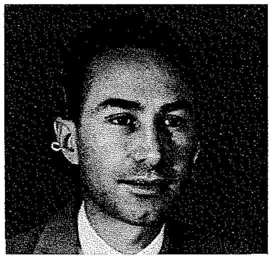
His electrical engineering education was gained at Drexel Institute with associated courses at University of Pennsylvania, Temple University, and Washington & Jefferson College.

Prior to joining RCA in 1936, Mr. Rhoads designed test equipment at the Atwater Kent Radio Co. Mr. Rhoads has worked in various phases of radio receiver engineering including export engineering in 1947. In 1950, Mr. Rhoads assumed his present post.



**LEOPOLD PESSEL.** Dr. Pessel received his PhD degree in Physical Chemistry at the University of Vienna and also has a diploma in E. E. from the Drexel Institute Evening School.

Dr. Pessel was formerly Technical Director for the Metals Coating Co. of America and has been connected with the Chemical and Physical Labs, RCA, Camden, for the past 15 years, engaged in chemical and metallurgical research and development. Dr. Pessel has 26 patents to his credit. He is a registered professional engineer in Pennsylvania and a member of RETMA Committees on Solderability of Components and on Printed Wiring, the American Chemical Society, the American Inst. of Mining and Metallurgical Engineers, the National Association of Corrosion Engineers, the Philadelphia Mineralogical Society, and the Aircraft Owners and Pilots Association.



E. D. FLECKENSTEIN

D. G. GARVIN

J. F. HIRLINGER

A. E. HOGGETT

# INTRODUCING THE TUBE DIVISION EDITORIAL REPRESENTATIVES

THE DUTIES and functions of RCA ENGINEER Editorial Representatives vary somewhat between divisions, and even within divisions, from one location to another. However, representatives in all areas throughout the Corporation have essentially the same basic objectives. Among these are the stimulation of interest in writing informative, interesting technical papers, and assistance in scheduling and obtaining approvals. Since such objectives are common to all Representatives — this brief description of the Tube Division Representatives' organization and responsibilities may interest all RCA ENGINEER readers. Those engineers whose work should be reported in the RCA ENGINEER may appreciate more fully how teamwork efforts of authors and editorial representatives will result in timely articles for publication.

On this page are photographs and short biographies of the Tube Division Editorial Representatives and their Chairman. These representatives have been selected to act not only as the Editor's contact at each of the eight respective plant locations (Camden, Cincinnati, Findlay, Harrison, Indianapolis, Lancaster, Marion and Woodbridge), but also as resident editorial contact at these locations. Broadly speaking, they carry out plans for technical articles, suggest topics, assist the author and coordinate all these activities with the Chairman and Commercial Engineering, as well as the magazine staff.

The representatives are prepared to acquaint you with the objectives and plans of this magazine. It is also their function to work with you on papers of interest in specific technical fields, to prepare schedules, and to serve as liaison for the Chairman on all RCA ENGINEER matters. If you have any questions about the RCA ENGINEER, your Editorial Representatives will be glad to advise and help you.

**E. D. FLECKENSTEIN**
***Editorial Representative***
***Cathode Ray and Power Tubes***
***Lancaster, Pa.***

Mr. Fleckenstein attended St. Mary's College and the University of California, and received his BS in EE in May, 1941. From July, 1941 to February, 1946 he served in the U. S. Navy on Radar Communications, terminating as a Lt. Commander. From March, 1946 to November, 1946, he was employed by the U. S. Navy at the Electronic Supply Center in Oakland, California. Mr. Fleckenstein was a member of the Technical Staff of the U. S. Atomic Energy Commission, San Francisco, Calif., from November, 1946 to January, 1955 at which time he joined the Tube Division at Lancaster, Pa. His present position is that of Manager, Engineering Administration, Power Tube Engineering.

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

Mr. Garvin graduated in 1950 from Kent State University with a BS in Business Administration. He joined RCA in January, 1951. His RCA experience has included work as a Specialized Trainee, Personnel, Camden; Job Analyst, EPD, Camden; Wage and Salary Analyst, General Office, Camden; Group Leader, Wage & Salary Administration, Lancaster, Pa.; Group Leader, Employment & Records, Lancaster, Pa. His present position is that of Administrator, Color Kinescope Administration, Lancaster, Pa.

**J. F. HIRLINGER, *Chairman***
***Editorial Board***
***Tube Division, Harrison, N. J.***

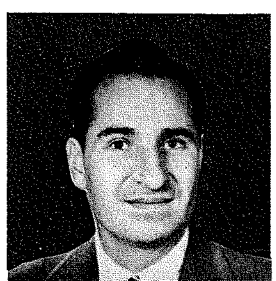
Mr. Hirlinger received his BS in EE from Purdue University in 1924. From 1924-1930 he was employed by the General Electric Company where he completed the Test Course at Schenectady, New York and later became a Vacuum Tube Engineer at Nela Park, Cleveland. In 1930 he joined the RCA Tube Plant at Harrison as a Power Tube Development Engineer. In 1932 Mr. Hirlinger became Assistant Supervisor, Power Tube Development. In 1943 he was appointed Power Tube Product Manager for the Lancaster Plant, and held this position until 1945 when he became Manager, Engineering Administration, Cathode Ray and Power Tube Engineering. His present post is Administrator, Technical Personnel Programs. Mr. Hirlinger is a Senior Member of the IRE and Member of Professional Group on Engineering Management.

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

Mr. Hoggett graduated in 1951 from the University of Missouri with a BS degree in Electrical and Mechanical Engineering. Upon graduation, he

R. L. KLEM

J. N. KOFF



P. M. LUFKIN

joined RCA in Manufacturing, as a Specialized Trainee, and was later assigned to the Tube Division at Cincinnati as a Manufacturing Engineer. Mr. Hoggett has had broad experience on receiving types at Cincinnati, and is now assigned to new types of amplifier pentodes.

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

Mr. Klem attended Sampson College in 1947-48 and Columbia University 1948-50 where he graduated with a BS degree in Engineering. Mr. Klem worked with the Bell Telephone Laboratories in 1942-43 and again in 1946-47, following service with the U. S. Army Air Force. In 1950, after graduation, Mr. Klem joined RCA as a design and development engineer in the Tube Development Shop. In 1953, he was appointed Staff Assistant to the Manager, Harrison Engineering and in 1954 became Manager, Engineering Administration, Engineering, Receiving Tube Operations Department.

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

Mr. Koff received his BS in EE from the City College of New York in 1936 and his MS from Stevens Institute of Technology in 1954. He was employed as a Shrinkage Control Engineer on electron tubes for the Western Electric Company from 1944 to 1950 and a Manufacturing Engineer at Sylvania Electric Products, Inc. He joined the Tube Division of RCA on March 6, 1950 as an Electron-Tube Manufacturing Engineer and is located at the Woodbridge, N. J. Plant.

**P. M. LUFKIN**
***Editorial Representative***
***Electronic Components***
***Findlay, Ohio***

Mr. Lufkin received his BS in EE from the Moore School of Electrical Engineering, University of Pennsylvania in 1948. He was employed by RCA as a Specialized Trainee in February of the same year. His Specialized Training Assignments included the Electronic Components Department, Camden; Receiving Tubes, Harrison; Home Instruments Department, Camden; and Engineering Products Department, Camden. In 1949 he was assigned to Transformer Development Engineering, Electronic Components Operations Department, Camden, N. J. In April, 1954, he transferred to Engineering, Electronic Components Operations Department, Findlay, Ohio.

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

Mr. Moore is a graduate of Swarthmore College, Class of 1938, with a BS in EE degree. His first employment after leaving college was with the York Ice Machinery Corporation in the Engineering and selling of air-conditioning and refrigeration units. He joined RCA in 1942 as a time and motion study engineer, and in 1944 was made Supervisor of the equipment-assembly time-study group. In 1942 he transferred to the Plant Budget Group for Component Parts and in 1947 moved into the Engineering Activity as Budget Administrator. On January 1, 1955, he was appointed Manager of the Administration and Services Activity, Engineering, Electronic Components Operations Department.

**J. W. RITCEY**
***Editorial Representative***
***Semiconductors***
***Harrison, N. J.***

Mr. Ritcey graduated from the University of Pittsburgh in 1950 with a BS in EE degree. From 1943 to 1946 Mr. Ritcey worked on Air-Warning Communications at Okinawa. He joined RCA in February, 1950 as a member of the Specialized Training Program and worked as a Design and Development Engineer in Receiving Tube Engineering. In 1953, Mr. Ritcey transferred to the Semiconductor design activity, and is presently Administrator, Engineering Administration, Semiconductor Operations Department. He is a member of Eta Kappa Nu, Sigma Tau, and Pi Eta Sigma.

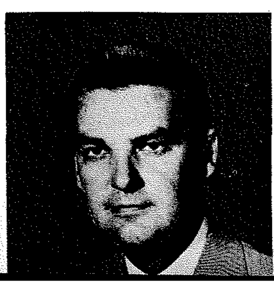
**M. N. SLATER,** ***Editorial Representative***
***Black and White Kinescopes***
***Marion, Indiana***

Mr. Slater attended the University of Manitoba, Canada, and received his Bachelor of Science degree in 1945. He then attended the University of Minnesota for graduate work in Physical Chemistry until 1951. At this time he joined the Gates Rubber Company, Denver, Colorado, and worked on the development of analytical methods, coatings, and adhesives. Mr. Slater joined RCA at the plant in Marion, Indiana in November, 1952, where he worked in the Chemical and Physical Laboratory on the development of cold-rolled-steel kinescope shells. He is currently working on filming and aluminizing. Mr. Slater is a member of the American Chemical Society and the Marion Engineers Club.

**L. H. URDANG**
***Editorial Representative***
***Receiving Tubes***
***Indianapolis, Indiana***

Mr. Urdang is a graduate of Pratt Institute, School of Science and Technology with a Bachelors Degree in Chemical Engineering. He was employed by RCA in February, 1943, at Harrison, where he worked on the development of glass processing for miniature tubes and small power tubes, and later as a Manufacturing Engineer for receiving tubes. From 1945-1946 he served in the U. S. Navy, attending the electronics technicians training program. After rejoining RCA at Harrison, in 1948 he transferred to the RCA Indianapolis Tube Plant as Group Leader, Glass Tubes, Manufacturing Engineering Activity. Mr. Urdang was promoted to Supervisor of this activity, and in January, 1954, he became Manager, Manufacturing Engineering, which is the position he now holds.

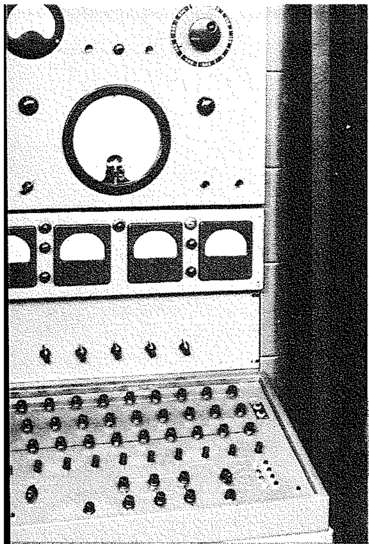
E. E. MOORE



J. W. RITCEY

M. N. SLATER

L. H. URDANG



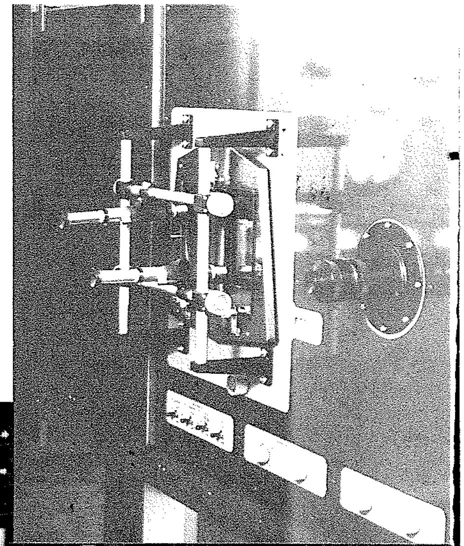
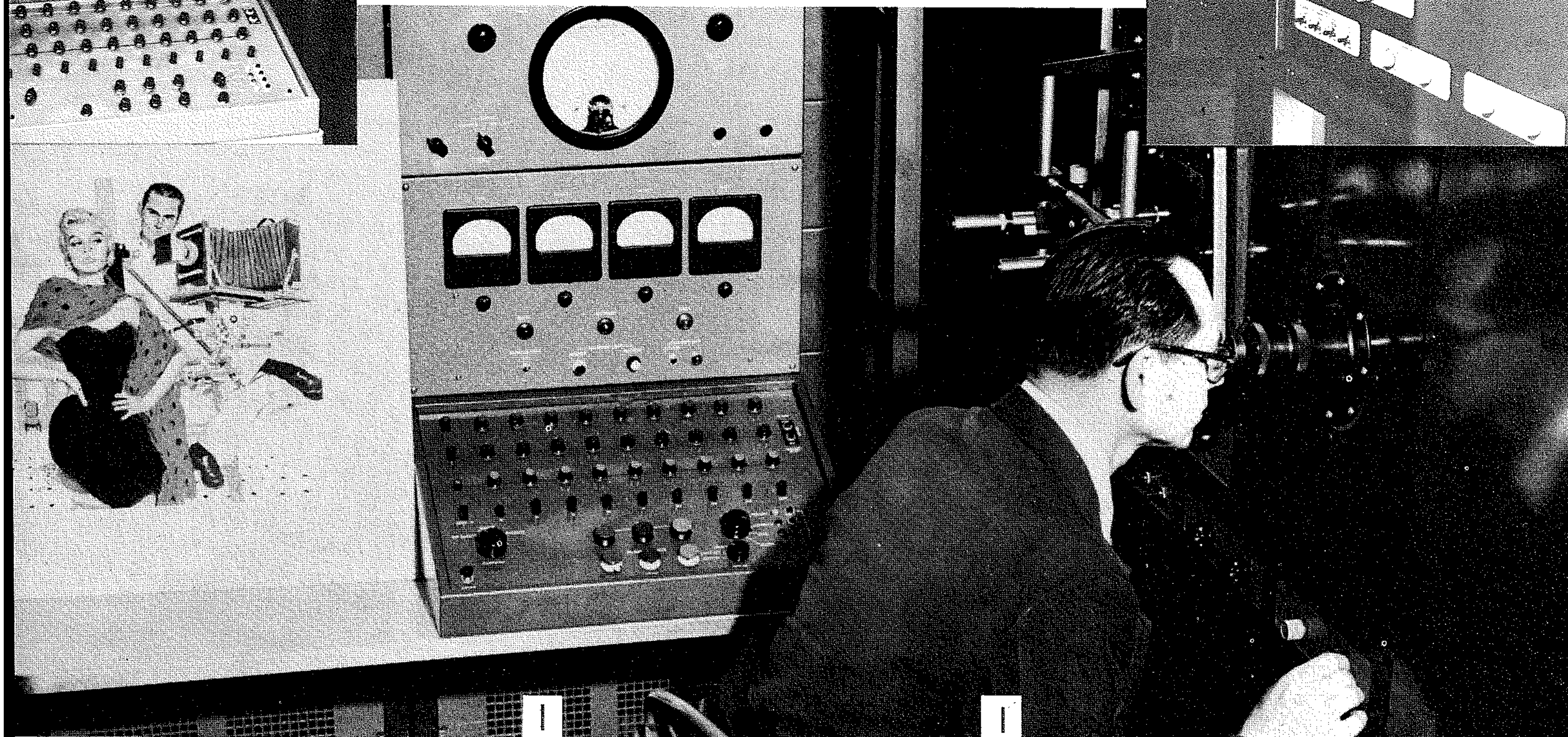


Fig. 2—*Electronic Control Panel*—The symmetrical array of 27 knobs represents the 9 x 3 Neugebauer matrix for adjustment of computer constants. Other controls are for the purpose of adjusting scanning and recording light levels and generally operating the equipment. ◀

Fig. 3—*Optical Control Panel*—The two rack and pinion controlled microscopes are used to check registration of separations. The ball and socket mounted telescope is used to position the light beam on test picture areas prior to scanning. ▶

Fig. 1—The author is shown adjusting position of testing spot on the rear-illuminated color separations which he is viewing through monitoring telescope. A "point-by-point" check of computed correction is made for specified picture areas. The registration assembly includes two rack and pinion-operated microscopes mounted at operator's left. While viewing superimposed test patterns, registration is optimized by manipulation of a series of lever switches. ▼



# THE RCA COLOR CORRECTOR

*by* **LOUIS SHAPIRO**
*Color Correction Engineering*
*Engineering Products Division*
*Camden, N. J.*

*system considerations and product design*

## THE SYSTEM

### OVERALL FUNCTION

BROADLY SPEAKING, the function of the RCA Color Corrector is to assist materially in the pictorial reproduction of a colored subject on the printed page. In addition to colorimetric accuracy, this reproduction must meet the high esthetic standards applied by the graphic arts industry to its products. Also, aside from colorimetric considerations, the picture must possess certain other photographic qualities variously designated as resolution, contrast, "snap," etc. The technical aspects of the application of the RCA Color Corrector to the Graphic Arts Industry will be treated by J. S. Rydz as a separate paper to be published in a future issue of the RCA ENGINEER. The color correction process necessarily operates within colorimetric limitations established by the nature of the printing inks and paper stock to be employed.

### PRINCIPAL CONSIDERATIONS

From a systems standpoint the operation of the RCA Color Corrector may be considered as progressing through three distinct stages. These stages are (1) sensing input information, (2) transforming this information to desired color corrected information. and (3) presenting this color corrected information to the user.

The above process is applied in approximately twelve (12) minutes to an input of three (3) color separations which are each analyzed by the equipment in terms of some fif-

$$R = R_w(1-c)(1-m)(1-y)(1-n) + R_c(1-m)(1-y)(1-n)c + R_m(1-c)(1-y)(1-n)m$$
$$+ R_y(1-c)(1-m)(1-n)y + R_{my}(1-c)(1-n)my + R_{cy}(1-m)(1-n)cy$$
$$+ R_{cm}(1-y)(1-n)cm + R_{cmy}(1-n)cmy + R_n(n)$$

$$G = G_w(1-c)(1-m)(1-y)(1-n) + G_c(1-m)(1-y)(1-n)c + G_m(1-c)(1-y)(1-n)m$$
$$+ G_y(1-c)(1-m)(1-n)y + G_{my}(1-c)(1-n)my + G_{cy}(1-m)(1-n)cy$$
$$+ G_{cm}(1-y)(1-n)cm + G_{cmy}(1-n)cmy + G_n(n)$$

$$B = B_w(1-c)(1-m)(1-y)(1-n) + B_c(1-m)(1-y)(1-n)c + B_m(1-c)(1-y)(1-n)m$$
$$+ B_y(1-c)(1-m)(1-n)y + B_{my}(1-c)(1-n)my + B_{cy}(1-m)(1-n)cy$$
$$+ B_{cm}(1-y)(1-n)cm + B_{cmy}(1-n)cmy + B_n(n)$$

Fig. 4—*The Four Color Neugebauer Equations*—This set of three simultaneous equations relates the Red, Green and Blue components of the original subject (as sensed by the optical system for each picture element area) to the percentage values of cyan, magenta, yellow and black printing inks required to reproduce the original color. The first term in each equation represents the contribution of the un-inked paper while the remaining terms represent contributions of the various inks, both singly and in overprints.

teen million fundamental picture elements.

Successful integration of such an equipment into the graphic arts industry posed the several requirements noted below:

1. Absolute validity of underlying philosophy and assumptions
2. Feasible integration with existing commercial procedures
3. Simplicity of operation and safety for operating personnel
4. Commercial ruggedness and reliability
5. Sound economic basis

Referring to the first item, it is noteworthy that the fundamental approach to transformation of colorimetric information in the RCA Color Corrector is based on the Neugebauer equations. The decision to use these equations in this equipment was made in 1941 by A. C. Hardy and F. L. Wurzburg, eminent authorities in this field, at the Research Laboratories of the Interchemical Corporation. The correctness of this decision has since been amply confirmed. Likewise, circuitry establishing black plate characteristics has been developed with provision for a great deal of manipulation of the ink relationships entering into the formation of this plate.

Next considered was integration of the RCA Color Corrector into the existing graphic arts industry. A good deal of study and deliberation was given to the form to be taken by the input information. Color separations were finally chosen. Not only does this method fit in very well with standard photographic shop practices, but it also provides a potentially highly precise method of transmission of colorimetric information from subject to equipment. The step involved in the preparation of separations is important too, in allowing for insertion of certain size and colorimetric adjustments in this information.

The output presentation of the RCA Color Corrector is presently in the form of corrected negatives. However, the system readily lends itself to incorporation of a screening process and, if desired, a photographic reversal. As such, the output will be directly applicable to fabrication of the final printing plates.

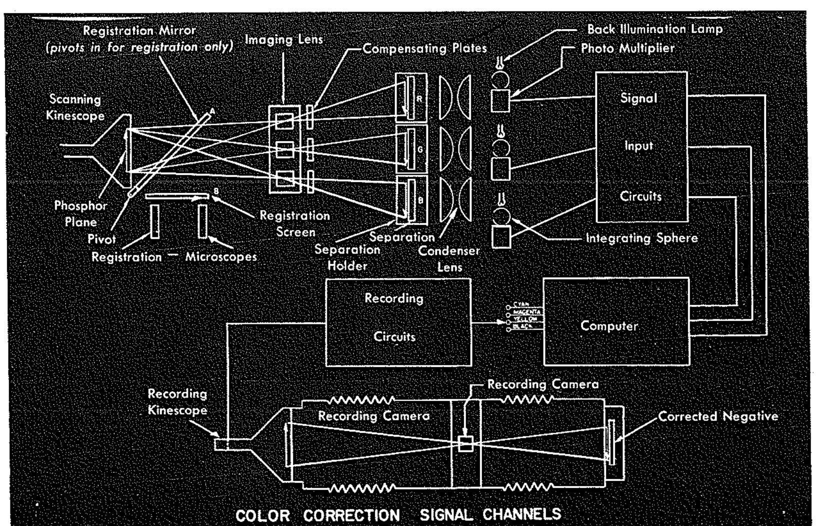
The foregoing is not the entire situation, however. Processes inherent in photographic and non-photographic manipulations involved in the printing of pictures have certain basic non-linearities or information-distorting characteristics. As such, for maximum equipment utility it is desirable to compensate for these effects. This compensation is provided for internally in the RCA Color Corrector by circuitry adjusted to meet the requirements of the individual user. In this manner, printing plates made directly from the equipment's output will require only those relatively small modifications which suggest themselves to an experienced art director when he views the proof and which we normally relegate to the domain of "artistic interpretation."

In essence, the foundation of the economic position of the RCA Color Corrector lies in its close integration with industry. As a tool in accomplishing quickly the great bulk of routine correction now done so laboriously by hand, it will be invaluable in releasing the time and energies of existing personnel for use in those areas of correction where artistic taste becomes the ruling factor. Incidentally, this situation will also be propitious for the production of more colored pictures. In a broad sense the RCA Color Corrector may be considered a fundamental cultural advance that substantially facilitates the use of an additional dimension — color — in that highly important present means of human communications—the printed page.

**REQUIRED PRECISION**

Consideration of the RCA Color Corrector as a system is conditioned at every point by the great degree of

Fig. 5—Chart showing Color Correction signal channels. The scanning kinescope provides a flying spot which is imaged on the red, green and blue separations. Resultant modulated light in each channel is collected by a condenser lens and integrating sphere for transmission to its photomultiplier. Signal input circuits feed these signals to the computer which determines the percentages of cyan, magenta, yellow and black inks required to reproduce original picture. The last step is the successive recording of these corrected ink negatives.



precision required. Based on the accepted value of .01 as the minimum discernible density difference of the human eye, it follows from densitometric and system considerations that the required degree of precision is .1% at the output. This value, however, does not directly define precision requirements throughout the system. The presence of an analog computer transforms this precision requirement back to the input channels in accordance with its overall transfer function. In certain important colorimetric situations, the relationship of output change to input change reaches a value in the neighborhood of 100. The result is to impose an unusually severe set of stability and precision requirements on the input channels.

In this connection it is worthy of mention that all handling of colorimetric information, whether in the form of light intensity, electric current, or electric voltage, is on a d.c. basis. Even where computation requires duty cycle modulation, d.c. levels must be meticulously preserved. To support the required degree of precision, all circuits and components were first evaluated for normal performance limitations inclusive of reasonable engineering margins. The resulting level of performance could, in most cases, be exceeded by coddled engineering prototypes. For the final design, however, no attempt was made to rely upon exceptional performance. Where initial performance was not adequate, the basic approach was reexamined until a satisfactory design was reached. We may add in passing that there is scarcely a circuit in the system which does not figure in at least one feedback loop. Free use is made of precision resistors. No premium tubes are used, however, and the total number of tube types is quite small. Information referencing is made to ground wherever possible, common mode cancellation is designed into all amplifiers, and all low level amplifiers have extensive compensation.

## THE INFORMATION SENSING PROCESS

### SURVEY OF OPTICAL SYSTEM

Sensing of input information is accomplished by the optical system shown at the top of Fig. 5. A flying spot raster is developed on the phosphor plane of the scanning kinescope. Each of three imaging lenses separately focuses this raster on its associated input color separation. Light passing through each separation is collected by its condenser lens and presented to the entrance aperture of an optical integrating sphere. Light issuing from the exit aperture passes to the photosensitive surface of a photomultiplier where it is converted into an electrical signal.

### COMPONENTS AND PERFORMANCE

Components of the optical system are of high quality. The flying spot kinescope was developed by the RCA cathode ray tube development group at Lancaster, Pennsylvania and is capable of exceedingly high resolution. Spot size is within .002″ and phosphor graininess is greatly reduced. To allow for accurate positioning of the phosphor plane, thickness data

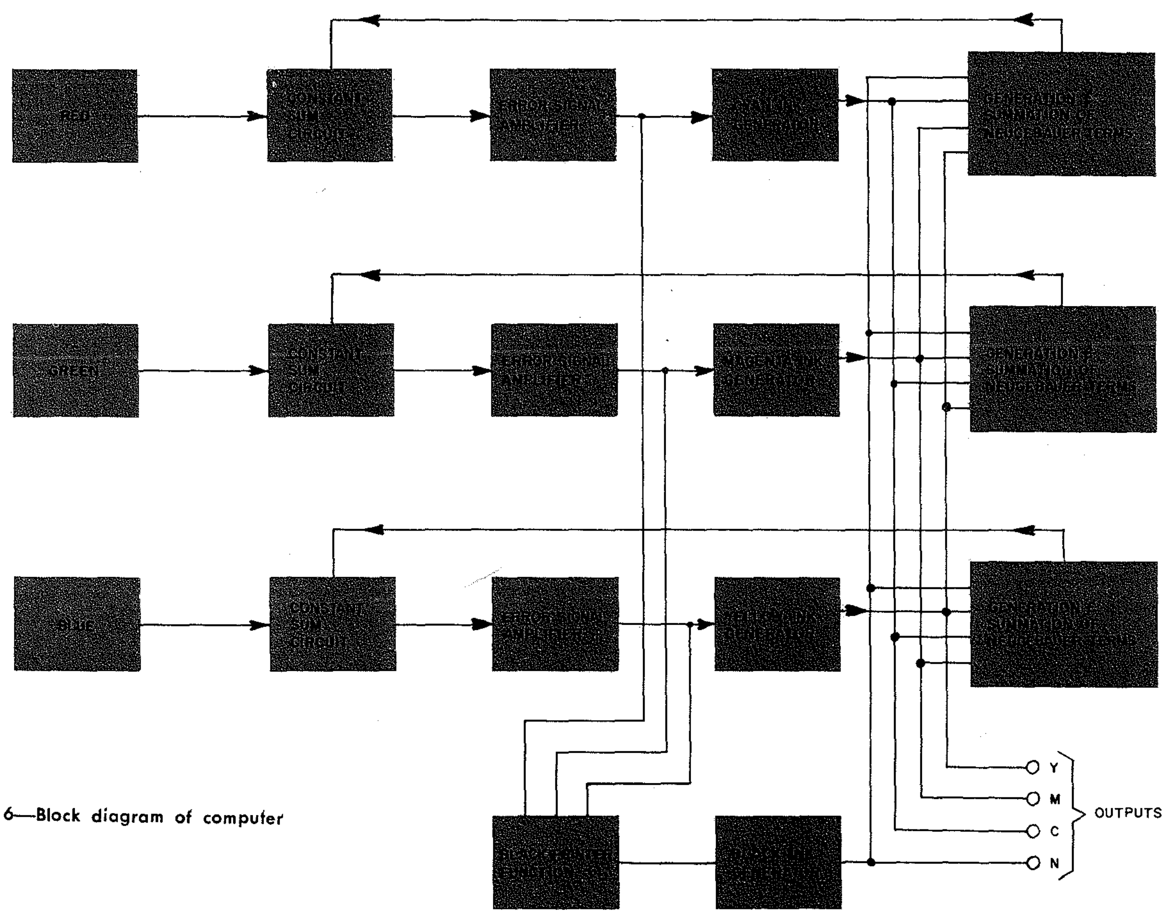



Fig. 6—Block diagram of computer

of the optically flat face plate is engraved to four significant figures. Residual effects of phosphor graininess as well as light intensity variations due to other causes such as phosphor wedging and various optical effects are effectively removed by means of a monitoring photocell head (not shown) which continually maintains a uniform spot brightness at the phosphor plane as seen by the imaging lenses.

Additional geometric light intensity variations take place in the individual channels due to differential raster field angles and resultant differential light handling properties of the various optical elements. These effects are compensated for by means of special methods. Also included in this assembly is a non-spherical corrector lens which compensates for certain abberations in the condenser lens. This corrector lens, together with the integrating sphere acts so as to furnish an undeflected spot of constant light distribution to the photosensitive surface of the photomultiplier.

The multiple lens optical unit utilizing high quality apochromat lenses effectively precludes the formation of spurious images or "ghosts." Overall resolution of the optical system (including the kinescope) is very high. Scanning lines are, of course, entirely invisible to the unaided eye. Measurements show that resolution of the kinescope alone is comparable to that of the imaging lenses while resolution of the composite system is only moderately below that of either element individually. A moment's reflection would indicate, however, that the foregoing is a necessary condition for the entrance of scanning techniques into the graphic arts industry.

#### REGISTRATION

Registration and focus must be achieved and maintained for the duration of a set of scannings. Purely optical components are positioned by means of precise mechanical adjustments with provision for periodic collimation. Registration is accomplished by the use of a "back-illumination" technique. Photomultipliers and integrating spheres are swung out of the way by push-button operated motors. This same operation brings a small incandescent light into the area formerly occupied by each integrating sphere. Due to the symmetrical properties of the lenses operating at one to one magnification, light from these lamps accurately image the separations (including registration or target patterns thereon) onto the phosphor plane behind the kinescope face plate. Alternatively, an accurately positioned mirror "A" (Fig. 5) brings the image out to "B" where each of two widely spaced registration marks may be observed through its own microscope to check for the required registration.

The desirable condition of maintenance of registration from one set of color separations to another is made feasible by the use of three point registration. This method utilizes a separation holder containing three accurately machined steel positioning pins against which the separation is spring loaded. In effect, we register separation holders rather than separations.

It is desirable that registration be maintained for at least a day, and preferably longer. To accomplish this the optical bed is based on a series of massive aluminum castings accurately positioned on four rigid steel rails. This structure inherently possesses a degree of thermal compensation.

A three point suspension technique is employed for support of the entire optical system. The structure is suspended from two points overhead while a snubber stabilizes the system from below. All three points of support are heavily damped. The sheer weight of the suspended structure provides excellent protection from higher frequency vibration or shock components.

## THE COLORIMETRIC TRANSFORMATION

#### MATHEMATICAL PROBLEM

It is the function of the computer to solve a composite problem consisting of the four-color Neugebauer equations (see illustration) in combination with an arbitrarily assigned black printer function for every fundamental picture element in the subject. In practice, this works out to approximately one and one-quarter million such solutions per minute, or fifty microseconds per solution and is performed by three chassis containing about 150 electronic tubes.

#### INTERNAL MECHANICS OF COMPUTATION

Computation is performed by coincidence, summation and feedback methods. A simplified diagram of the computer is shown in Fig. 6. Ink signals are developed in the ink generator chassis with percentage ink being represented in each case by a percentage duty cycle with accurate d.c. reference. Each percentage, in turn, is controlled by the value of a d.c. input voltage, arriving from the associated error signal amplifier. To avoid spurious beat frequencies repetition rates of the various ink generator signals are unrelated.

Multiplication in each Neugebauer term is performed by quadruple coincidence of the "on" portions of these duty cycles. Multiplying constants are assigned by adjusting rheostats in the cathode circuits of the coincidence tubes. Plate current passing through the coincidence tubes thus becomes the contribution of that term to the equation. An integrating condenser of appropriate value sums up the various terms in the equations and equates the result to the color separation signal for that particular equation (R, G or B).

First order correction considerations naturally lead us to equate R to an equation in which c is most important, G to an equation in which m is most important and likewise with B and y. It is convenient circuit-wise to develop the quantities 1-R, 1-G and 1-B in the input amplifiers. By so doing we are enabled to insist that the sum of the 1-R signal and the summation of the terms in the c dominated equation equal a constant value. This is done by means of the circuit shown in Fig. 7. The high variational resistance of the constant current source acting as a common plate load allows a large error signal to develop when the above equality is not met. This error signal is amplified and enters the ink generator chassis where it corrects the appropriate percentage ink value by adjusting the duty cycle value for that particular ink signal.

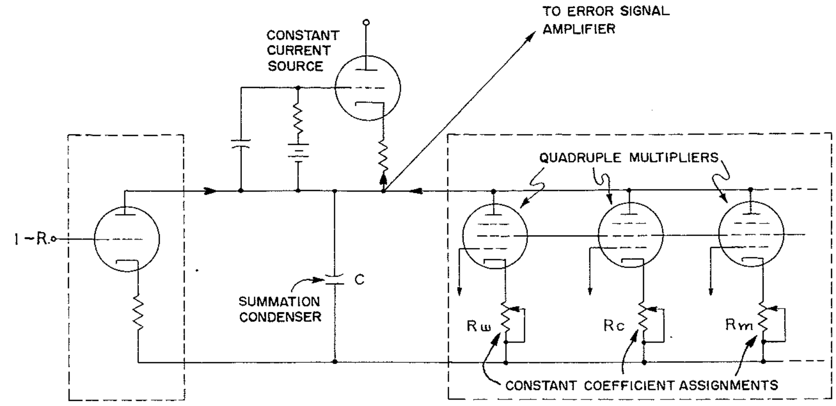



Fig. 7—Diagram of Constant-Sum Circuit

**LOUIS SHAPIRO** is the holder of an M.S. Degree in Physics-Mathematics from Washington University, St. Louis. Later, he was a member of the faculty with the School of Mines and Metallurgy of the University of Missouri where he developed a pulse generator which was accepted for exhibition at the 1948 Colliquium of College Physicists at Iowa University. Since 1951 Mr. Shapiro has been employed by RCA in Color Correction of which he is the Project Engineer. He has written various papers on this subject and has seven patent applications. An accomplished pianist, Mr. Shapiro's chief interest aside from the job is music.

### OPERATING CONSIDERATIONS

Initial adjustment of the computer is checked, or trimmed up, by halting the scanning spot on various test patches on the margins of the picture or on portions of the picture where the operator desires certain specific percentage ink values. In this way, computation leading to desired correction is insured. As we have previously inferred, the desired result may not necessarily correspond to an accurate colorimetric reproduction of the original. In effect, the operator may insert predetermined distortions of the so-called "color-solid" into the correction process and thus, to a certain extent, paint his own picture.

We may note that, should the necessity for them arise, the computer is completely amenable to the addition of extra terms to the Neugebauer equations. Such might be the case, for example, where it may be desired to allow for the small difference between a black-yellow overlay and a black-magenta overlay.

The initial version of the equipment records one ink signal at a time requiring four scannings for production of a complete set of corrected ink negatives.

## THE PRESENTATION

### SUMMARY OF RECORDING CIRCUITRY

Upon leaving the computer, the corrected ink percentage signals are routed to the tone compensation circuit where previously mentioned nonlinearities are inserted to linearize the overall industrial process from original subject to final printed picture. The signal then enters the modulation circuitry of the recording kinescope. This latter kinescope, which is of the same type as the original scanning kinescope, is built into a camera which photographs the face of the kinescope for the duration of a scanning. The resulting picture is the output of the equipment and is processed for production of the ultimate printing plate for that particular ink.

Linearity and accuracy of recording kinescope modulation is secured by a monitoring photocell head located within the camera which constantly samples the intensity of light existing within the camera. The output of this photocell head is compared with the computed signal which is being recorded. In the event of deviation, error signals are developed which provide corrective action. The overall circuit is adjusted for operation within specified recording limits of the photographic plate used.

### DEFLECTION CONSIDERATIONS

Recording of the corrected negative entailed development of an unusually exact deflection system. There is a basic difference between the scanning and recording process. Scanning is essentially an instantaneous process with picture element information being sampled without regard, necessarily, to the geometric location of the preceding picture elements. Thus, a small amount of velocity modulation of the deflection process would scarcely be noticed. The situation is entirely otherwise in the camera, however. Here the photographic plate is a light integrating device with a very well defined memory for the geometric distribution of the picture elements. Where picture elements are crowded together (recording spot light intensity modulation limits remaining unchanged) the picture shows effectively greater exposure and conversely for areas where picture elements are unduly separated. The result was an unusually tight specification on deflection precision.

Separate problems were encountered in the horizontal and vertical deflection, depending upon the nature and frequency spectrum of the noise involved. To insure consistent satisfactory rasters it proved necessary, among other things, to utilize cathode followers with the utmost care, avoid push-pull types of circuits and make use of the newly developed polymer dielectric type of condenser for development of the basic vertical deflection voltage. Incidentally, detection of low frequency noise on the latter slowly rising voltage required design of a special type of sensing circuit.

Translation of the above level of precision requirement to actual engineering data resulted in a positioning specification of the recording spot on the phosphor plane to the order of microinches. The electrical environment necessary to accomplish this included a 25 kilovolt power supply with fractional volt stability as well as specially designed and precisely mounted deflection and focus coils. Focus modulation circuitry is, of course, utilized.

## OPERATIONAL FEATURES

### PERSONNEL AND OPERATIONAL FACILITY

It is anticipated that personnel operating the RCA Color Corrector will be recruited from the graphic arts. As such they will have a graphic arts rather than electronic background. In addition, they will have (or acquire) a basic knowledge of color theory and skill in certain optical manipulations (as required, for example, in registration).

In the above connection we may note that the general level of operational complexity of the equipment is above that required for, say, a home television receiver.

Adjustments for a typical sequence of operations begin with the loading of separations into the optical system. The operator then establishes brightness limits and trims up computer constants. The final step prior to actual scanning is the establishment of recording light limits.

To facilitate the above, all electrical operational controls are grouped at a single operating position (see Figs. 3 and 4). Frequently used controls are arranged on a sloping shelf while other controls are recessed just above this shelf. The optical control panel is conveniently reached by the operator by rotating his chair. He may then observe the picture and scanning spot from a seated position.

Grouping is on a functional basis with colored patterns serving to identify controls applying to particular optical or ink channel. Convenient operating positions were sought to make frequently used controls accessible with restful arm positions. Similarly, critical controls needing protection from accidental jarring were placed in positions rendering such accidents unlikely.

### AUTOMATIC FEATURES

Required operational adjustments made it desirable to relieve the operator of steps which could be made automatic. With this thought in mind, an automatic tabulation system was incorporated to indicate at a glance which ink plates had already been run off. The size adjustment of the camera was made semi-automatic. Other automatic features include indicating lights to advise the operator when the equipment is ready to start a picture scan or, alternately, when some important operation has to be completed before scanning can commence.

### SAFETY SYSTEM

The safety system can be separated into three categories; namely, the safety of the operator, the safety of the equipment, and the safety of the scanning process. A set of interlocks and "emergency off" switch provisions insure maximum safety for the operator. Additional precautions include the elimination of "floating" high voltage switches and the addition of auxiliary internal enclosures to preclude possible exposure of personnel to high voltages. Design of the optical system enclosure and camera is such as to safeguard the operator against kinescope implosion.

Protection of the equipment, particularly high resolution kinescopes and photomultipliers, is important. Cut-off biasing voltages "stand by" continuously for application to the kinescopes at the first sign of grid drive or scanning spot deflection failure. Additional circuitry prevents operation of the photomultipliers during periods when picture study is utilizing rear illumination in the optical system. Circuitry is provided to de-energize the entire equipment in event of failure of any single power supply.

Protection of the scanning process is provided by the automatic operation control features mentioned above as well as by circuits which prevent occurrences such as the scan of only part of the raster. In cases where a scanning is attempted while, say, the shutter of the light-tight enclosure is open, the "Not Ready" light will remain lit, while the scanning switch will refuse to stay closed and insist on returning to the "Off" position.

### CONCLUSION

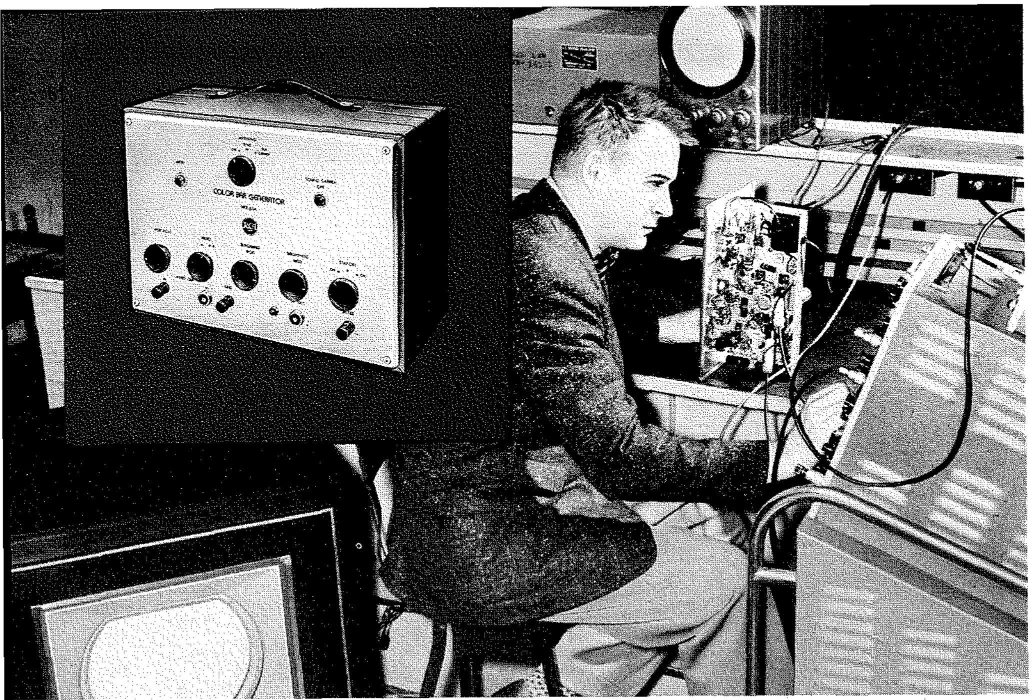
Generally speaking, the RCA Color Corrector represents an operation which has reached and, in some cases, extended "state of the art" limitations. These areas include optical resolution, kinescope resolution, photomultiplier signal-to-noise ratio, electronic d-c stability and speed of complex computation. Upon release to the graphic arts industry, the RCA Color Corrector will represent a very real step forward in the field of industrial scientific instrumentation.

## INGENIOUS CIRCUIT FOR RECORDING LIMITS

A. J. Walsh, Senior Color Correction Technician, contributed greatly with his design of an ingenious circuit and technique for setting up recording end limits in the RCA Color Correction equipment. The problem posed here was the establishment of precise light exposure limits in the camera.

Such a camera is utilized in the RCA Color Corrector for recording the color corrected negative as it appears on the face of a high-resolution kinescope. Accurate adjustment of light intensity limits is essential in order to insure correct exposure of the photographic plate. Previously, problems had been encountered due to factors such as blanking during retrace time, spot movement beyond the face plate, temporary spot or line burn-in, small phosphor blemishes, pin holes, etc. The method devised by Mr. Walsh is based on a well designed Lissajous pattern which continuously provides a sample of spot brightness appearing over a considerable portion of the picture area. In this manner a good averaging effect is obtained and a much more precise adjustment of recording light limits is possible than was heretofore available. This circuit has been installed in the RCA Color Corrector as a permanent feature.

**A. J. WALSH** served as Communications Sergeant, 8th Armored Division, during the war in the European Theater of Operations. He completed advanced courses in FM and AM radio at the Army Technical Training School, Holibird Signal Depot, Baltimore, Maryland. Following military service in 1946, Mr. Walsh completed the Radio-Television course of Melville Institute, New York City. He then accepted a position with Interchemical Corporation at Buchanan, N. Y. in their color correction program, and came to Camden in 1951 when further development of color correction equipment was started by RCA.



**Editor's Note:** The successful engineering development of the RCA WR-61A represents a radical departure from established Color-Bar Generator design practice. It typifies the benefits that often result from investigating unusual ideas and avoiding stereotyped approaches. Designed primarily as a portable servicing tool, the new 13 lb. unit has the advantages of compactness and low cost, previously unavailable in conventional designs of Color-Bar Generators. This new, lightweight, Color-Bar Generator is indispensable for use in the development, production and servicing of color receivers. The WR-61A is also being used as a standard of color-phase accuracy in numerous broadcast stations, both network and independent.

# WR-61A COLOR-BAR GENERATOR DESIGN


*by* **STEVEN WLASUK**
*Special Project Engineering*
*RCA Service Co., Inc.*
*Cherry Hill, N. J.*


ANY COLOR-BAR generator designed for service use must be light in weight, compact, stable, accurate, easy to use, and inexpensive. It must provide all the facilities required for complete checking of the color functions in a receiver, including:

(1) Accurate check on demodulator phasing adjustments of all major angles (I, Q, R—Y, B—Y, G—Y).

(2) Check on matrixing.

(3) Check on color-sync action for normal and weak color-sync-burst signals.

(4) Check on registration or "fit" of the luminance and chrominance signals on the kinescope.

(5) Check on the over-all r-f, i-f, video response for color signals.

(6) Check on effectivenes of sound i-f rejection in minimizing beat interference between the color subcarrier and the sound carrier at the correct ratio of picture to sound carrier amplitudes.

(7) Check on non-linear amplitude characteristics that might effect color reproduction.

For readers who are not familiar with the conventional method of producing color-bar signals, it may be helpful to start with a brief outline of this method.

### CONVENTIONAL COLOR-BAR GENERATORS

Conventional color-bar generators, of the type commonly used in television laboratories, factories, and broadcast stations, utilize delay lines (made from standard coaxial cable or its lumped equivalent) to obtain the required phase difference between the reference color-sync burst and each of the color-bar signals.

This method is indicated in simplified form in Fig. 1. The output of the 3.579545 megacycle subcarrier oscillator is gated to produce the reference color-sync burst, which is timed to occur on the "back-porch" of horizontal blanking. The output of the subcarrier oscillator is also passed through a delay line and is gated to produce a color-bar signal of the desired duration and position in each horizontal scanning-line period. The final composite signal, including the reference burst, the color-bar signal, and the necessary horizontal and vertical blanking and synchronizing pulses, can be used to produce a bar of color on the kinescope of a color receiver. The color-bar signal shown in Fig. 1 would appear as a wide vertical bar of color at the center of the screen.

The color or hue of the bar depends on the phase difference between the reference burst and the color-bar signal. The phase difference depends on the length of the delay line.

Only one color-bar signal is provided in the simplified arrangement of Fig. 1, but for speed and convenience in testing and adjusting receivers, the generator should provide several different color-phase signals for simultaneous viewing on the color kinescope, and for simultaneous observation of the bar waveforms on an oscilloscope.

The composite video waveform of a conventional color-bar generator is shown in Fig. 2. Separate sections of delay lines and amplifiers, with sequential gating, are used to produce the six color-bar signals. The amplitudes and brightness levels of the signals are normally adjusted to produce fully-saturated colors on the receiver. Black and white luminance reference levels are also provided. Horizontal and vertical blanking and synchronizing signals are furnished from an internal or external source, and the composite video signal is used to modulate an internal or external r-f oscillator operating at the picture-carrier frequency of the desired TV channel.

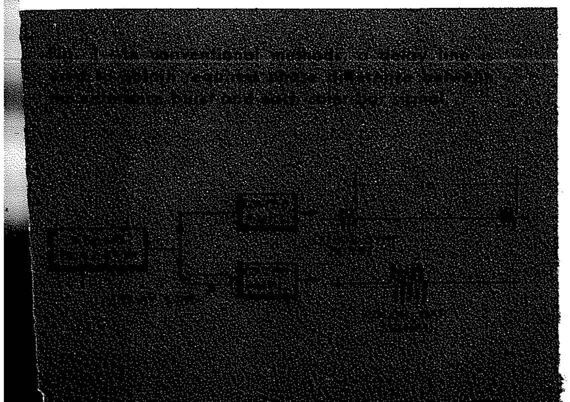
In addition to the fully-saturated primary and complementary color-bar signals, most color-bar generators also provide color signals at phases corresponding to some of the demodulator axes (I, Q, R—Y, B—Y, G—Y). These signals are usually operated at black level (no luminance component), and are extremely useful and necessary in checking the phasing adjustments of demodulators in color receivers and in color video monitors as well as color stabilizing amplifiers and other signal correcting devices.

### APPLICATION OF CONVENTIONAL DESIGNS

The conventional type of color-bar generator is designed primarily for use in television laboratories, factories, and broadcast stations, where the factors of size, weight, and cost are relatively unimportant. It is obvious from the complex waveform of Fig. 2 that this type of generator is neither simple nor inexpensive, especially if it contains standard H and V blanking and synchronizing pulse-generating equipment, and also the modulator and r-f carrier that are required for testing the over-all operation of color receivers.

### A LIGHTWEIGHT SERVICING DESIGN SOUGHT

Anticipating the need for an accurate, lightweight, compact, inexpensive, and "fool-proof" color-bar generator for use in servicing color receivers, the Engineering Department of the RCA Service Company investigated the possibility of finding other and simpler methods for producing color test signals. This investigation resulted in the development of an entirely different and unique method that completely eliminates the need for delay lines (or equivalent phase-shifting networks) and their attendant multiple gating circuits. This method is unique because no color signals, as such, are developed in the generator, yet it produces ten bars of different colors simultaneously on the color kinescope, each bar accurately phased at 30° intervals!

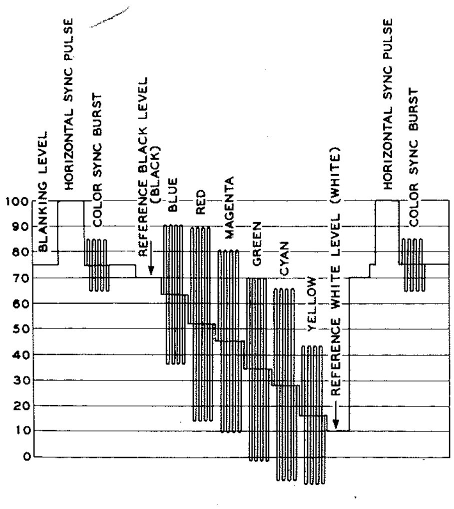


By using this method, together with simple circuitry for deriving the horizontal sync pulses, and by restricting the r-f output to a single channel, it was found possible to meet all of the requirements. The final design, marketed by the Test Equipment Section of the Tube Division, and designated as the RCA WR-61A Color-Bar Generator, weighs only 13 pounds and has a user price of $247.50. Although originally designed primarily as a servicing instrument, the WR-61A has proved to be so stable and accurate that it is now used in numerous broadcast stations and in color line-network operations as a standard of phase accuracy. It permits adjustment of stabilizing amplifier phasing within a few degrees of the specified angles.

### BASIC PRINCIPLES OF THE WR-61A

The basic principle used in the WR-61A may be described as the "offset-subcarrier" method, because the frequency of the subcarrier is offset from the normal value, of approximately 3.58 mc, by an amount equal to the horizontal scanning rate. (For reasons explained later, the black-and-white horizontal scanning rate of 15,750 cycles is used in this generator.)

Fig. 2—Waveform of pattern produced by conventional type of color-bar generator.




The offset-subcarrier method is based on experimental observation that a "rainbow" of colors can be produced by simply applying a c-w signal of 3.58 mc minus 15,750 cycles (or 3.58 mc plus 15,750 cycles) to the video input of a color receiver.

Using a frequency of 3.58 megacycles minus 15,750 cycles, the rainbow appears as indicated roughly in Fig. 3. (With a frequency of 3.58 mc plus 15,750 cycles, the order of colors is reversed, with green on the left, blue in the center, and red on the right). Yellow hues are lost because they occur during the horizontal-retrace period.

The frequency of the subcarrier in the WR-61A is offset on the low-frequency side. The exact frequency is 3.579545 megacycles minus 15,750 cycles, or 3.563795 mc. This signal has a maximum production tolerance of ±20 cycles.

When the offset-subcarrier signal is applied to the video amplifier of a color receiver, each of the demodulators in the set receives two different signals as indicated in Fig. 4:

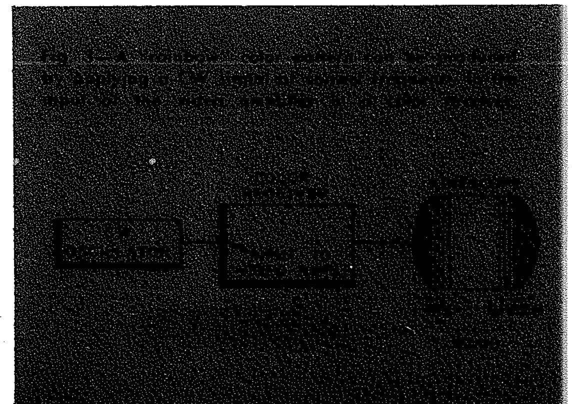
(1) A signal of 3.58 mc from the local "color" oscillator in the receiver.

(2) A signal of 3.58 mc minus 15,750 cycles, from the external oscillator.

Because there is one cycle difference between these two signals in each complete horizontal scanning-line period, each demodulator produces a sine-wave output of one cycle-per-line, or 15,750 cps. (A portion of each cycle is lost due to blanking during flyback time.) The relative phasing of the output signal is different at each demodulator owing to the difference in phasing of the signals from the local 3.58 mc oscillator at each demodulator.

### KINESCOPE BAR PATTERNS

The signals developed at the grids of the kinescope, and the resultant pattern on the kinescope, are indicated



in Fig. 5. The red signal is positive over the left-hand half of each horizontal scan, with peak amplitude (and maximum red brightness) at the quarter-way point. The blue signal is positive over the center-half of each horizontal scan, with peak amplitude (and maximum blue brightness) at the center. The green signal is positive over the right-hand third of each horizontal scan, with peak amplitude (and maximum green brightness) at the right-hand edge. The areas where red and blue overlap have magenta hues. The area where blue and green overlap have cyan hues.

It can be observed in Figs. 5 and 6 that, with the offset-subcarrier method, one complete 360° rotation of color phase is assured for each complete horizontal scanning-line period.

#### BARS IDENTIFY COLOR SIGNAL ANGLES

In considering means for identifying different color-phase angles, especially the demodulation angles, it was noted that the R—Y, B—Y, and G—Y angles are located at or very close to multiples of 30° from burst, while the I and Q angles are only 3° off from 30° multiples. Hence it was evident that identification should be provided at 30° phase intervals referenced to burst phase.

Remembering that, with the offset-subcarrier method, the time for one complete 360° rotation of color phase is the same as for one complete horizontal scanning-line period, the required identification can be provided by using a square-wave signal to gate the subcarrier on and off at a rate to produce 12 bursts, or bars, of subcarrier signal in each complete horizontal line period (or in each 360° of color phase rotation). In this way, the bars of subcarrier signal are accurately spaced at 30° phase intervals. The required gating frequency, for a horizontal scanning rate of 15,750 cycles, is 12 x 15,750 cycles or 189 kc.

#### OTHER DESIGN DEVELOPMENTS

Other steps in development included crystal control for the offset-subcarrier oscillator, and the addition of horizontal sync pulses obtained from a multi-vibrator triggered by every 12th cycle of the 189 kc subcarrier gating signal, which is also of crystal accuracy to insure correct offset. One of the 12 bars of subcarrier signal is blanked out to provide space for the horizontal sync pulse.

As a result of the previously described developments, the offset-subcarrier method was transformed from a laboratory novelty to a stable and precise method for checking and adjusting demodulator phasing. In addition, the horizontal sync pulses, which pass through the luminance channel in the receiver, provide a luminance reference level for checking matrixing.

Further steps in development included the addition of:

(1) Controls to adjust the duration of the color bars in order to produce a standard duration burst of eight cycles.

(2) Luminance signals at the edges of the color bars to aid in checking the registration or "fit" (relative time delay) of the luminance and color signals as they appear on the kinescope. The luminance signals produce a thin dark vertical line on the left-edge of each color bar, and a thin white vertical line on the right-edge of each color bar.

(3) A 60-cycle luminance signal that produces a horizontal area of increased brightness across the color-bar pattern. This signal provides a check on amplitude distortion in the receiver by showing whether the hue of the color bars change in the light and dark areas. This luminance signal can be switched off.

(4) Controls for adjusting the amplitudes of the offset subcarrier and the horizontal sync pulses, and a rectifier circuit for metering these amplitudes. Front panel control of the subcarrier amplitude (including the bar that acts as the reference color-sync burst) provides a good check on ability of the color sync circuits in the receiver to "hold" on burst signals of less-than-normal amplitude, a condition encountered in some receiving locations due to multipath reception.

(5) A crystal controlled r-f oscillator operating at the picture-carrier frequency of channel 3. This carrier is modulated by the composite video signal. R-f output is essential for checking the over-all operation of color receivers. (High and low impedance video outputs are also pro-

vided for checking color video monitors, and for trouble-shooting the video portion of color receivers.)

(6) An unmodulated crystal-controlled r-f oscillator operating at the sound-carrier frequency of channel 3. This carrier can be switched on and off to aid in checking beat interference between the offset subcarrier and the sound carrier. The sound carrier is essential to ensure correct adjustment of the fine tuning control when checking a color receiver.

The waveform of the offset subcarrier and the horizontal sync pulse in the WR-61A is shown in Fig. 6. There are 11 bars of offset-subcarrier signal in each horizontal scanning-line period. (The 12th bar is removed to accommodate horizontal sync.) The bar immediately following horizontal sync functions as the reference color-sync burst. The timing of this burst, with relation to horizontal sync, is within FCC standards. The remaining 10 bars produce output from the demodulators, as shown in Fig. 7.

It was mentioned in the preceding paragraph that the first bar of the off-set-subcarrier signal, following horizontal sync, acts as the reference color-sync burst. The local 3.58 mc oscillator in the receiver "locks up" on the average phase of this bar, which remains the same from line to line. In receivers that have a phase detector and a reactance-tube-controlled 3.58 mc oscillator, the correction voltage is the same with the off-set subcarrier as it is with the standard color-subcarrier frequency. In receivers that utilize a "ringing" or injection type of 3.579545 mc color-reference source, the pass band for the gated burst is narrow and hence provides an averaging effect of phase, equivalent to the phase at the center of the burst.

#### BLACK AND WHITE SCANNING RATE USED

The reader may wonder why the black and white horizontal scanning rate of 15,750 cycles was selected instead of the color rate of 15,734 cycles.

The reason is to prevent averaging out (on the kinescope) of beat interference between the subcarrier and the unmodulated sound carrier (the color horizontal scanning rate was chosen to minimize this beat). Unless the beat is visible, the user is unable to determine the correct adjustment for the fine-tuning control when checking or adjusting a receiver. If the beat is visible (not averaged out) the user can adjust the fine-tuning control accurately by tuning for minimum-intensity beat.

Vertical sync pulses are intentionally omitted in the WR-61A to aid in revealing any residual visible hum in the receiver.

#### APPLICATIONS OF THE WR-61A

Study of the waveform patterns of Fig. 8, is helpful in understanding the application of the WR-61A.

For example, at the output of an R—Y demodulator (or at the red grid), the third and ninth bars should have maximum amplitude, while the sixth bar (B—Y) which is 90° out of phase, should be zero.

Conversely at the output of a B—Y demodulator (or at the blue grid), the sixth bar should have maximum amplitude, while the third and ninth bars (R—Y) which are 90° out of phase from B—Y, should be at zero.

The method of using the horizontal sync pulses as a luminance reference level, for checking matrixing, is shown in the three lower waveforms of Fig. 8.

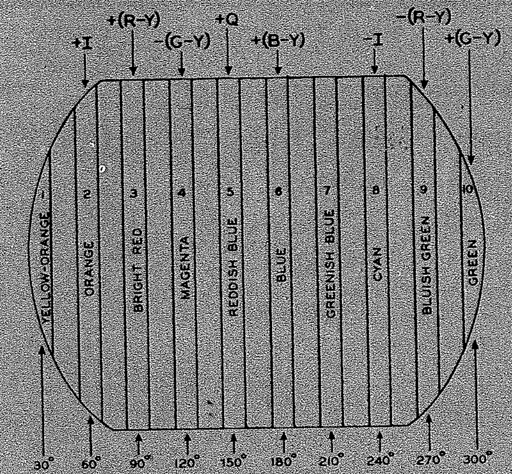
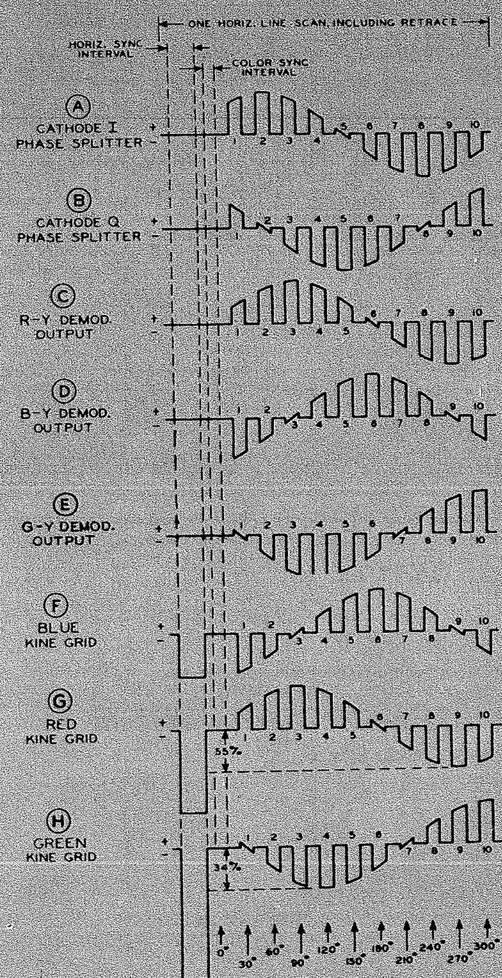
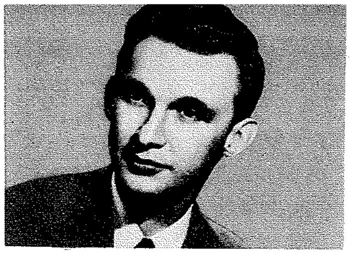



Fig. 7—Bar pattern of WR-61A as seen on color kinescope. The amplitude of the subcarrier signal is zero in the spaces between the color bars.

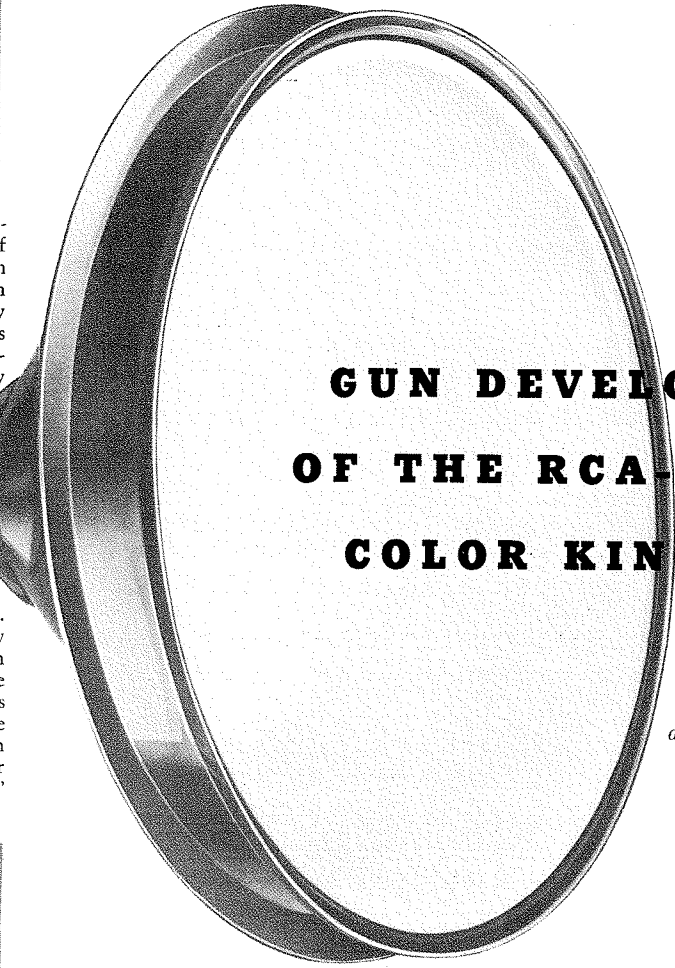
Fig. 8—Idealized representation of waveforms produced by WR-61A signals at the demodulators and kinescope grids. The actual waveform of each bar is greatly modified by the 0.5 and 1.5 megacycle bandwidth of the chrominance band-pass amplifier and the demodulator output circuits. The patterns are not drawn to scale.




**STEVEN WLASUK** is Manager of the Special Projects Engineering Group in the Consumer Products Division of the RCA Service Company. He attended Drexel Institute of Technology, and has had experience as Chief Technician and Branch Manager in the RCA Service Company. Mr. Wlasuk was a Navy Electronics officer during the war. He won the RCA Award of Merit in 1953.



**ROBERT E. BENWAY**—Mr. Benway is a graduate of the University of Wisconsin with a B.S. in E.E. Degree in 1950. He joined RCA after graduation and has worked in the Cathode Ray Design Laboratory. His work includes product development and advanced development of Color Tubes. Mr. Benway is a Member of the IRE.



# GUN DEVELOPMENT OF THE RCA-21AXP22 COLOR KINESCOPE

*by* **ROBERT E. BENWAY**
*and* **RICHARD H. HUGHES**
*Color Tube Engineering*
*Tube Division*
*Lancaster, Pa.*

**RICHARD H. HUGHES**—Mr. Hughes is a graduate of the University of Kentucky in 1939 with a B.S. in E.E. degree. He worked on Cathode Ray, Power and Pickup Tube Process Development for several years. Since 1951, Mr. Hughes has been engaged in the design of Black & White and Color Projection Tubes—and "Direct-View" Color Tubes.

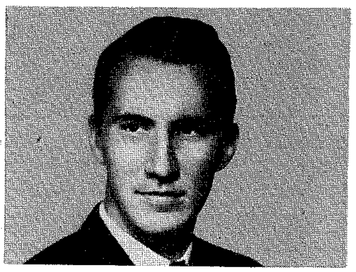


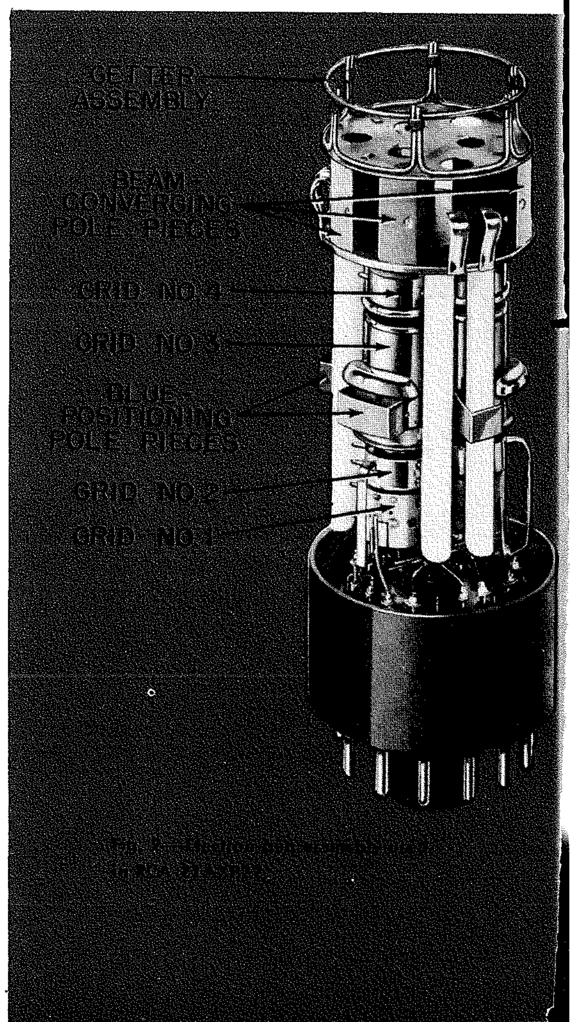
Fig. 1 — RCA-21AXP22 three-gun, shadow-mask, metal-envelope color kinescope.

THE RCA-21AXP22 direct-view, metal-envelope color kinescope, shown in Fig. 1, utilizes three newly developed electrostatic-focus guns to provide separate electron beams for excitation of the three different phosphor arrays on the viewing screen. Each gun includes a separate indirectly heated cathode, a grid No. 1 (control electrode), a grid No. 2 (accelerating electrode), a grid No. 3 (focusing electrode), and a grid No. 4 which is connected to the ultor. A photograph of the electron-gun assembly is shown in Fig. 2.

The broad objectives of the electron-gun development program for the 21-inch color kinescope were based on previous experience with the magnetic-convergence, electrostatic-focus guns used in the RCA-15GP22 15-inch color kinescope. Briefly, these objectives were as follows:

1. to shorten tube length by one to 1½ inches;
2. to provide proper convergence with the shorter gun;
3. to reduce beam diameter at the deflection plane;
4. to achieve resolution equal to or better than that obtained with the longer guns used in earlier color kinescopes;
5. to improve mechanical accuracy and strength;
6. to eliminate shift of gun parts during tube warmup;
7. to reduce the change in focus (grid-No. 3) voltage for optimum focus from low drive to high drive on the grid No. 1.

This paper describes the methods by which these objectives were attained and the over-all performance achieved with the RCA-21AXP22.



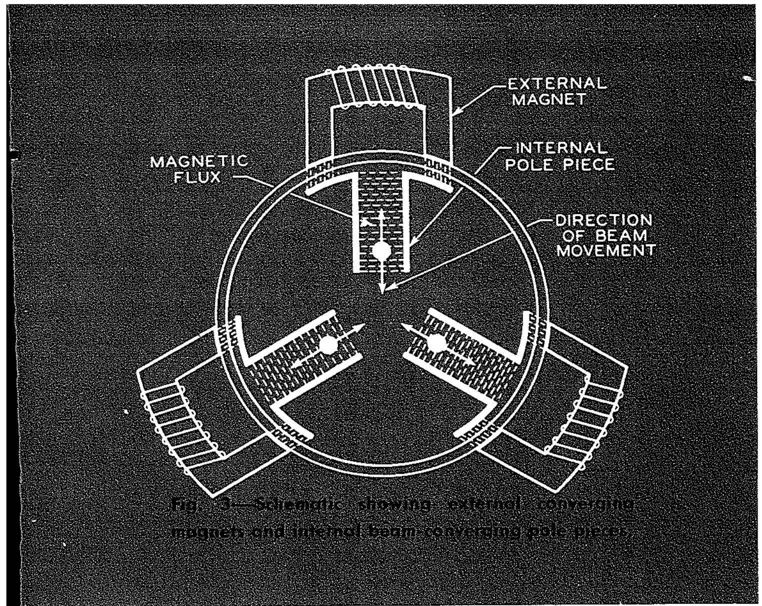


Fig. 3—Schematic showing external converging magnets and internal beam-converging pole pieces.

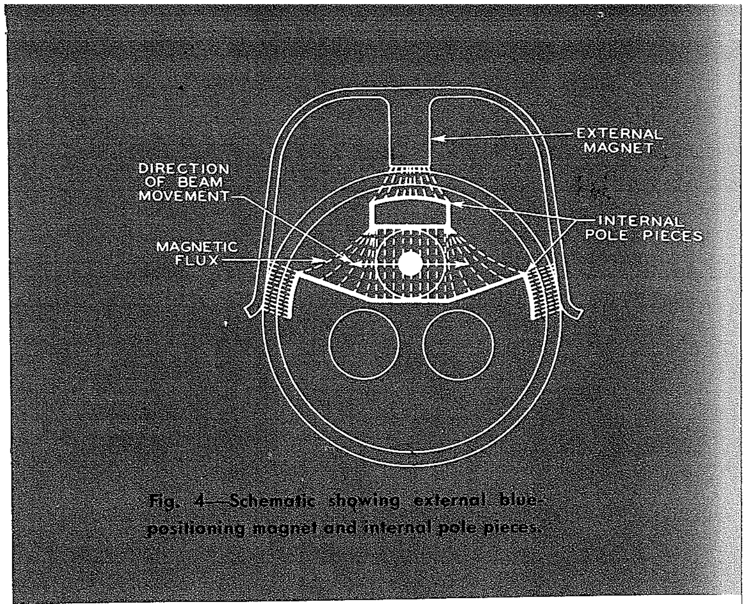


Fig. 4—Schematic showing external blue-positioning magnet and internal pole pieces.

#### SHORT GUN

It is advantageous to utilize as short an electron-gun structure as possible to provide a short picture-tube length and thus permit a small cabinet size for the television set. When the dimensions of the gun are reduced, however, careful consideration must be given to the electron optics to provide optimum conditions for tube operation. The length of the 21AXP22 gun is 1⅜ inches shorter than that of the 15GP22 gun and permits an over-all tube length of 25⁵⁄₁₆ inches. This length is not much larger than that of popular 21-inch black-and-white kinescopes.

#### BEAM CONVERGENCE

Convergence refers to the control of the three beams to activate a given phosphor-dot trio on the viewing screen. Lack of convergence results in color fringing, or a condition similar to lack of register in color printing. In three-beam color tubes, the relative angles of the three beams are altered or varied slightly to maintain convergence as the beams scan the screen. Proper convergence becomes much more difficult as the deflection angle is increased or as the beam spacings in the deflecting yoke are increased.

At relatively small deflection angles, such as those used in the 15-GP22, design features may be incorporated in the deflecting yoke to reduce the effect of varying convergence displacements of the three beams. In such tubes, therefore, a single convergence lens may be used for all three beams. This method of convergence has not proved feasible at larger deflection angles. The use of reduced spacing between beams to minimize the effects of varying beam displacements is also undesirable because this method would require a reduction in the diameter of all the holes in the shadow mask and would cause a substantial reduction in light output.

The three electrostatic-focus guns of the 21AXP22 are spaced 120 degrees apart and are positioned so that their respective electron beams converge at the spherical shadow mask of the tube. The angle at which each of the three beams approaches the shadow mask determines the particular color of phosphor dots which it will energize. Convergence of the beams is controlled by means of magnets which provide for radial motion of all three beams and tangential motion of the blue beam. Individual convergence control on each beam is provided by three external magnets mounted on the neck of the tube, as shown in Fig. 3. The magnetic flux from the magnets is coupled through the glass neck to the internal beam-converging pole pieces. Adjustment of the strength of the magnetic flux between the pair of pole pieces associated with each beam changes the convergence angle of the beam. By means of these adjustments, the three beams can be kept in convergence at all deflection angles.

The converging action of the three external magnets shown in Fig. 3 is supplemented by a fourth magnet which permits shifting of the lateral (tangential) position of the blue beam. As shown in Fig. 4, this magnet provides magnetic flux which is coupled through the neck of the tube to a pair of blue-positioning pole pieces. The relative placement of components on the neck of the 21-AXP22 is shown in Fig. 5.

#### BEAM DIAMETER

The use of a small beam diameter in the deflection plane increases the efficiency of the screen unit and permits a wider tolerance on the landing accuracy of the electron spot with regard to the phosphor dot. The efficiency of the screen can be expressed as the product of a constant K and the quantity $(\sqrt{3} - D/S)^2$, where D is the beam diameter in the deflection plane and S is the offset of the beam from the tube axis in the deflection plane. A reduction in the value of D, therefore, results in greater screen efficiency and more light output for the same beam current.

Although the same desirable effects could be obtained by an increase in the value of S, the beam-to-axis spacing in the deflection plane, this value is limited by the physical size of the gun in the neck of the tube and by the misconvergence at the screen which would result from the deflection of three widely separated beams in the yoke. As the beam spacings in the yoke are increased, it becomes more difficult to maintain convergence of the three beams over the entire screen. The optimum value of S, therefore, is determined by considerations of circuit complexity, components, and maximum allowable misconvergence of the three beams at the screen.

The effect of beam diameter in the deflection plane, D, on screen toler-

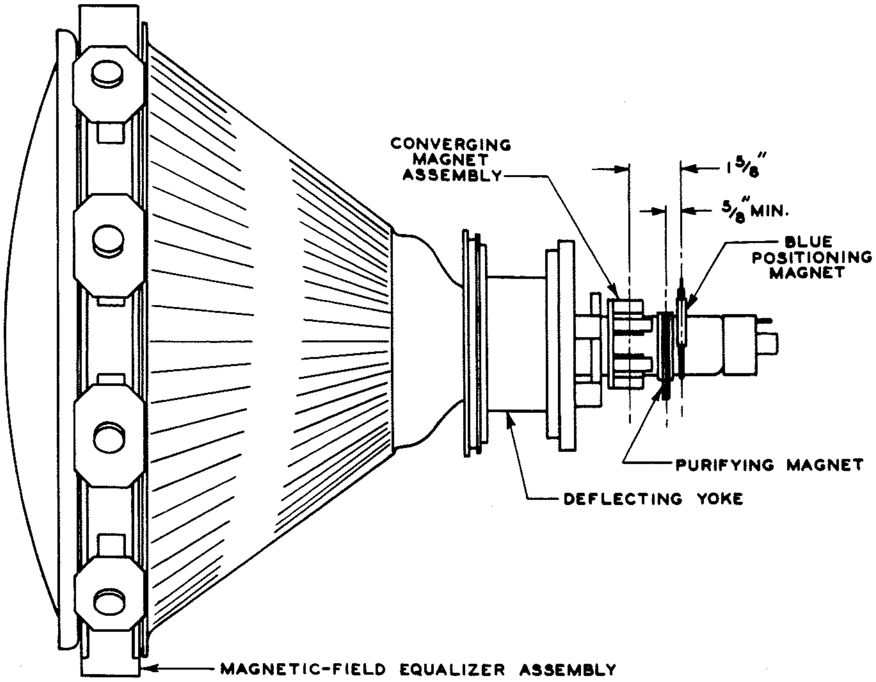



Fig. 5—Sketch showing relative placement of components on neck of 21AXP22.

ance may be visualized if the apertures of the shadow mask are considered to be pin-hole cameras which form images of the beam on the phosphor screen. The size of the images depends upon the size of the beam in the deflecting plane of the yoke. The register of the electron spot, therefore, is less critical when an image having a smaller diameter is obtained. The beam diameter in the deflection plane of the electrostatic-focus guns used in the 21AXP22 is 0.050-inch, as compared with 0.110-inch for the long guns used in 15-inch color kinescopes. This small beam diameter permits an increase of 0.002-inch in the allowable tolerance for registration of the 0.010-inch-diameter apertures in the shadow mask with the 0.016-inch-diameter phosphor dots on the screen. In the 21AXP22, a projected spot having a diameter of 0.012-inch is registered with a 0.016-inch phosphor dot.

#### RESOLUTION

Resolution equivalent to or better than that obtained with the long gun used in the 15-inch color kinescope is provided in the 21AXP22 by special design features incorporated in the prefocusing section of the short gun. Fig. 6 shows this portion of the new short gun, together with that of the 15GP22 long gun, including the cathode electron-emitting surface, the grid No. 1 (control grid), the grid No. 2 (screen grid or accelerating grid), and grid No. 3 (prefocusing and final focus grid). In the short gun, shown in Fig. 6(a), the prefocus section of the gun acts as a converging lens and determines the solid angle, $\alpha$, of the beam as it leaves the cross-over region and approaches the final focus lens formed between grids No. 3 and No. 4. In normal operation, the final focus lens, which is a strong converging field, is adjusted to focus an image of the beam cross-over on the viewing screen, as shown in Fig. 7. The combined converging effect of the prefocus and the final focus lens fields, which are both converging types, can be assigned to an equivalent effective lens located between the two lenses. The distances from the effective lens plane to the screen and to the cross-over are factors in the determination of the magnification of the resulting spot.

In general, magnification is reduced and resolution is increased as the prefocus lens is weakened and the gun is lengthened. However, because both of these changes increase the diameter of the beam leaving the gun, they are undesirable from the standpoint of final-focus-lens aberrations, deflection defocusing, and small depth of focus field. As previously mentioned, an increased beam diameter also requires more critical register of phosphor dots and shadow-mask holes. The optimum strength of the prefocus lens for the desired balance between beam diameter and resolution was determined by adjustment of the spacing between grid No. 2 and grid No. 3 and variation of the lower-aperture diameter on grid No. 3.

In the long gun used in the 15-GP22, shown in Fig. 6(b), the prefocus lens is formed by the curved electrostatic field which extends downward from grid No. 3 into the cup-shaped grid No. 2 and partly through the grid No. 2 aperture. After the electron beam passes the first cross-over point, it diverges at a very wide angle. The function of the converging prefocus lens is to reduce this solid beam angle to a reasonable value, as indicated by $\theta$ in Fig. 6(b). The thickness (approximately 1/4-inch) of the prefocus lens of the cup type appears to allow the beam to become overly large. The effectively thinner lens used in the 21AXP22 provides a smaller beam diameter

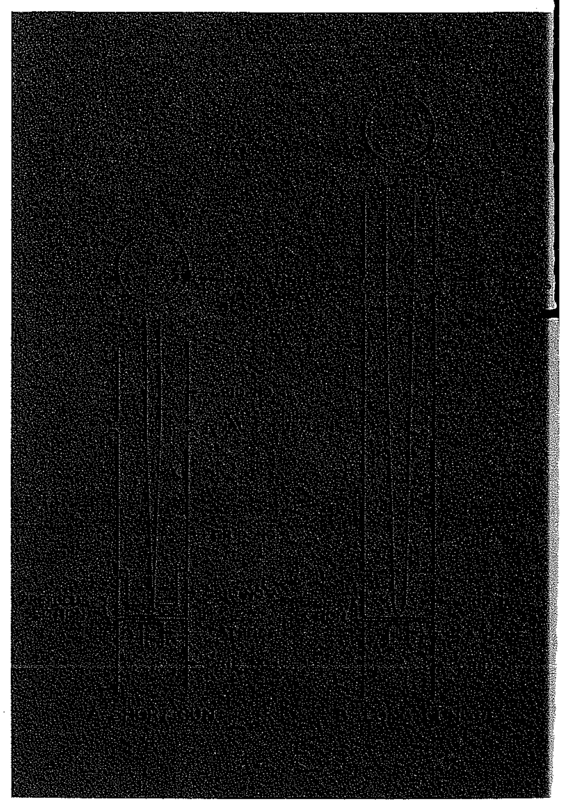


Fig. 6—Sketch of short and long electron guns showing prefocus section and final focus lens.

without changing the beam divergence angle and thereby impairing resolution.

Because the gun used in the 21-AXP22 has a short grid No. 3, the focus voltage required is lower than that for the long gun. The combination of the particular aperture spacing, the short prefocus lens space, and the low voltage gradient makes it possible to use a very small beam size and still maintain good resolution. The lower focus voltage also reduces base and socket insulation requirements, permitting an inexpensive black phenolic base to be used on the 21AXP22.

Fig. 8 shows the relative resolution produced by the long and the short guns in terms of spot size on the screen at different beam currents. Although it is not feasible to apply focus modulation to maintain optimum focus at the different values of beam current required in a normal picture, the short gun maintains nearly optimum focus from low-lights to high-lights in the picture when it is used at a fixed value of focus voltage.

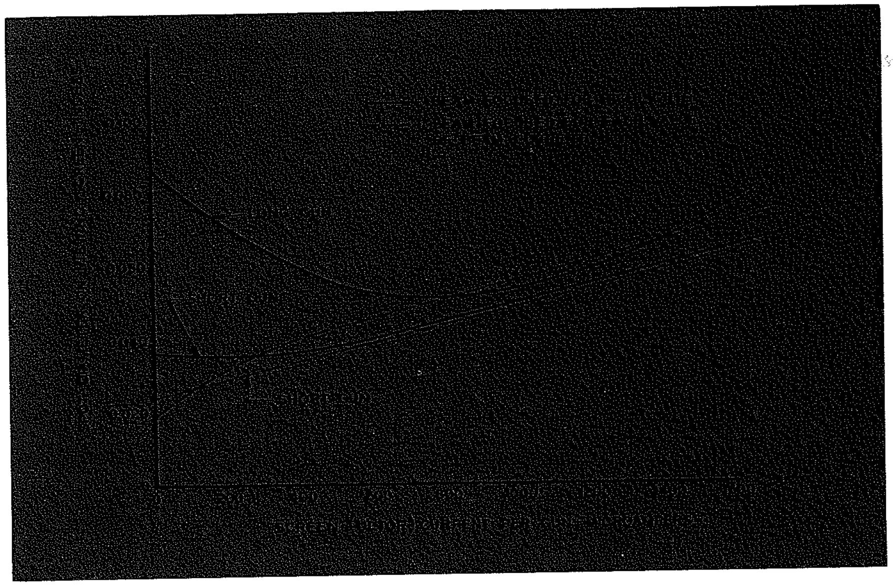


Fig. 8—Relative resolution of short and long electron guns in terms of spot size on screen at different beam currents.

**MECHANICAL ASPECTS**

The use of a short electron-gun structure is advantageous from the standpoint of mechanical accuracy and strength because the short axial distance between the support members of the gun permits improved alignment of the electron beam in the various lenses, apertures, and cylinders.

In early gun designs, some shift of beam convergence was experienced during tube warmup. Investigation revealed that the spacing of 120 degrees between the two insulating glass support beads made it possible for expansion of grids No. 1 and No. 2 to shift the apertures of grids Nos. 1, 2, and 3 with respect to each other. This shift causes a change in the lens structure which, in turn, changes convergence. Ideally, the two beads should be located 180 degrees apart so that heat expansion of gun parts would not change the alignment of the individual lenses of the gun. Although a distance of 160 degrees is used in the 21AXP22 because of structural limitations, convergence shift during tube warmup has been negligible.

**ACKNOWLEDGMENT**

The authors wish to acknowledge the valuable contributions of D. L. Prosser, J. Crisfield, and W. H. Wood and the guidance of Dr. R. B. Janes throughout this gun-development program.

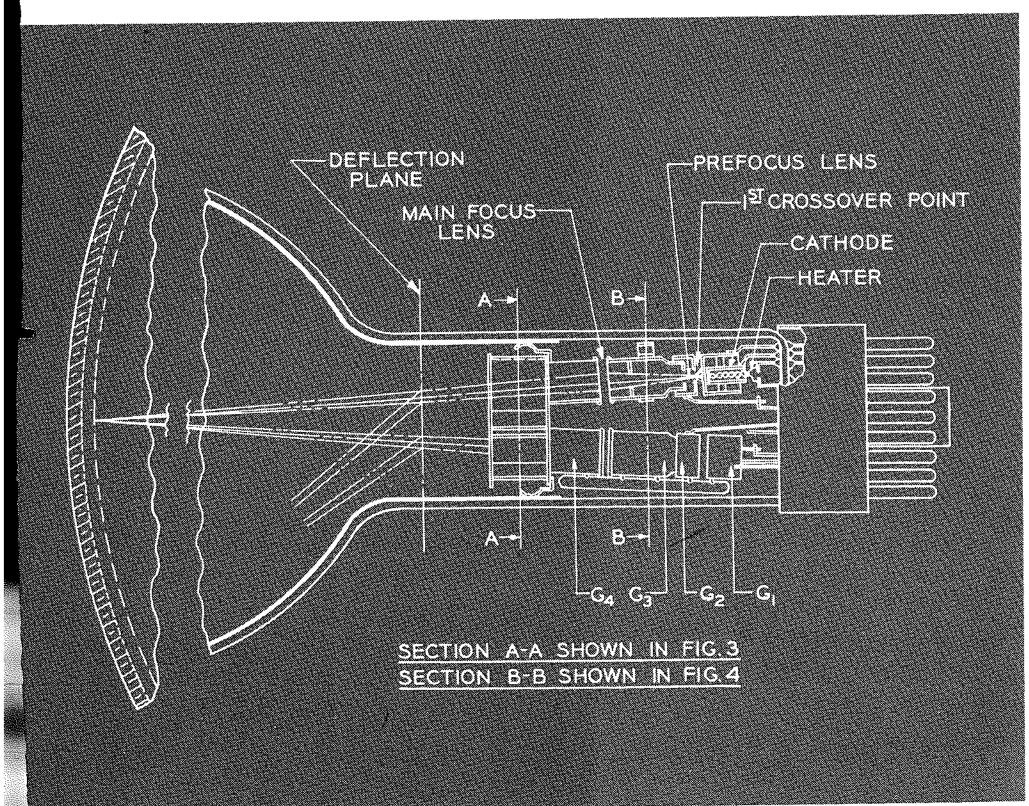



Fig. 7—Sketch illustrating effect of converging forces to produce final spot on screen of 21AXP22.

# THE GENERATION OF ELECTRICITY DIRECTLY

*by*

**E. G. LINDER, P. RAPPAPORT, and J. J. LOFERSKI**

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THE DIRECT conversion of radiation into electricity has recently attracted considerable attention. The types of radiation which are of concern include charged particle types such as electrons or beta rays, alpha rays, etc., and also uncharged types such as electromagnetic radiation in the form of light, X-rays, gamma rays, etc. However, radio waves are not included since the methods to be described are not generally workable with such radiation. At the present time, judging from available publications and reports, about a dozen research organizations have active projects in this direct conversion field. It appears that the immediate interest lies in the possible application of such a process to produce simple, compact and long-life power sources. As will be made clear later, only low power sources seem to be practical at the present time, the range of power extending from microwatts to milliwatts generally speaking. The field of large power generation cannot be considered as feasible now, although the basic principles which are under study may eventually be extended into this region.

The present article will summarize the various methods of direct conversion, by which is meant a one-step process of converting radiation into electrical energy. Some of the more interesting and promising methods will be given specific attention and those which have been studied especially at the RCA Laboratories will be described in greater detail.

### SOME SIGNIFICANT FACTS ABOUT RADIATION

Consider first the power available from radiation. Although at the present time the atomic converter or battery is limited to the microwatt region, and the solar converter to the milliwatt range, it is of interest to estimate the eventual potentialities.

The grand total of primary power available from radioisotopes is limited by the supply of fission products produced mainly as by-products of nuclear reactors. It has been estimated that if all the present electrical power consumed in the United States were produced by nuclear reactors, the annual output of radioactive waste would be sufficient for the production of radioactive power at the rate of 400,000,000 watts, which represents only a few hundredths of 1% of the energy consumed in the country. It is estimated also that by 1965 the U.S. output of fission products should be 6 x $10^6$ grams. This would correspond to 3 x $10^{10}$ curies, which would have a heat power level of 6 x $10^6$ watts at age of one year. However, only a small fraction of this total power would be convertible to electricity by direct processes. It is evident from these estimates that fission products cannot be considered as a possible principal source of power; in fact, their availability in large quantities is contingent upon the use of reactors as the principal source of commercial electric power. They should be considered rather as a possible auxiliary source of considerable magnitude, with a possible future maximum roughly equivalent to that now produced by chemical batteries.

On the other hand, the primary power available from solar radiation is much greater. It amounts to about 100 w/ft². Thus over an area of 60,000 square feet (or less than that of a square city block), the power from the sun is equal to that estimated for fission products in 1965. Sunlight however is intermittent and dependent on weather, and thus for

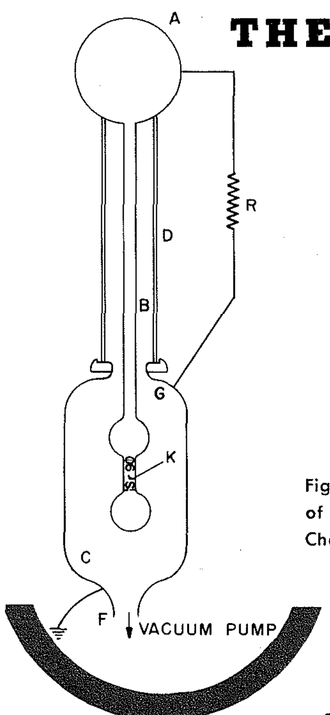



Fig. 1—Direct Charging, Vacuum Type of Nuclear Converter.

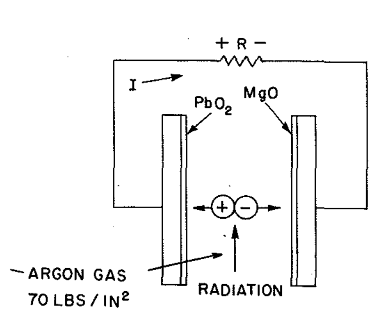
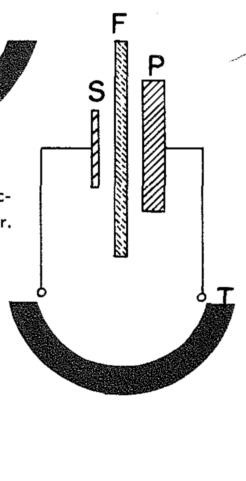



Fig. 2—Schematic Diagram of Dielectric Type of Direct Charging Converter.



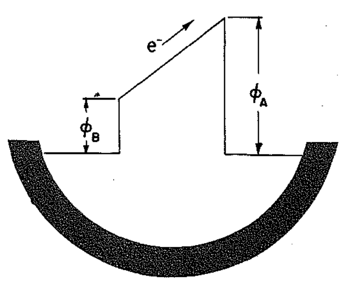




Fig. 3—Diagram of Contact Potential Device (Top). Relation Between Work Functions of Surfaces and Interelectrode Field (Bottom).

# FROM RADIATION

many applications would require an auxiliary storage battery.

### THE PRINCIPAL DIRECT CONVERSION METHODS

The processes of direct conversion may be classified into four categories:

(1) Direct charging methods,
(2) Contact potential methods,
(3) Thermocouple methods,
(4) Semiconductor junction methods.

### DIRECT CHARGING METHOD

Early work on the direct charging type of device was done by Linder and Christian and was published in several papers in 1947 and 1948. A sketch of their apparatus is shown in Fig. 1. The radioactive material which was strontium-yttrium 90 was contained in electrode K. This was connected by a supporting shaft B to the high-voltage terminal A. K was surrounded by a collector C. The high-voltage insulator D, separates and insulates the two terminals A and C. The collector C was evacuated so that negatively charged beta rays or electrons passed from K to C leaving a positive charge on K and charging C negatively. This type of device is essentially a self-charging condenser. Using 250 millicuries of radioactive material, a voltage of about 365,000 volts was generated. The power generated was 0.2 milliwatts at an efficiency of 20%.

Fig. 2 shows a second type of direct charging device. In 1953 papers on this appeared by P. Rappaport and E. G. Linder. The device consists of three principal parts; a radioactive source S, a dielectric film F, and a metal collector P. The dielectric film acts as an insulator between the electrodes S and P. It is penetrable by beta rays but is a good insulator for current due to low-energy carriers. This device can produce several thousand volts; for example using 50 millicuries of Sr-Y90 it was shown that 6600 volts could be generated. The current and the impedance depend upon the amount of radioactive material used. However the use of large amounts is unfeasible due to the present high cost of such materials. Hence all direct charging devices are now limited in their usefulness by low current and high impedance.

### CONTACT POTENTIAL METHODS

The second conversion method to be discussed is the contact potential method. The basic principle is illustrated in Fig. 3. Here are shown two electrodes of dissimilar metals or surfaces, between which there is enclosed an atmosphere of gas, for example argon. Radiation of any type having sufficient energy to ionize the gas produces carrier pairs. These are acted upon by the field due to the contact potential difference of the metal surfaces, the positive ions flowing in one direction and the negative electrons in the opposite. This produces an electric current which may pass through an external load R, and do useful work. This particular device has an especially low efficiency due mainly to the small absorption coefficient of gases for radioactive radiation, and the high ionization energy for gases (about 30 ev) as compared to semiconductors (about 3 ev). However, the efficiency may be improved by using low-energy radiation or gas under pressure.

### THERMOCOUPLE METHOD

The third or thermocouple method converts radiant energy directly to heat and this in turn to electricity by means of the thermoelectric effect. If the absorption of the radiation is complete, and in practice it could be made nearly so, the efficiency of the method would be that of the thermojunction. Since the efficiency increases with junction temperature difference, it will in general be low for low power inputs. A thermocouple device of this type using polonium 210 has been studied by K. C. Jordan and J. H. Birden, of the A.E.C. Mound Laboratory. With 146 curies the electrical power delivered to a load was 0.2 percent of the power developed as heat. The maximum power delivered was 9.4 milliwatts. Using solar radiation, efficiencies of about 1.0 percent have been attained, and by using concentrating reflectors or lenses, it is estimated that an efficiency of about 5 percent would be possible.

The thermocouple method has not gotten as much attention as the two previous methods, but is clearly a simple, rugged and long-life process. Furthermore, the application of modern solid-state theory and experience towards the improvement of thermocouples would likely prove to be profitable. It appears that this method is worthy of further study.

### SEMICONDUCTOR JUNCTION METHOD

The fourth or semiconductor method is one in which there has been much recent interest. No doubt the most familiar example is the selenium photovoltaic cell used in photographic exposure meters. However important improvements have been made during the past few years, and the principle has been extended to other types of radiation than light. For example, the use of such devices with electrons or beta radiation was described by P. Rappaport in 1954. The recent versions of this method employ a p-n junction similar to those used in transistors and made of materials such as silicon, or germanium. They may be energized by radiation of either the charged particle or uncharged electromagnetic type. By a simple process utilizing the internal potential difference the radiation energy is converted directly into electrical energy. When light is used the process is called the photovoltaic effect, and when electrons are used it is termed the electron voltaic effect.

The construction of this device is shown schematically in Fig. 4. The junction itself, may consist of, for

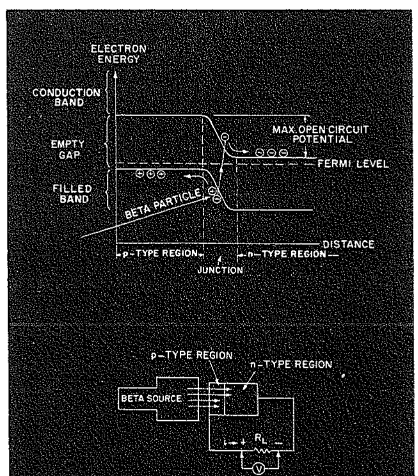



Fig. 4—Energy Levels in a p-n Junction Showing Motion of Carrier Pairs (Top). Schematic Diagram of Semiconductor Type Converter and Circuit (Bottom).

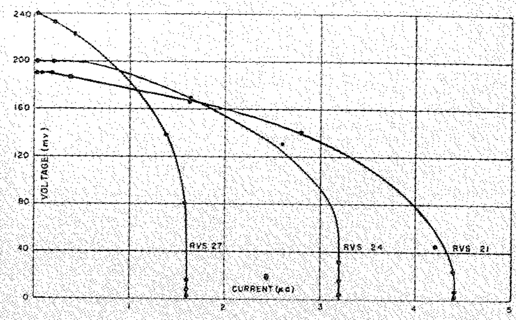



Fig. 5—Current-Voltage Curves for Silicon Units Activated by Beta Radiation.

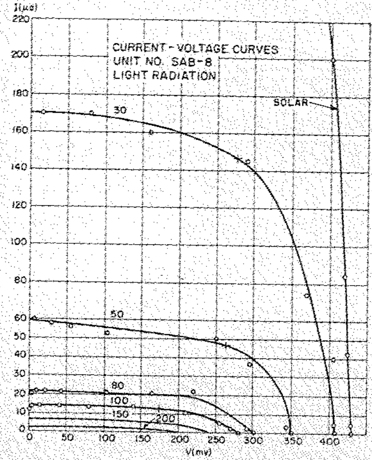



Fig 6—Current-Voltage Curves for Silicon Units Activated by Light.

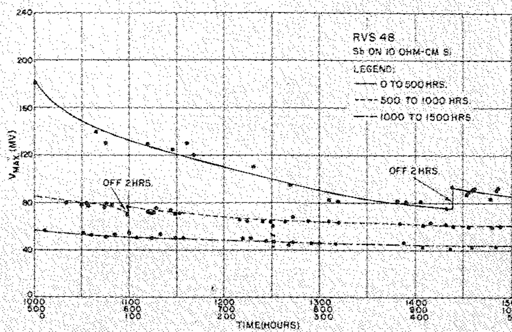



Fig. 7—Life Test Showing Radiation Damage Due to Beta Radiation from Sr-Y90.

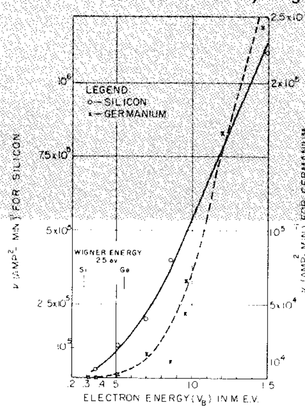



Fig. 8—A function of the Probability of Atomic Displacement vs. Bombarding Electron Energy for Si and Ge.

example silicon, with p-type on the left and n-type on the right. A lead is connected to each of these regions by means of an ohmic contact. These leads in turn are connected to a load resistance $R_L$. To the left of the junction is shown a source of any type of ionizing radiation.

At the top of the figure the internal conversion process is illustrated. Here are shown the energy levels in the p-region, the n-region, and in the intermediate region, in which the junction occurs. Each of these regions contains a filled band, a forbidden band or empty gap, and a conduction band. As shown there is an electric field in the region of the junction. Incident ionizing radiation creates free carrier pairs, the electrons being raised into the conduction band, and the holes remaining in the filled band. These carriers diffuse to the junction where they are then acted upon by the junction electric field, so that the electrons move to the right and the positively charged holes to the left. Thus an electric current is created due to the motion of these charged particles. This current then may flow into an external circuit and do useful work. Experimental current-voltage curves are given in Figs. 5 and 6. The former is for operation with beta rays, the latter for operation with light. The semiconductor units in both cases are essentially the same.

This type of semiconductor device has an important characteristic which enables it to overcome an outstanding disadvantage of the direct charging types of devices, which was pointed out previously, namely that of having a small current and high internal impedance. These disadvantages are overcome by high current multiplication in the semiconductor. In other words, each beta particle that penetrates the semiconductor material will produce on the average about 200,000 new electrons, assuming that radiation from strontium-yttrium 90 is being used. This increases the output current by a similar factor and reduces the internal impedance by the same factor. In the case of light operation this multiplication does not exist, but the same net result is obtained because of the high light intensity available.

**RADIATION DAMAGE IN SEMICONDUCTOR TYPES**

On the other hand, this semiconductor type of converter is susceptible to radiation damage when used with radioactive material of certain types. If the incident radiation is sufficiently energetic it may damage the structure of the crystal by knocking atoms out of their equilibrium lattice positions. This atomic displacement results in a deterioration of the device and a decrease in efficiency and output. An example of this is illustrated in Fig 7, which shows the results of a 1,500 hour test on a unit using beta rays from strontium-yttrium 90. It is seen that the voltage drops rapidly at the beginning, but it is almost stabilized at the end of 1,500 hours. However, during that interval, the output voltage has dropped from 180 millivolts to about 50.

Fortunately there appear to be remedies for atomic displacement damage. As has been said the damage is a function of the quantum energy of the radiation. The radiation from strontium-yttrium 90 which was used in the test just described, is quite energetic, the average quantum energy being about 1,000,000 electron volts. It has been found that if the energy of the radiation is decreased, the damage decreases rapidly and a threshold energy can be found below which damage does not seem to exist. This effect is illustrated in Fig. 8. Here a function related to the probability of atomic displacement is plotted against quantum energy. It is seen that the probability drops very rapidly and appears to approach zero at about 0.325 mev for Ge and 0.145 mev for Si (as shown by recent data not included in Fig. 8). Thus by using radiation whose quantum energy does not exceed the threshhold value, it may be possible to construct semiconductor converters whose life is not limited by this type of radiation damage. Of course damage of the atomic displacement type does not occur with operation by visible light, because of its very small quantum energy. It should be mentioned that there is also the possibility of other types of radiation damage such as surface chemical effects, but these are thought to be of minor importance.



**ERNEST G. LINDER** was born in Waltham, Massachusetts. He was awarded the Ph.D. degree by Cornell University in 1931, and the M.S. and B.A. by the University of Iowa in 1927 and 1925 respectively. He served as instructor at the California Institute of Technology 1927-28, was Detroit Edison Research Associate at Cornell 1928-31, was a member of the Research Division of the RCA Manufacturing Company 1932-41, and has been with the RCA Laboratories since 1941. Dr. Linder has research experience, publications and patents in the fields of thermoelectricity, photoelectricity, crystals, electrical discharges in gases, mass-spectrography, microwave tubes, microwave propagation, electron physics, radar, semiconductors, nuclear and solar batteries. He is a member of the American Physical Society, Sigma Xi, and a Fellow of the Institute of Radio Engineers.

**PAUL RAPPAPORT** studied Chemistry at Temple University for three years before entering the U. S. Navy in 1944. Mr. Rappaport spent two years in the Naval Service as an electronic technician working on radar and counter measures, and nine months as an instrumentation physicist with the Naval Air Experimental Station in Philadelphia. As a civilian, he entered Carnegie Institute of Technology, and received a B.S. in physics in 1948 and an M.S. in physics in 1949. Mr. Rappaport joined RCA Laboratories in 1949, where he has worked on secondary electron emitting surfaces, radioactive materials in electronics, and the use of semiconductors in conjunction with radioactive materials. He is a member of the American Physical Society, Pi Mu Epsilon and Sigma Xi.

**JOSEPH J. LOFERSKI** was born in Hudson, Pennsylvania on August 7, 1925. He served with the U. S. Army for 27 months. He received a B.S. degree from the University of Scranton in 1948, M.S. and Ph.D. in Physics from the University of Pennsylvania in 1949 and 1953 respectively. He was a Research Associate at the University of Pennsylvania during 1952-1953. He joined RCA Laboratories Division in July 1953, where he has been engaged in research on semiconductor radiation convertors. Dr. Loferski is a member of Sigma Xi, American Physical Society, American Association of Physics Teachers and A.A.A.S.

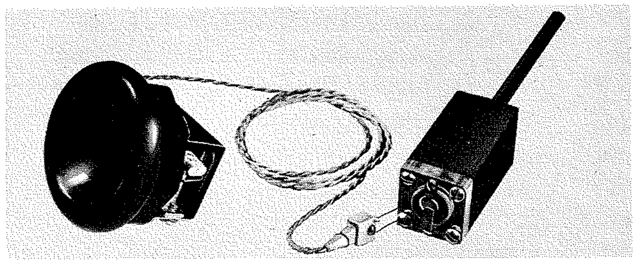


Fig. 9—Experimental Transistorized Audio Oscillator (Left) Powered by Nuclear Battery (Right).

The efficiency of the best Sr-Y90 units is about 3% and the power output of the one-fourth inch diameter units is 1.6 microwatts. If such a unit is used as a solar converter the efficiency is about 6% and the output would be 1.8 milliwatts. Calculations indicate that the performance of a nuclear converter would substantially equal that of a solar converter if operated at the same power input level, but the cost of radioactive material prohibits this at the present time.

#### EXPERIMENTAL EXAMPLES

As an example of an experimental application of a p-n junction type of unit, Fig. 9 shows a transistorized audio oscillator powered by a single silicon junction about one-fourth inch in diameter and ten mils thick, which delivered about one microwatt of power.

A second example is shown in Fig. 10, which illustrates a simple transistorized broadcast receiver operated by a light-battery. The battery comprised twelve silicon p-n junction units mounted in a Lucite case. It was capable of operating the receiver with average room light. The receiver was designed for local reception and its sensitivity was such as to receive local New York stations in New York City using a built-in antenna.

The future usefulness of both the nuclear and solar types of converter depends upon the solution of several problems which have been mentioned in this discussion. These include the high cost of radioactive material, radiation damage, radiation shielding, and low efficiency for nuclear batteries, and large-area junctions and a storage device for solar converters. The difficulties of the nuclear converter could be largely solved by the appearance of a low quantum energy material of low cost and suitable half life. This would eliminate the problems of cost, damage, shielding, and efficiency. Nickel-63 is a possibility if its cost could be drastically reduced. However, none of the existing problems appear to involve any basic difficulties for either the nuclear or solar type of cell. They are such as, in other fields, have yielded to intensive research, and there is hope that they will do so here.

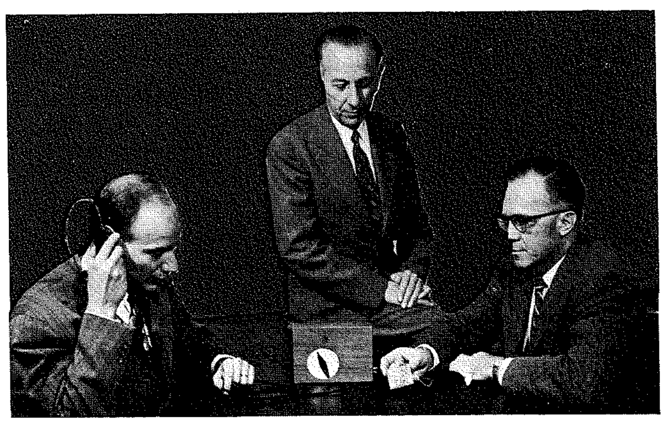


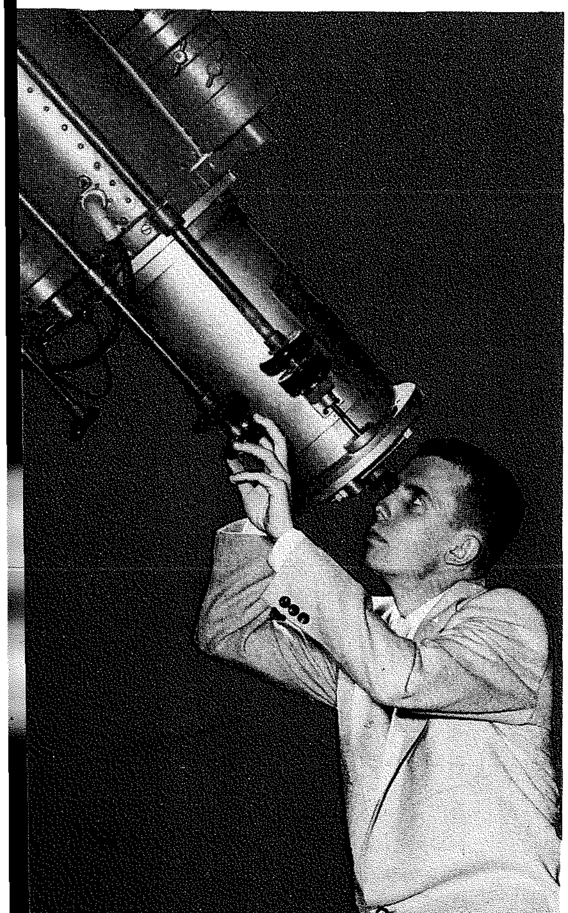
Fig. 10—Simple Transistorized Broadcast Receiver Designed by L. E. Barton (center) is Demonstrated by P. Rappaport (Left) and E. G. Linder (Right), Using a Light Converter for Power.

# THREE-POINT 1955-56 EDUCATIONAL AID

RCA's overall educational program for 1955-56 is underway with the continuation of scholarship and fellowship plans. The complete program consists of a three-point program which consists of:

(1) RCA Tuition Loan and Refund Plan for Employees
(2) RCA Scholarships for College Student Undergraduates and RCA Fellowships for Predoctoral Graduate Students
(3) RCA Fellowships for RCA Engineers and Scientists

This comprehensive program has two primary purposes; one to train RCA employees so they will be qualified for advancement, and the other to provide financial assistance to students presently enrolled in colleges and universities. A brief description follows of the three-point program mentioned above.



Emerson Martin, Jr., of Kokomo, Ind. is one of a number receiving RCA Scholarships for the current school year. Mr. Martin, shown here at the telescope of Indiana University Kirkwood Observatory, received an A.B. degree in Mathematics in June. He plans to return to Indiana in the fall to work on an advanced degree.

#### TUITION LOAN AND REFUND PLAN

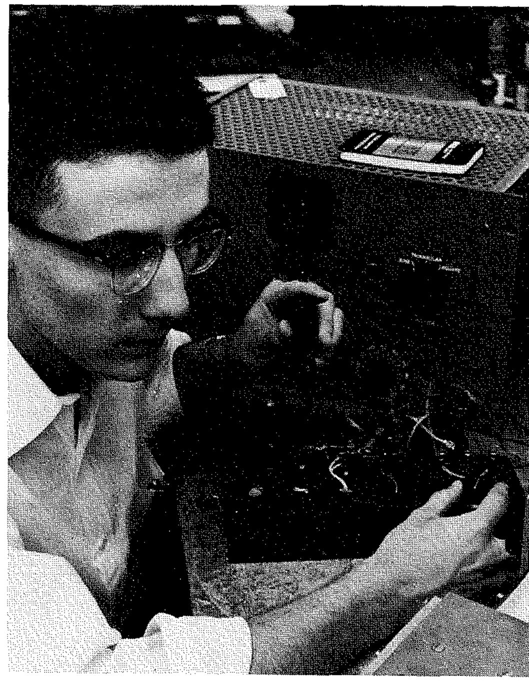
This is an extension of the present plan whereby RCA employees are permitted to add to their education by completing selected courses. Employees are reimbursed for the full cost of courses upon completion. During 1954, $141,000 was invested in the reimbursement of more than 1500 employees who completed courses at various colleges and universities.

In appreciation for the cooperation of over 60 colleges and universities where RCA employees have furthered their education during the 1954-55 academic year, the Corporation has made grants of up to $2,500 to each institution. Colleges and universities which have received the gifts are located in the following states: California, Delaware, Florida, Georgia, Illinois, Indiana, Louisiana, Michigan, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee and Texas, as well as the District of Columbia.

#### RCA SCHOLARSHIP AND FELLOWSHIP PLAN

With the scholastic year 1955-56, RCA begins its eleventh year during which it has supported a scholarship-fellowship plan. At the end of World War II, a real need was anticipated for men and women trained in the field of electronics to carry wartime developments into peacetime commercial applications. To implement this, RCA inaugurated the scholarship plan in 1945 and extended it to include graduate fellowships in 1947.

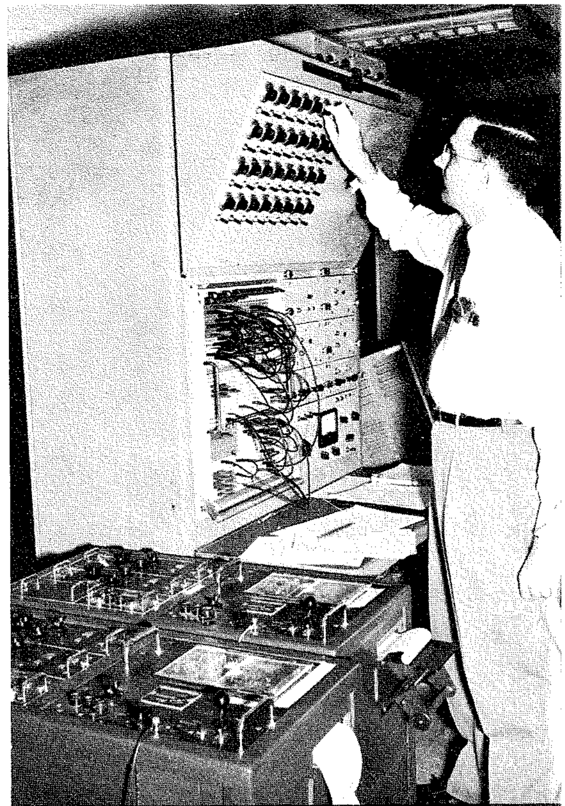
During 1955-56 the Corporation will award 33 RCA Scholarships to undergraduates and 20 RCA Fellowships to "pre-doctorates." These scholarships and fellowships are established in all classes of colleges and universities, and are valued at $96,400. Since 1945, RCA Scholarships and Fellowships have aided 193 individuals in the completion of their studies. The objective of RCA's Scholarship Plan is to encourage the training of new scientific personnel for the growing requirements of electronics.



James S. Meditch, RCA Scholar is shown here adjusting an electronic pen recorder in the E.E. laboratory at Purdue University. Mr. Meditch is a student in Electrical Engineering.

The grants for RCA Scholarships are $800 and for RCA Fellowships, $3,500. Of the amount allocated for a fellowship, the student receives $2,100 to help defer living expenses, $650 is paid toward tuition, and $750 is an undesignated gift to the university attended by the RCA Fellow. The RCA Scholarships and Fellowships awarded at the various institutions are *administered directly by the various colleges or universities.* The institutions set up the requirements for the awards and select the recipients.

# PROGRAM UNDERWAY



W. A. Curtin of Engineering Products is shown in Laboratories at Moorestown, N. J. He is setting up a test problem to be run on the Electronic Analog Computer. Shown at left is recording oscillograph equipment. Mr. Curtin is one of the six RCA engineers who were awarded fellowships. Mr. Curtin, who also studied under a scholarship during the past year, will continue graduate work in Electrical Engineering at Massachusetts Institute of Technology.

**RCA SCHOLARSHIPS**

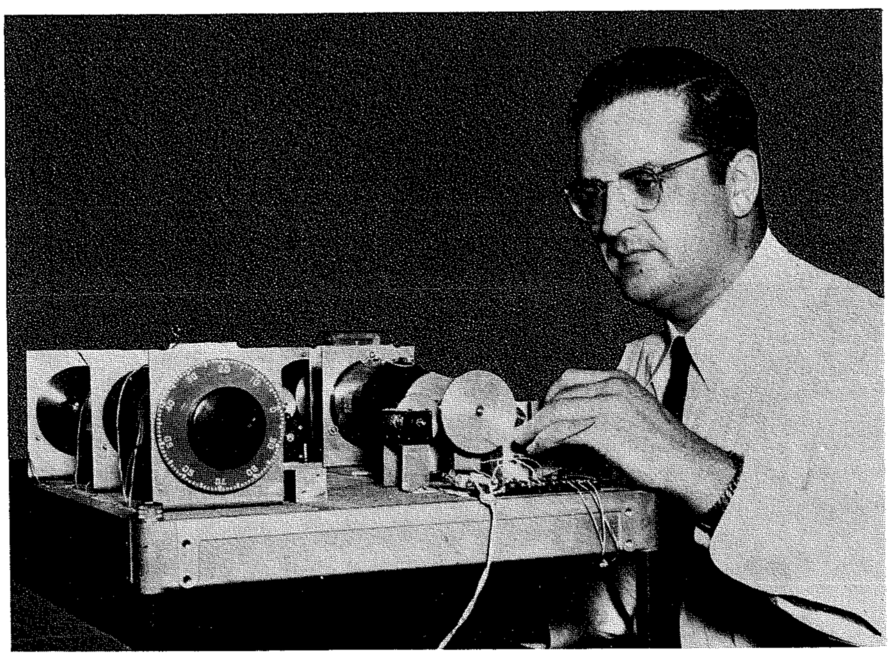
The 33 Scholarships, each providing grants of $800, to be awarded during 1955-56 will be apportioned as follows:

Twenty-eight scholarships for undergraduate students in the field of science, unless otherwise indicated, at: California Institute of Technology, Carnegie Institute of Technology (dramatic arts), University of Cincinnati, Columbia University, University of Florida, Franklin and Marshall College, Harvard University, Howard University, Indiana University, Iowa State College (science and dramatic arts), University of Kansas, University of Michigan (industrial relations), University of Minnesota, North Carolina State College, University of Notre Dame, Oberlin College (music), Princeton University, Purdue University, Rutgers University, University of Santa Clara, Swarthmore College, University of Washington, Wellesley College, West Virginia University, University of Wisconsin and Yale University (science and dramatic arts).

One scholarship is awarded each year to an outstanding graduate of RCA Institutes who wishes to continue his education in an engineering school. The award is continued until the student receives his baccalaureate degree.

**RCA FELLOWSHIPS**

The 20 RCA Fellowships, each providing grants of up to $3,500 to be awarded during 1955-56 will be apportioned as follows: Ten fellowships for graduate students studying in the designated departments at: California Institute of Technology, New York University, Princeton University, Rutgers University, University of Illinois (electrical engineering); Columbia University, (physics); Cornell University (engineering physics); Yale University and Carnegie Institute of Technology (dramatic arts). One additional fellowship is to be established at a university which will be announced later. Four more RCA fellowships for graduate study in electronics are currently administered by the National Research Council.



David Lobel shown in the Shoran and Specialties Engineering Lab at Camden, N. J. Mr. Lobel is making an adjustment on a "breadboard" computer similar to those used in Shoran Equipment. Mr. Lobel was awarded one of the six fellowships allocated to RCA engineers. He will study at the Moore School of Electrical Engineering towards his M.S. degree in E.E.

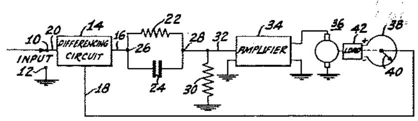
**FELLOWSHIPS FOR RCA ENGINEERS**

Six fellowships are reserved for employees of the Corporation. Five of these are awarded to engineers in the operating units of RCA for graduate study and research in electronics. The other fellowship, established for 1955-56, will be awarded to an employee of the National Broadcasting Company for study in dramatic arts or television production.

The administration of scholarships, fellowships and other educational matters of the Radio Corporation of America is under the direction of the RCA Education Committee, of which Dr. Jolliffe is Chairman.

# *Patents Granted*

## TO RCA ENGINEERS



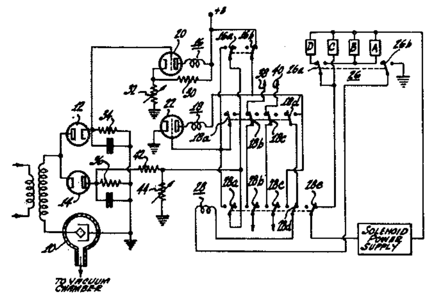

Pat. No. 2,708,258

**ANTI-HUNT CIRCUIT FOR ELECTRIC MOTOR FOLLOW-UP SYSTEM** (Patent No. 2,708,258)—granted May 10, 1955 to D. H. WESTWOOD, ENGINEERING PRODUCT DIVISION, Moorestown, N. J. To introduce into an error signal a rate-of-change signal, the error signal is inverted and differentiated and fed to one of two terminals of an "interrupter" or "chopper" switching arrangement, the output from which then contains desired proportions of error signal and rate-of-change signal.

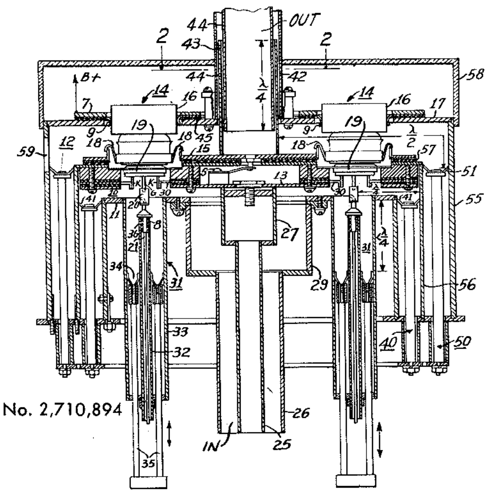
BASED ON SUMMARIES RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

**MULTI-TUBE CAVITY RESONATOR CIRCUIT** (Patent No. 2,710,894)—granted June 14, 1955 to T. M. GLUYAS, JR., ENGINEERING PRODUCTS DIVISION, Camden, N. J. A plurality of vacuum tubes are arranged in a circle in a common annular input cavity and a common annular output cavity. Claim 8 is directed to subcombination whereby tube contact fingers provide inductive reactance to neutralize interelectrode capacitance of tube.

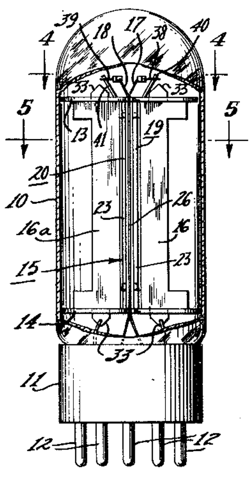
**MOUNTS FOR ELECTRON TUBES HAVING FILAMENTARY CATHODES** (Patent No. 2,708,248)—granted May 10, 1955 to N. H. GREEN, TUBE DIVISION, Harrison, N. J. A tube having a filamentary cathode includes spaced mica plates having registering peripheral indentations to facilitate a side mounting of the cathode after other electrodes have been mounted.




Pat. No. 2,707,249



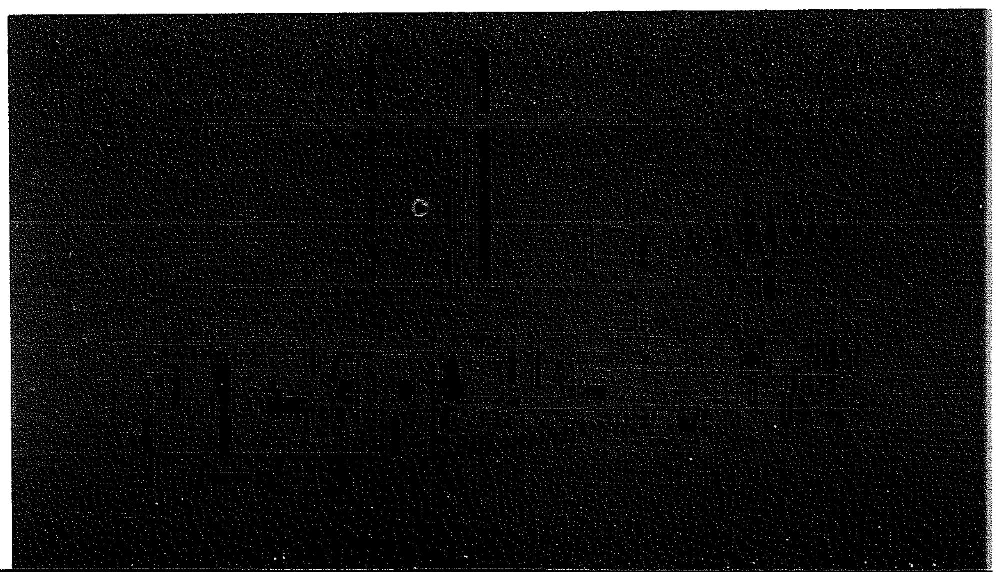

Pat. No. 2,710,894



Pat. No. 2,708,248

**DISCHARGE GAGE CONTROL OF VACUUM SYSTEMS** (Patent No. 2,707,249)—granted April 26, 1955 to H. F. SCHNEIDER, ENGINEERING PRODUCTS DIVISION, Camden, N. J. There is provided a plurality of relays 16, 18 and 28 which control electrical circuits to operate the valves A, B, C, D of a vacuum pumping system 4, 6 and which also control electrical circuits to a work performing means within a chamber evacuated by the pumping system. The relays are, in turn, operated by the conduction of a pair of vacuum tubes 20, 22. The output of an ionization type vacuum gauge 10 is rectified 12, 14 and divided into a positive and negative voltage component which is used to control the conduction of the aforesaid vacuum tubes.

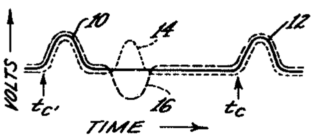
**RECORD CHANGING CONTROL SYSTEM FOR AUTOMATIC RECORD CHANGERS** (Patent No. 2,706,639)—granted April 19, 1955 to E. J. SPERBER, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. Spindle housed record changing apparatus is manipulated by a control shaft held stationary with respect thereto in a change cycle. To stop the shaft, a detent engages a clutch disc which is mounted on the shaft and frictionally engages a friction collar fixed to the shaft. The record changing apparatus upon malfunctioning such as jamming acts through the shaft to overcome the frictional engagement and free the shaft for rotation, whereby motor over load and other possible damage is prevented.



## PATENTS GRANTED

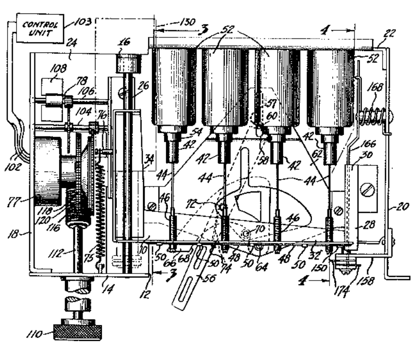
*continued*

**MULTI-BEAM CONVERGENCE CONTROLLING SYSTEMS** (Patent No. 2,706,796)—granted April 19, 1955 to D. A. Tannenbaum and A. J. Torre, RCA Victor Television Division, Cherry Hill, N. J. A particular wave forming circuit in which a horizontal deflection frequency parabolic wave is converted to a sinusoidal wave by a series tuned circuit and is added to a vertical deflection frequency parabolic wave to form a composite wave for impression by horizontal and vertical frequency convergence wave output transformers upon the beam focusing and convergence electrodes of the tri-color kinescope.



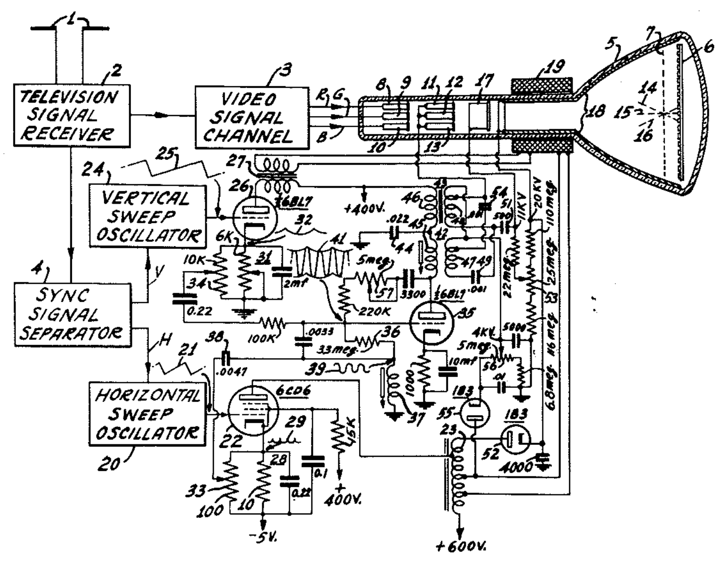

Pat. No. 2,707,210

**PULSE AMPLITUDE MULTIPLEX CROSSTALK** (Patent No. 2,707,210)—granted April 26, 1955 to H. R. Mathwich, Engineering Products Division, Camden, N. J. L-F crosstalk eliminated by providing d.c. clamping level which is renewed for each frame. Keying pulse generated in response to sync pulse, positioned at unmodulated portion of wave train. Keying pulse used to unblock series-connected tubes; when these are unblocked, base line of pulse train is restored to predetermined d.c. level.

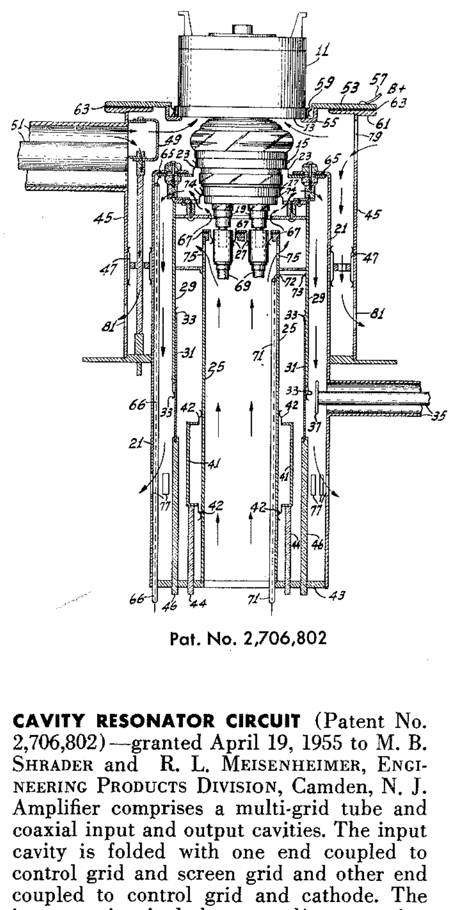



Pat. No. 2,706,787

**SIGNAL SEEKING TUNING SYSTEM** (Patent No. 2,706,787)—granted April 19, 1955 to E. J. Sperber, RCA Victor Television Division, Cherry Hill, N. J. The tuning elements of the tuner are mounted on a carriage which is driven by a spring. An air governor restricts the rate of movement of the carriage. At a predetermined limit of travel the carriage is returned to the starting position by a solenoid thus re-extending the spring. A signal responsive clutch has one plate coupled to the carriage drive and the other plate coupled through a worm gear to a manual tuning control knob. When no signal is being received the clutch permits the carriage to be driven by the spring. Upon reception of a signal, the clutch plates engage causing the carriage to be braked by the manual tuning control means.

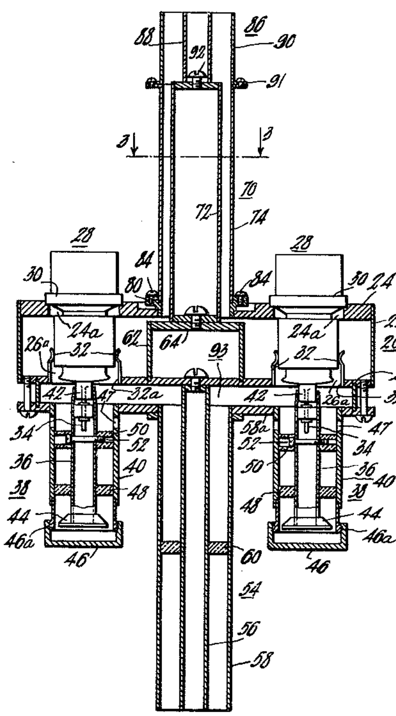



Pat. No. 2,706,796



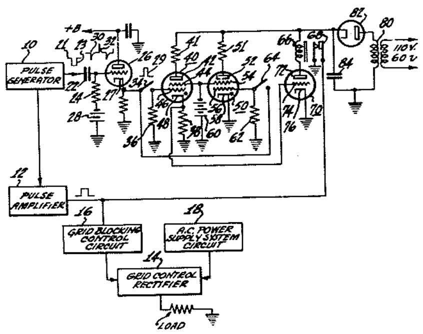
Pat. No. 2,706,802

**CAVITY RESONATOR CIRCUIT** (Patent No. 2,706,802)—granted April 19, 1955 to M. B. Shrader and R. L. Meisenheimer, Engineering Products Division, Camden, N. J. Amplifier comprises a multi-grid tube and coaxial input and output cavities. The input cavity is folded with one end coupled to control grid and screen grid and other end coupled to control grid and cathode. The input cavity includes an adjustment impedance section.



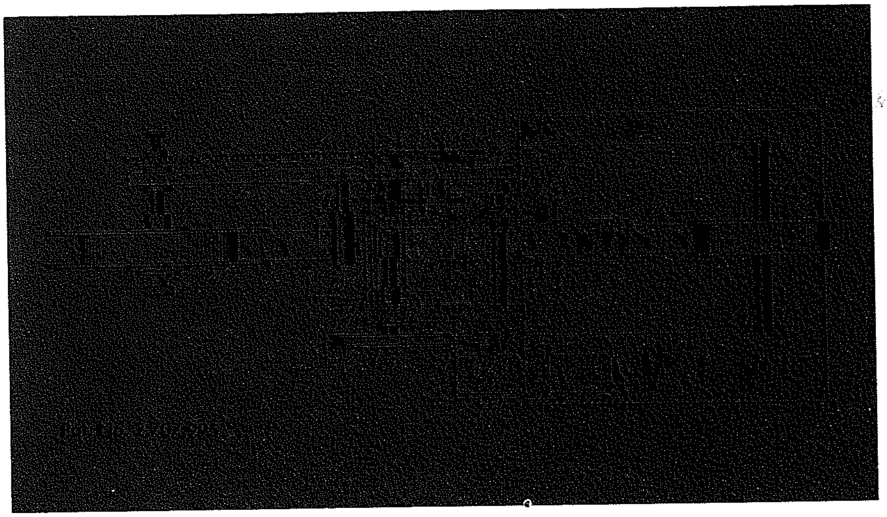
Pat. No. 2,707, 772

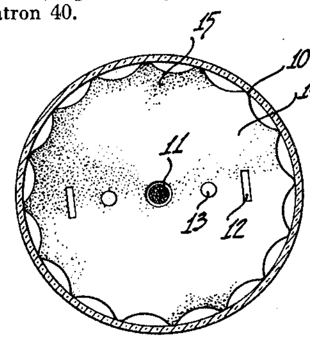
**COAXIAL TRANSMISSION LINE SECTION** (Patent No. 2,707,772)—granted May 3, 1955 to T. M. Gluyas, Jr., Engineering Products Division, Camden, N. J. The inner conductor of a coaxial line is formed with longitudinal ridges and the outer conductor is also formed with such ridges. One of the conductors is rotatable with respect to the other to vary the shunt capacitance of the line section.




Pat. No. 2,707,250

**INTERLOCK CIRCUIT** (Patent No. 2,707,250) —granted April 26, 1955 to M. V. HOOVER, TUBE DIVISION, Lancaster, Pa. To control the moment of "turn on" or "turn off" of a pulse controlled rectifier 14 so that is it not turned on just before an "off" command is given by a pulse or it is not turned off just after an "on" command has been given by a pulse, there is provided an interlock circuit which only permits turn on or turn off at a safe time after the application of pulses. The pulse being applied has a portion differentiated to start the rectifier. The trailing edge of this pulse is applied to a thyratron 40 to render it conductive and to open the contacts of a relay 68 which normally shorts the rectifier input. To stop the rectifier, the differentiated pulse trailing edge is applied to a second thyratron 50 which, upon firing, deionizes the first thyratron 40.

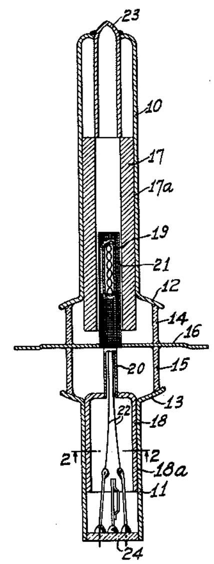




Pat. No. 2,708,168

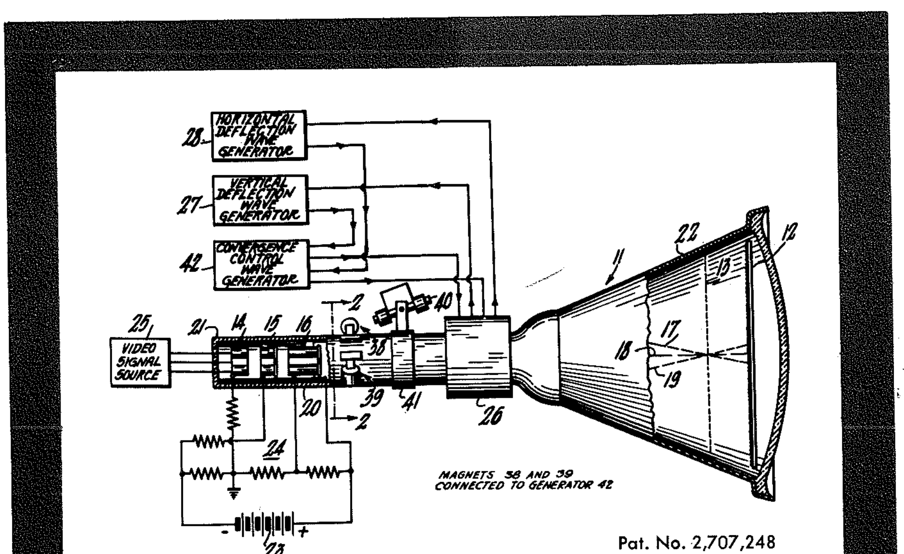
**APPARATUS FOR MAKING FINE MESH EXPANDED MATERIAL** (Patent No. 2,707,995) —granted May 10, 1955 to J. BIBBY, TUBE DIVISION, Harrison, N. J. A machine is provided for simultaneously slitting and expanding sheet metal to provide a grid-like structure suitable for use in electron tubes. The machine includes a reciprocating cutting head movable to slit the sheet metal and to separate the edges defining a slit to provide openings in the sheet metal. Since the same cutting head is used for each of the several slits, a uniformly apertured structure results.

**INSULATING COATINGS FOR ELECTRICAL INSULATORS AND SPRAY MATERIALS FOR SUCH COATINGS** (Patent No. 2,708,168) —granted May 10 to R. H. ZACHARIASON, TUBE DIVISION, Lancaster, Pa. An improved coating material for insulators includes aluminum oxide, a silicate of low alkalinity and water. The particle size of the aluminum oxide is critically related to the amount of silicate and water used, for providing a coating of reduced electrical resistance. Such reduced resistance prevents build-up of objectionably large charges.



Pat. No. 2,708,249

**ULTRA-HIGH-FREQUENCY ELECTRON TUBE** (Patent No. 2,708,249)—granted May 10, 1955 to N. E. PRYSLAK, TUBE DIVISION, Harrison, N. J. For supporting a tubular cathode in a pencil type of tube, a tubular support is affixed to one end of the cathode and snugly engages the inner walls of a tubular end portion of the tube. To strengthen this engagement, the tubular support includes a longitudinal inwardly curved portion providing a tight fit between the support and end portion, thus dispensing with welding or brazing.




Pat. No. 2,707,248

**ELECTROMAGNETIC BEAM CONVERGENCE SYSTEMS FOR TRI-COLOR KINESCOPES** (Patent No. 2,707,248)—granted April 26, 1955 to H. C. GOODRICH, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. To effect beam convergence in a tri-color kinescope, separate magnets with extended pole pieces are mounted so as to produce fields transverse to the respective beam paths. The fields are varied in strength statically by individual means and dynamically by means of a convergence control generator which derives energy directly from the energizing apparatus for the common raster-scanning deflection yoke.

# RCA ENGINEERS DESIGN FIRST AIR FORCE EQUIPMENT USING TRANSISTORS

*by*
**D. E. SHUMAKER**
*Shoran and Specialty Engineering*
*Engineering Products Div.*
*Camden, N. J.*

DELIVERY, in early 1955, of a quantity of transistorized Microphone Preamplifiers by the Los Angeles plant marked another achievement in electronic equipment design by RCA engineers. This shipment, according to officials of the Engineering Laboratory at Wright Field Air Development Center, represented the first Air Force equipment design utilizing transistors.

The new preamplifier, which is designed around three p-n-p junction transistors, eliminates the need of replacing a plane's complete interphone system in order to employ modern equipment. The new unit consists of a compact three-stage amplifier which is quickly and easily installed. A modern headset is simply plugged into the input of the new preamplifier which is connected to the plane's existing interphone system. The new preamplifier enables the direct replacement of outmoded carbon microphones with modern dynamic types, thus providing appreciably improved performance and greater intelligibility of speech communication.

It is possible that the design of this equipment will presage a general trend in airborne electronics toward modernization and transistorization. This would result in (1) a substantial reduction in size and weight, (2) an increase in reliability, (3) reduced power consumption, and (4) virtual elimination of susceptibility to shock and vibration.

### TRANSISTORS HELP SOLVE DESIGN PROBLEMS

Soon after World War II, RCA began

Fig. 2—The transistorized adapter amplifier is small enough to conceal in the hand and enables quick, simple, and economical conversion of airborne intercommunications systems.

the development of the AN/AIC-10 Intercommunication Equipment to meet Air Force specifications. The equipment specifications called for an entirely new interphone system without necessity of keeping it compatible with existing interphone equipment then in use. When the AIC-10 equipment reached the field in 1952 and 1953, it was apparent to engineers of RCA that the Air Force might experience difficulty during the transition period unless a small, convenient, amplifier-adapter could be designed. The use of vacuum tubes in designing such an amplifier-adapter was not considered practicable or feasible. It would involve great amounts of rewiring on the aircraft and the end result would still not be good enough to warrant the design and production of a "tube-powered" unit. Thus, transistors were carefully investigated and seemed to offer the perfect solution to this problem.

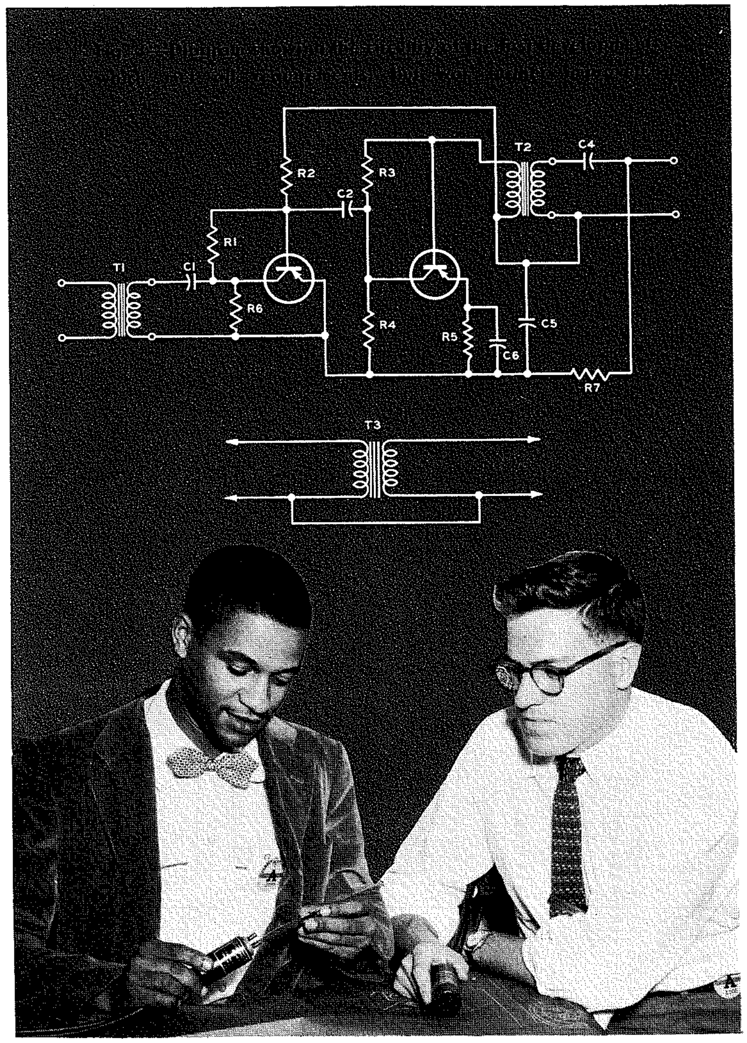



Fig. 4—In this photo, N. E. Quick (left) and A. D. Llewellyn (right) RCA engineers are shown discussing design features of the transistorized equipment.

#### DESIGN REQUIREMENTS

To achieve the desired results, it was necessary to develop and design a preamplifier having sufficient gain and power output capability to take the relatively low output of a dynamic, noise-cancelling microphone, and raise this output signal to a level equivalent to that of a carbon microphone. The voltage supply which was previously required to bias the carbon microphone could now be used to power the transistor amplifier. As a result no additional wires were needed in the existing interphone system. It was also necessary to include a matching transformer to match an 8 ohm headset into a 600 ohm output of the previous interphone amplifiers. With a preamplifier of this design, the high-performance headsets and microphones in the AIC-10 equipment could be used in conjunction with the older interphone systems. The advantages were two-fold. Aircraft crew members would require only one headset and one microphone and the performance of the system would be greatly improved. In addition to meeting the performance requirements, it was necessary to achieve a final design which would be very small in size and low in weight. It must also have a high degree of reliability! The unit was to be capable of stable, reliable operation in all temperatures from —55°C to +71°C. It could not be susceptible to either shock or vibration and must stand all the other rigors of military service. The ultimate result of this development program (see photo of figs. 1 and 2) is a small, microphone preamplifier weighing less than 8 oz., and having a gain of 47 db, and an output of +4 dbm. All of the special performance and environmental requirements mentioned above have been met in the production unit. Although this particular amplifier was designed for a specific application, it is equally applicable to any requirement of microphone preamplification and can be used universally to bring the level of a dynamic microphone up to approximately zero level.

#### CIRCUIT DEVELOPMENT CONSIDERATIONS

Even though the art of designing and building transistor and amplifier circuits was known at the time this project was begun, the circuits which existed at that time did not meet the full range of military requirements such as temperature and stabilization. It was necessary to carry on further development work to arrive at a circuit which would accept the wide tolerance of transistor gains which were experienced at that time. Further development was also needed to achieve stabilization of Ico (leakage current) and to maintain a constant gain at all temperatures from —55 to +71° C. The first circuit, which was developed (see fig. 3) met the performance requirements of 47 db gain and an output of +4 dbm. It was given a field evaluation and considered to be satisfactory in all operational respects. The spread of transistor characteristics, however, yielded gains which varied as much as ±4 db. The temperature stabilization in the circuit was within temperature limits of −55 to +55°C. The gain of the circuit was not sufficient to permit using part of this gain for stabilization purposes. Although the unit seemed to meet Air Force requirements, further development work was done. The circuit shown in Fig. 5 is the final one, and is currently being used by the Air Force. This circuit meets all of the performance specifications and requirements, and has a high degree of reliability and stability.

### BASIC OPERATION

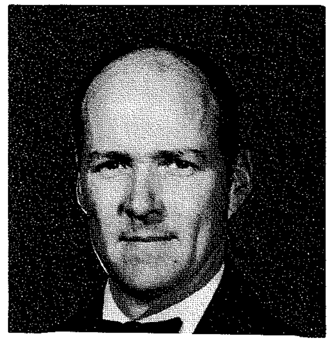
Signals from the microphone are fed into the 5 ohm winding of transformer T1 (see Fig. 5). From this point, the signal is amplified through three, base-fed, common-emitter stages in cascade. Power for the unit is fed from the voltage which was previously used to bias the carbon microphone. Gain stability in this unit is accomplished by negative feedback through resistors R3 and R9. The bias on the transistors is provided through Resistors R1, R4, and R8. Temperature stabilization for the unit is obtained through resistors R5, R7, R10 and R11. Capacitors C1, C2, and C3 are used as blocking capacitors for the DC voltages between stages and capacitor C4 is used as emitter by-pass to prevent degeneration in the last stage. This circuit, as shown, has a gain stability within 1½ db when transistors having Beta (current gain) values from 20 to 60 are employed. The transistors operate well within ratings at all temperatures from −55°C to +71°C, and overall performance at the temperature extremes is the same as at room temperature.

### MECHANICAL DESIGN

The basic circuit is assembled on a printed board, and all of the components with the exception of the transistors are enclosed in an extruded aluminum case filled with potting resin. The transistors themselves are inside a watertight compartment which is constructed by use of a metal cap and an "O" ring seal. Two cable clamps are furnished to secure the amplifier-adapter to the frame of the aircraft.

### FURTHER APPLICATIONS

The amplifier is small, compact, and practically indestructible in its mechanical design. The electrical design is such that the transistors cannot be damaged due to instability of Ico or variations in temperature. It makes the transition from carbon microphones and magnetic headsets to dynamic microphones and headsets much smoother than would have been possible without transistors. Although specifically designed for airborne requirements, the amplifier should work equally well for any type of microphone preamplification required. It is possible to use such a unit in any application where carbon microphones were previously used as audio transducers. The distortion and noise level of the basic circuit of this amplifier are such that the unit may be used in tape recorders. It is felt that this circuit can be used wherever the need for amplification of low-level signals is required.



**DONALD E. SHUMAKER.** Mr. Shumaker received his A.B. in Physics at Wabash College, and did additional graduate work at the University of Minnesota and Harvard University. He has nine years of experience in the design of communication equipment and is a leader in the Electrical Design Unit. He was a project engineer on the electrical systems of the AN/AIC-10, and has specialized in the transistorization of a variety of electronic equipments. He served as a Radar Officer with the U. S. Army Signal Corps prior to his association with RCA.

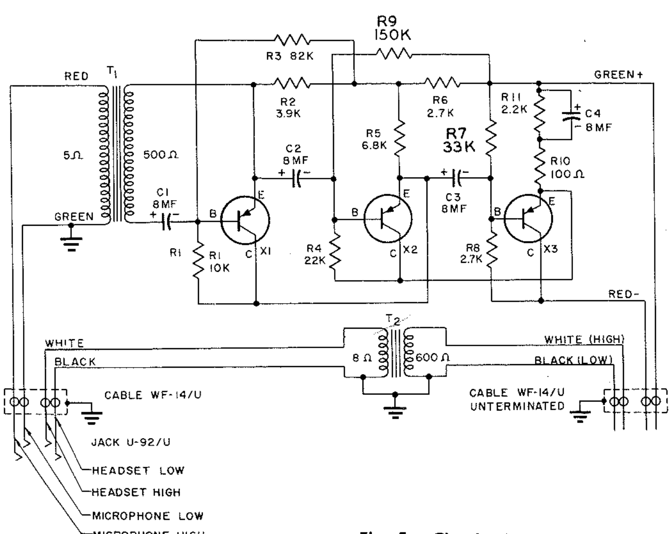



Fig. 5—Circuit diagram showing the final design which provides a high degree of stability and reliability.

### ACKNOWLEDGMENT

The author wishes to acknowledge the work done on the basic circuit of this adaptor by John Tom and Alan Paris who are now in the Armed Forces. The final production design and release to manufacturing was accomplished by Art Llewellyn and Nat Quick of the Shoran and Specialty Engineering.

# PEN and PODIUM

Based On Reports Received Over a Period of About Two Months

**ANALYSIS OF SYSTEMS CONTAINING DIGITAL COMPUTERS** . . . By E. Arthurs, Engineering Products Division, Moorestown, N. J. Presented at the National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in the 1955 AERONAUTICAL ELECTRONICS DIGEST. The great advances in recent years in the art of constructing digital computers and digital equipment has opened new vistas of approach to systems design. The use of a digital computer in a system requires that the dynamic interaction between the digital and analog units be understood. A principal result of this paper is a procedure for the design of computer programs to perform linear operations such as linear prediction, linear noise filtering, differentiation, and integration.

**TRANSISTOR COMMUNICATIONS RECEIVER** . . . By H. J. Woll, Engineering Products Division, Camden, N. J. Presented at the National Conference on Aeronautical Electronics, at Dayton, May 9-11. Improvements offered by transistors over tubes in portable radio equipment is described. Low power requirements permit compactness (see illustration, size is 3″ x 1.2″ x 6″). The receiver has two r-f amplifier stages, mixer oscillator, three I-F stages, diode detector, a first audio and AGC amplifier, and a complimentary symmetry audio output stage. Freq. range 2 to 8 mc, 2 bands. Sensitivity is 12 microvolts at a signal-to-noise ratio of 10 db. Image rejection 30 to 40 db. Total battery drain is 100 milliwatts.

**THE APPLICATION OF THE NEUGEBAUER EQUATIONS TO ELECTRONIC COLOR CORRECTION** . . . By J. S. Rydz, Engineering Products Division, Camden, N. J. Presented to Technical Association of the Graphic Arts Convention, May 9, Boston, Mass., and published in the Convention Proceedings. The paper shows the methods by which subject areas may be colorimetrically changed in the reproduction. The color of areas may be shifted in dominant wavelength, purity, or luminance, and methods for making these shifts are presented. The derivation of the Neugebauer equations is reviewed.

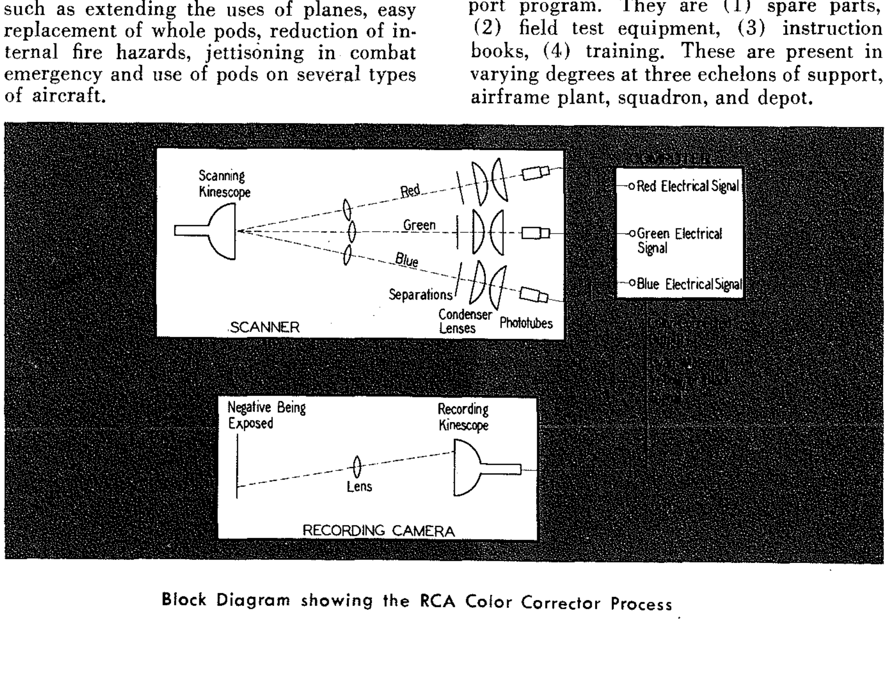
**MEASUREMENT OF SIGNAL GENERATOR MODULATION FACTOR** . . . By H. S. Ingraham, Jr., Engineering Products Division, Camden, N. J. Presented May 3, 1955 at spring meeting of Union of Radio Scientific Institutes ("URSI"), Washington, D. C. The presentation is devoted to the following objectives (1) a review of techniques being used to monitor modulation factor in signal generators (2) a discussion of techniques for precision measurement and calibration of modulation factor, and (3) a detailed presentation of precision techniques developed at RCA.

**POD MOUNTED ELECTRONIC EQUIPMENT HAS ADVANTAGES** . . . By H. A. Brelsford, Engineering Products Division, Camden, N. J. Presented at the National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in 1955 AERONAUTICAL ELECTRONICS DIGEST. The paper describes a "pod" which is a lightweight, thin metallic, or plastic shell aerodynamically designed for low drag — and attached or suspended from beneath the wings of the aircraft. The advantages in fighter craft utilizing this equipment are described, such as extending the uses of planes, easy replacement of whole pods, reduction of internal fire hazards, jettisoning in combat emergency and use of pods on several types of aircraft.

**STUDY OF AGING EFFECTS ON MILITARY PLATED CRYSTAL UNITS** . . . By P. D. Gerber, Engineering Products Division, Camden, N. J. Presented at Signal Corps Synposium on Frequency Control, Asbury Park, N. J., May 26. Crystal units, tests, facilities for testing, frequency ranges, effects on frequency by preaging, comparisons of groups preaged and not preaged, test results, and the aging of signal corps units were some of the studies discussed. Causes, effects and remedies for contamination were described.

**PRACTICAL MANUFACTURING TECHNIQUES FOR PRINTED WIRING** . . . By G. F. Brietwieser, Engineering Products Division, Moorestown, N. J. This paper was presented before the Guidance and Control Committee of American Ordnance Association, June 16, 1955, at Naval Air Missile Test Center, Point Mugu, Calif. This paper describes the process used in RCA to produce printed-wiring boards and mentions briefly steps used in the "photo-resist-etch" process, i.e., the preparation of photomaster drawing, application of photosensitive solution to the copper surface, contact printing of glass negative on the sensitized copper surface, developing in the Trichlorethylene solution, and etching in a solution of Ferric Chloride, machinery for shearing, hole punching, ladder chaining, component insertion and solder printing is discussed.

**FIELD SUPPORT OF COMPLEX AIRBORNE ELECTRONIC EQUIPMENT** . . . By H. W. Brown, Engineering Products Division, Camden, N. J. Presented at National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in 1955 AERONAUTICAL ELECTRONICS DIGEST. The paper explains that a reliability program is not completed when the designer has selected his components and checked out his circuitry, or when the factory has shipped the equipment. The exacting complexity of military airborne electronic equipment necessitates a well planned support program. A description is given of several elements that go toward making up a support program. They are (1) spare parts, (2) field test equipment, (3) instruction books, (4) training. These are present in varying degrees at three echelons of support, airframe plant, squadron, and depot.




Block Diagram showing the RCA Color Corrector Process

**PHILBRICK ANALOG COMPUTER** . . . By MARGUERITE HEYER, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Published in ENGINEERS DIGEST, May-June, 1955. The model GAP/R Computer, manufactured by G. A. Philbrick Researchers, Inc. and available in Aviation Systems, Moorestown, is a flexible, all-electronic, "fast-time" repetitive device. The functions of the various components are described.

**ELECTRONIC COMPUTERS AS ENGINEERING FACILITIES** . . . By D. G. C. LUCK, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in May-June ENGINEERS DIGEST. It is pointed out that simulation of the behavior of dynamic systems is the purpose for which computers are most widely used as engineering laboratory facilities. Modern computers can be used either for numerical computation or for simulation of functional behavior of actual devices.

**THE MEASUREMENT OF WIND NOISE** . . . By R. M. CARRELL, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in BROADCAST NEWS, May 1955. The author describes the techniques for the testing and evaluation of wind noise effects. The wind noise sensitivity and sensitivity to mechanical shock have a direct bearing on the utility of a microphone for outdoor use.

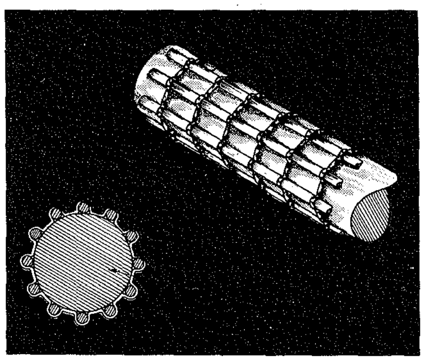
**COLOR TELEVISION** . . . By C. P. SMITH, TUBE DIVISION, Lancaster, Pa. Presented at Garden Spot Williamson Club, Lancaster, Pa., May 20, 1955. This paper describes briefly the physical layout and facilities of the RCA Tube Division plant at Lancaster, Pa. where color kinescopes are manufactured. The operation of the color kinescope is described, and construction details of the tube are reviewed. Various components used with the kinescope are discussed, including convergence and focusing devices. The theory of the RCA Compatible system of color television is analyzed, and the decoding principle employed in the color receiver is explained.

**ENGINEERING AND YOU** . . . By N. R. HANGEN, TUBE DIVISION, Lancaster, Pa. Presented at Oxford Joint Schools, Pa., May 26, 1955. This paper defines the accepted concept of "engineering," and discusses the responsibility of engineers to society. Eleven qualities required of engineers by industry are enumerated, described, and evaluated. Examples are given of specific jobs in the RCA color-kinescope operations at Lancaster, Pa. which utilize various engineering talents. Several types of engineers and their respective duties are discussed. The engineer's responsibilities to himself, industry, and society are summarized.

**144-MEGACYCLE TRANSMITTER** . . . By R. M. MENDELSON, TUBE DIVISION, Harrison, N. J. Published in RCA HAM TIPS, May, 1955. The appearance of a new tube often prompts the adventurous ham to re-appraise his equipment with a critical eye. This paper describes a transmitter that takes advantage of the best features of the new high-frequency twin beam power tube, RCA-5894. The transmitter incorporates stable VFO tuning, broad-band multipliers for a minimum of switching controls, a high-efficiency tank circuit, and coaxial output with antenna switching. The circuit can handle modulated input powers up to 72 watts at a frequency of 144 megacycles per second. Complete wiring and contruction details are given.

**FEEDBACK CONTROL SYSTEMS USING SAMPLED DATA** . . . By L. E. MERTENS, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Presented at National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in 1955 AERONAUTICAL ELECTRONICS DIGEST. A description is given of methods for determining response of any combination of linear filters and periodic samplers by using certain transform relations together with transfer functions of the filters. Skip-sampling systems are discussed and other topics of interest are the response of sampling systems to statistical type inputs and the effects of nonlinear transmission characteristics. Two methods are outlined for determining the mean square output fluctuations of a sampling system with a random noise input. Several methods are discussed for analyzing sampling systems with a zero memory nonlinear characteristic.

**SOUND-EFFECTS TRACK NOISE-SUPPRESSOR** . . . By J. F. BYRD, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in SMPTE JOURNAL, June, 1955. A simplified noise-suppressor for the effects track in CinemaScope reproduction is described. The unit operates in the speaker line, thus using the full gain of the system, and uses two tuned circuits. One accepts and rectifies the 12-kc control tone to operate a speaker relay, and the other rejects the 12-kc tone from the wanted program material in the effects speakers. Unit uses no tubes or power supply.



Sketch showing Fabrication Detail of Pencil-Tube Grid

**TECHNIQUE FOR FABRICATING SMALL CYLINDRICAL GRIDS OF NOVEL DESIGN FOR USE IN PENCIL TUBES** . . . By H. J. ACKERMAN, TUBE DIVISION, Harrison, N. J. Published in ELECTRONICS (Production Techniques Section), May, 1955. Novel designs of grids are now employed in developmental pencil tubes to shorten transit time and obtain a more uniform field along the cathode. Design of triodes for better uhf performance requires smaller grid-wire size, smaller pitch between grid turns, and smaller grid-cathode spacing. The geometry of the present commercial pencil-tube grid limits the uhf performance obtainable. This paper discusses techniques employed to produce conventional grids for use in commercial pencil tubes and modifications and changes in grid configuration which improve uhf pencil-tube performance. Two new grid-fabrication methods are described: (1) a technique for making a formed pencil-tube grid, and (2) a technique for making a pencil-tube grid in which the grid lateral wires are inside the siderods.

**APPLICATION OF FERRITES TO DEFLECTION COMPONENTS** . . . By B. V. VONDERSCHMITT, TUBE DIVISION, Camden, N. J. Presented at Metal Powder Association Annual Meeting, Philadelphia, Pa., May 12, 1955. Specific properties of ferrite cores are probably used to greater advantage in deflection components, deflecting yokes, and transformers for commercial television receivers than in any other portion of the receiver. Ferrite-core manufacturers, however, have frequently found it difficult to determine the optimum properties for deflection applications. This paper discusses effects on performance of variations in core parameters such as losses, permeability, and mechanical fit. Specific measurements necessary to define the merit of the core are described, and precautions necessary in the evaluation of core material are enumerated. Suggestions are given for improvements in properties which can make ferrite cores even more suitable for application to deflection components.

**NEUTRALIZATION AND UNILATERALIZATION** . . . By C. C. CHENG, TUBE DIVISION, Harrison, N. J. Published in Transactions of IRE Professional Group on Circuit Theory, June, 1955. The subject of neutralization and unilateralization is of great interest in the field of transistor design because of the inherent bilateral property of transistors. This paper presents a systematic study of unilateralization in terms of generalized network theory presented in matrix form. Results are listed in tabulated form for easy use in practical circuit design. Examples illustrating the adaptation of the general procedure to the design of transistor amplifiers and vacuum-tube amplifiers are also included.

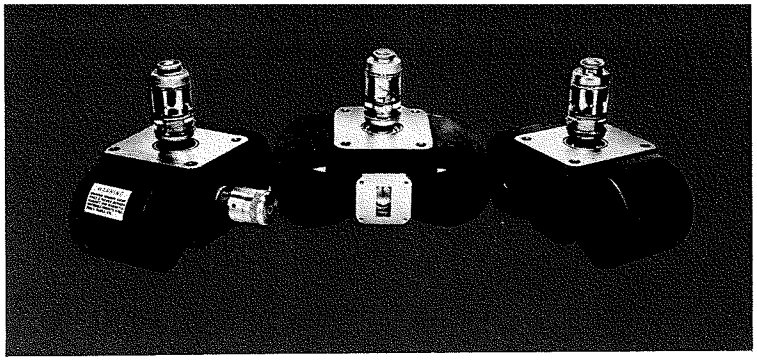
**AN OPTICAL AND PHOTO-ELECTRIC ANALOG OF THE EYE** . . . By O. H. SCHADE, SR., TUBE DIVISION, Harrison, N. J. Presented at Symposium of Image Evaluation, Institute of Optics, Rochester, N. Y., June 15-17, 1955. The quality of optical images is determined by three fundamental characteristics of the imaging system: the transfer characteristic, signal-to-noise ratio, and the sine-wave response characteristic. The corresponding subjective impressions of tone range, graininess, and sharpness can be evaluated or predicted objectively by including characteristics of the process of vision in the evaluation. For this purpose an analog of the process of vision is constructed from observed data. The analog has the form of a television camera system followed by a coder and computer (the brain). The analog system duplicates observed characteristics up to the coded signal input to the computer, permitting comparisons at that point. It is obvious that the interpretation of these signals by the "computer" into likes and dislikes and their comparison with stored information requires far more extensive knowledge than available. There is little room for variation of contents or characteristics if they are to remain in agreement with observed data. Of particular interest are the high quantum efficiency at low light values (70 per cent), the process of adaptation (dual-camera and variable band-width mechanism), and the two factors limiting acuity (resolution): the noise level at low lights and the limitations of the optical system at high lights. A technique for measuring the sine-wave response of the eye was discussed briefly.

**DEVELOPMENTAL LOW-NOISE TRAVELING-WAVE TUBES FOR L-S- and C-BAND OPERATION** . . . By P. R. Wakefield and A. G. Hogg, Tube Division, Harrison, N. J. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 11, 1955. This paper describes developmental traveling-wave tubes having low-noise, wide-band characteristics for application as low-level microwave amplifiers. The developmental low-noise tubes operate at center frequencies of 1300, 3000, and 6000 megacycles per second. All tubes utilize a three-region, velocity-jump electron gun to obtain noise reduction, and operate at voltages below 800 volts with beam currents of approximately one-half milliampere. Noise figure, frequency response, and gain characteristics are described.

**DEVELOPMENT OF THE PREMIUM UHF TRIODE 6J4-WA** . . . By George W. Barclay, Tube Division, Harrison, N. J. Published in RCA REVIEW, June, 1955. This paper describes development of the 6J4-WA, a premium version of the 6J4 uhf amplifier triode for military applications. Electrical and mechanical features of the 6J4-WA are discussed, together with design modifications which increase interelectrode insulation, reduce heater-to-cathode leakage, and minimize temporary grid-to-cathode shorts. Manufacture of the close-wound grid is also discussed, and considerable emphasis is placed on quality-control procedures and special processing used.

**RELIABILITY MEASUREMENT AND PREDICTION** . . . By C. M. Ryerson, Engineering Products Division, Camden, N. J. Presented at National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in 1955 AERONAUTICAL ELECTRONICS DIGEST. The presentation points out the emphasis, by RCA in all organizational branches, placed on increased reliability of equipment. The discussion involves the division of the field of Reliability Engineering into specific areas which yield to further development. Scope, figure of merit, life characteristics, types of equipment, reliability accomplishments, numerical assessment, part and equipment relationship and many other factors are explained. Summaries are made and description given of a "Calculator" for Reliability.

**A NOVEL ULTRA-HIGH FREQUENCY HIGH-POWER AMPLIFIER SYSTEM** . . . By L. L. Koros, Engineering Products Division, Camden, N. J. Published in RCA REVIEW, June, 1955. The paper describes a novel type of power amplifier, especially developed for high-power ultra-high-frequency monochrome and color television transmitters, but also applicable to other services such as scatter-propagation. The amplifier employs type 6448 beam-power tubes for Class-B service up to 15 kilowatts peak of sync output with an amplification factor of 15 at 6 megacycles bandwidth (.5 decibel points) and, for Class-C service with a power amplification factor of 50. The amplifier design is applied in the TTU-12A transmitter.



View of High-Power Tunable Pulse Magnetrons

**A DEVELOPMENTAL HIGH-POWER TUNABLE X-BAND PULSE MAGNETRON FOR AIRBORNE APPLICATIONS** . . . By Willis F. Beltz, Tube Division, Harrison, N. J. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 11, 1955. This paper describes a developmental tunable X-band magnetron in which a new tuning technique is employed to provide stable, wide-band tuning. Operating frequency is varied by adjustment of dimensions of separate tuning cavities which are contained in the tube and coupled into the magnetron resonant system. Good mode separation and stable operation is obtained over a wide tuning range. Stabilizing effects of the cavities and the incorporation of an effective getter improve performance. The tube provides relatively flat power output with no resonant "holes" over the band. Frequency variation is linear with tuner movement, and there is good thermal and short-time frequency stability. Missing pulses due to arcing and moding are low. Because frequency pushing and pulling are also low, the tube has a symmetrical spectrum with low side lobes.

**THE BK-6A MICROPHONE** . . . By L. M. Wigington and R. M. Carrell, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, May, 1955. The authors describe the small, BK-6A dynamic TV microphone designed to be worn by performers or concealed on the set. It can be concealed in the hand or behind a tie. Directional characteristics are discussed and curves illustrated.

**NEW DISTRIBUTION AMPLIFIERS FOR TELEVISION BROADCASTING STUDIOS** . . . By Robert G. Thomas, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, May, 1955. Two new amplifiers; one a pulse distribution amplifier, the other a video distribution amplifier are described. The utility and need for each in achieving good performance in a TV station's system layout is explained.

**NIFTE—EPD'S OWN DIGITAL COMPUTER** . . . By L. S. Bensky and J. R. Taylor, Engineering Products Division, Camden, N. J. Published in ENGINEERS DIGEST, May-June, 1955. "NIFTE", novel instrument for test engineering, is a general purpose digital computer built by General Engineering Development, for use as an engineering facility. The paper describes the uses for which NIFTE is intended.

**THE BK-5A UNIAXIAL MICROPHONE** . . . By J. W. O'Neill and R. M. Carrell, Engineering Products Division, Camden, N. J. Published in BROADCAST NEWS, May 1955. The authors describe a versatile unidirectional microphone for television broadcasting, designed as a successor to the 77-D. The BK-5A is rugged and suited to boom use or stand mounting. Construction, response and other engineering considerations are described.

**THE OPERATION AND ECONOMICS OF PHASE-TO-AMPLITUDE MODULATION IN AM BROADCAST TRANSMITTERS** . . . By C. J. Starner, Engineering Products Division, Camden, N. J. Presented at NARTB Convention, Washington, D. C., May 22-26. Phase-to-Amplitude circuitry was reviewed and its adaptability to modern AM Broadcast Transmitter requirements discussed. The potential equipment and operating economics which can be obtained by proper use of modern power tubes and optimum design parameters were pointed out. Means for achieving these goals were outlined, and measured performance at a 50 KW power level presented. Installation, operating and maintenance economics of a 50-KW Ampliphase transmitter were compared with similar data on 50-KW Amplitude modulated transmitters using other modulation systems.

**STANDARDIZATION MANUAL** . . . published by the National Committee on Standardization of the National Association of Purchasing Agents. A book of Principles and Practices for Purchasing Personnel (1955 Edition). In acknowledgement, the editors stated: "Sam H. Watson, Manager of Engineering Standards Dept., RCA, Camden, N. J., assisted us, and his extensive knowledge and long experience in the field of standards were generously contributed to make this booklet an outstanding milepost in the advancement of standardization in Purchasing. To Mr. Watson we extend our sincere gratitude."

**THE "FACTOR" CONCEPT IN ENGINEERING** . . . By Carl G. Osgood, Engineering Products, Camden, N. J. Published in ENGINEERS DIGEST, May-June, 1955. The author points out that a significant portion of difficulty in designing equipment and its attendent structures lies in the absence of useful factors for properly describing the physical aspect of the equipment, and indirectly its relation to the surroundings. The elimination or reduction of "cut-and-try" methods and "blind reliance" on past experiences is encouraged.

**PROLOGUE TO CREATIVE ENGINEERING** . . . By M. Holbreich, Engineering Products Division. Published in ENGINEERS DIGEST, May-June, 1955. The author describes Creative Engineering as "the application of constructive imagination by those skilled in the art of engineering." The phases of invention, worry, dreaming are discussed. Thought is divided into 3 classes (1) Imaginative (2) Analytical (3) Judicial, for purposes of description."

**ANTENNA SYSTEM FOR MISSILE TELEMETERING** . . . By GARTH E. BOWER and JAMES B. WYNN, JR., TELEMETRY ENGINEERING, RCA SERVICE CO. Published in ELECTRONICS, June 1955. The paper describes dual helical antennas, low-noise preamplifier and multicoupler which form antenna system for receiving signals telemetered from guided missiles. Overall gain exceeds 30 db. Antennas track missile in overwater flight from Florida to Puerto Rico.

**A UHF-VHF TELEVISION TUNER USING PENCIL TUBES** . . . By W. A. HARRIS and J. J. THOMPSON, TUBE DIVISION, Harrison, N. J. Published in RCA REVIEW, June 1955. The use of pencil tubes in a television tuner covering all channels in the uhf and vhf bands is discussed. Input and output resonant frequencies of the pencil tubes are high enough to allow the use of shunt-tuned circuits in a uhf-vhf tuner, and the feedback inductance is low enough to insure stability in the required frequency ranges. The shunt-tuning method has the advantages of providing small over-all dimensions and a moderate number of switching components. The measurements of the tube characteristics at high frequencies and the use of such data in the design of the tuner circuits are discussed.

**SHORT-CIRCUIT PROTECTION FOR METERS** . . . By P. KOUSTAS, TUBE DIVISION, Harrison, N. J. Published in RADIO AND TELEVISION NEWS, June, 1955. When microammeters and low-range milliammeters are used in a supply delivering several hundred volts, they may be damaged beyond repair by sudden short circuits. In such applications, fuses and relays are not adequate protective devices. This paper describes three circuits which can be used to prevent damage to current meters of any range from short-circuit voltages as high as 5000 volts.

**A DEVELOPMENTAL WIDE-BAND, 100-WATT, 20-DB, S-BAND TRAVELING-WAVE AMPLIFIER UTILIZING "PERIODIC" PERMANENT MAGNETS** . . . By W. W. SIEKANOWICZ, TUBE DIVISION, Harrison, N. J. and F. STERZER, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at Electronic Components Conference, Los Angeles, California, May 27, 1955. A developmental, 100-watt, S-band traveling-wave amplifier utilizing ceramic "periodic" permanent magnets to focus the electron beam is described. The use of such magnets in place of conventional solenoids or permanent magnets producing uniform magnetic fields effects a considerable reduction in the weight and size of the focusing system. Constructional features of the tube which permit operation with the "periodic" magnet are discussed. RF characteristics of this amplifier are evaluated, and the complete "package" assembly is described.

**ELECTRONIC ASSOCIATES ANALOG COMPUTER** . . . By H. H. NISHINO, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Published in ENGINEERS DIGEST, May-June, 1955. A description is given of this device which is located at Moorestown. It is a d-c machine of the differential analyzer type and aids in solution of ordinary, linear or non-linear, differential equations, and simultaneous algebraic equations.

**NEW ALLOYS FOR P-N-P ALLOY-JUNCTION GERMANIUM TRANSISTORS** . . . By C. CARLSON, M. BENTIVEGNA, and L. D. ARMSTRONG, TUBE DIVISION, Harrison, N. J. Presented at IRE Semiconductor Research Conference, Philadelphia, Pa., June 20, 1955. The requirements and desirable properties of alloys for alloy-junction transistors are reviewed. Gallium has many advantages, but physical characteristics limit its application. Means of overcoming the metallurgical difficulties are discussed. Characteristics of junctions and transistors made with gallium alloys are given, together with a discussion on the correlation between experiment and theory.

**8-15 CM PLATE-PULSED RE-ENTRANT OSCILLATOR CIRCUITS FOR USE WITH THE 5893 PENCIL TRIODE** . . . By W. E. BABCOCK, TUBE DIVISION, Harrison, N. J. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 11, 1955. Because of its mechanical simplicity and excellent performance, the re-entrant oscillator is commonly used in radar beacons and other applications operating at wavelengths shorter than 15 centimeters. A simplified explanation of the re-entrant oscillator is given as applied to the 5893 pencil triode. Various methods of tuning are discussed and one possible method of temperature compensation is described. Precautions necessary to minimize cavity losses and methods of extracting power from the circuit are given. Data are presented showing power output and cavity dimensions over a range of wavelengths from 8 to 15 centimeters. Effects of eliminating some of the adjustments necessary for obtaining optimum performance are considered.

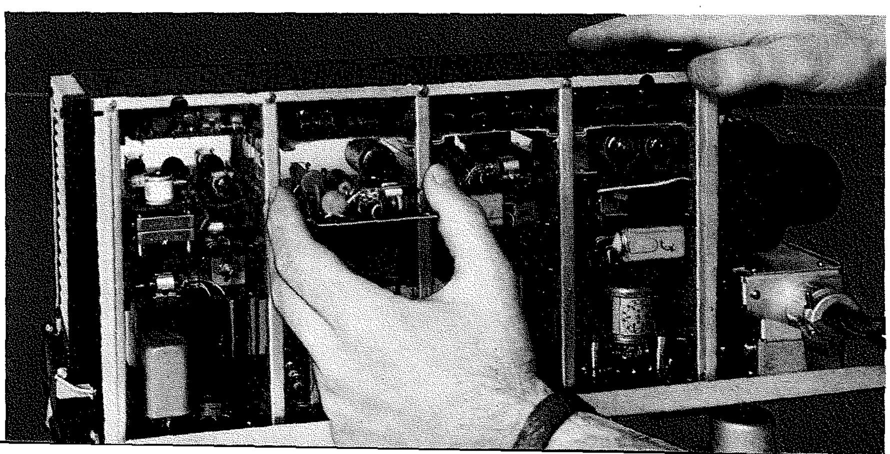
**STUDY OF NOISE REDUCTION BY FEEDBACK IN ULTRA-HIGH FREQUENCY AMPLIFIERS** . . . by DR. A. B. GLENN, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 11, 1955, and published in the AERONAUTICAL ELECTRONICS DIGEST. The paper describes an investigation to determine the degree to which high-frequency tube noise generated in the r-f amplifiers may be cancelled and to determine whether such cancellation could be used practically. An integral part of this investigation was to determine the sources of the tube noise.

**ABOUT THE STANDARDS ENGINEERS SOCIETY** . . . By M. S. GOKHALE, STANDARDS ENGINEERING, Camden, N. J. Published in THE MAGAZINE OF STANDARDS, June 1955. The author describes standardization as a planned engineering activity, outlines the formation, growth and purpose of the Standards Engineers Society, and points out objectives of the society, as well as its relation to American Standards Association. Membership qualifications, future plans and aspirations were also described. Emphasis is placed on development of the Standards Engineer.

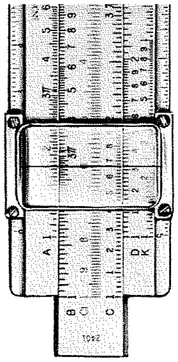
**DESIGNING 2000 mc COMPONENTS FOR COMMUNICATIONS** . . . By N. C. COLBY, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Published in ELECTRONICS, May 1955. When designing a UHF circuit for commercial application the following factors must be considered: (1) The circuit must be sufficiently large physically despite the parasitic capacitance of associated tubes, (2) It must be easily tunable, in many applications, over a wide frequency range, (3) The associated tube must be accessible for replacement, (4) The design should be such as to make ventilation of the tube easy, (5) Coupling devices must be simple, and (6) The circuit must be economical to build. The oscillator and amplifier circuits described in this paper meet all of the above requirements. A tuning range of two to one is obtained using 2C39-A tubes at a nominal frequency of 2000 megacycles. Some specific designs, including a cascade circuit, are described and performance data given.

**INTEGRATION OF COLOR AND MONOCHROME TV** . . . By A. H. LIND, L. E. ANDERSON and N. J. OMAN, ENGINEERING PRODUCTS DIVISION, Camden, N. J. Presented at NARTB Convention, Washington, D. C., May 22-26. The TV Broadcaster faces many questions as he takes the necessary steps to enter color telecasting. A number of helpful considerations were discussed that will aid him in planning for an efficient transition to combined monochrome and color operation. New equipment and techniques which have recently become available that further increase flexibility and versatility of color generating equipment were described. This information should be of particular interest to the broadcaster who is considering facilities for local color origination. Also included was a discussion of considerations that apply to the handling of color signals by the TV transmitter.

**A NEW PACKAGING DESIGN WELL SUITED TO AUTOMATION** . . . By D. H. WESTWOOD, ENGINEERING PRODUCTS DIVISION, Moorestown, N. J. Presented at the National Conference on Aeronautical Electronics at Dayton, May 9-11, 1955 and published in 1955 AERONAUTICAL ELECTRONICS DIGEST. The paper describes a new packaging design for altimeter sub-miniaturized high-range equipment suited to automation. "Apartment house" type packaging which consists of printed board electronic modules, arranged in horizontal rows and supported by connector racks containing vertical riser wires is described. Complete wiring and interconnection flexibility and good cooling are features explained.



View of Sub-miniaturized Equipment using "Apartment House" Packaging

# *Engineering*  NEWS *and* HIGHLIGHTS

## DR. G. R. SHAW HONORED

**35-YEAR SERVICE ANNIVERSARY LUNCHEON FOR DR. G. R. SHAW, TUBE DIVISION CHIEF ENGINEER . . .** At a luncheon held at the Military Park Hotel, Newark, N. J. on July 1, 1955, Dr. G. R. Shaw was feted for his 35 years of engineering.

Dr. Shaw graduated from Washington and Lee with AB and AM degrees, and from Wisconsin with a PhD degree in 1920. He served as an instructor in chemistry at both Universities. Dr. Shaw was with the GE National Lamp Works from 1920 until 1929 when he joined the RCA Manufacturing Company Radiation Division as head of the Chemical Section. Successively, Dr. Shaw held positions as Manager of the Research and Engineering Department, Manager of Harrison Engineering, and in 1945 became Chief Engineer for the RCA Tube Division, which is his present post.

Dr. Shaw is a member of the American Chemical Society, American Physical Society, and a Fellow of the IRE. He received the "Coffin Award" while at GE, and in 1950-51 received the RCA Award of Merit.

Among the twenty luncheon guests present were W. W. Watts, Executive Vice President, Electronic Products, and D. Y. Smith, Vice President and General Manager, Tube Division.

**A. ROSENBERG RECEIVES MASTER'S DEGREE . . .** Mr. A. Rosenberg, Test Equipment Development Group, Tube Division, Camden, was awarded his Master's Degree in electrical engineering from Drexel Institute of Technology in June, 1955. He received his BS in ME from Drexel in 1928 and joined the General Electric Company the same year. He came to Camden in 1930 and has worked in Test Maintenance, Test Equipment Design, Product Control, Quality and Design Engineering.

**ENGINEERING COURSE COMPLETED AT FINDLAY PLANT . . .** Educational opportunities in technical fields are hard to come by in some plant areas, but the Engineering Staff at the Findlay, Ohio plant, working through the Plant Training function, overcame this by "moving the mountain to Mohammed."

Arrangements were made with the Engineering Department of Toledo University to offer a graduate level course in Electro-Magnetic Devices on the plant premises. One evening each week, the instructor made the 100-mile round trip to conduct a two-hour session for the design engineers in Findlay. Each engineer had enrolled in the course under the RCA Tuition Loan and Refund Plan in order to make this possible.

The course, which lasted 15 weeks, was well received and it is hoped that similar arrangements can be made for other courses this fall.

The course instructor was Dr. Earl E. Hays, Associate Professor of Engineering Physics. The course was organized by B. V. Dale, Manager Electronics Components Engineering, J. K. Kratz, Manager, Findlay Engineering, J. R. Wagenseller, Administrator, Personnel Operations, Harrison, and W. R. Linke, Manager, Personnel, Findlay.

**J. L. WEAVER,** Pick-up and Phototube Development Engineer at Lancaster received his Masters Degree in Physics at Franklin and Marshall College, June 13, 1955. He received the degree as a result of study under the Company's Tuition, Loan and Refund Plan. Mr. Weaver had previously received a BS degree in EE from Lehigh University in 1948, after which he joined the Tube Division at the Lancaster Plant.

**ROBERT E. SALVETER** has been accepted as a Professional Engineer in Chemical Engineering in the State of Indiana. He received his BS in ChE degree from Purdue University in 1949 and joined RCA Marion immediately after graduation. He is now supervisor of the Chemical Process Engineering Group at Marion.

## ASSISTANT EDITORIAL REPRESENTATIVES APPOINTED

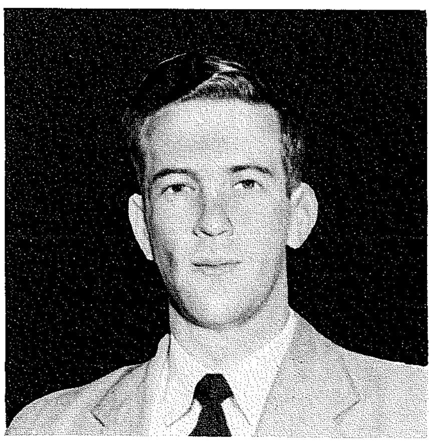
**Marion Plant Appoints Assistant Editorial Representatives for New "RCA Engineer" Technical Journal**

. . . Because of the diversified engineering activities at the Marion plant, Morris Slater has appointed two assistants to insure complete editorial coverage for the RCA ENGINEER.

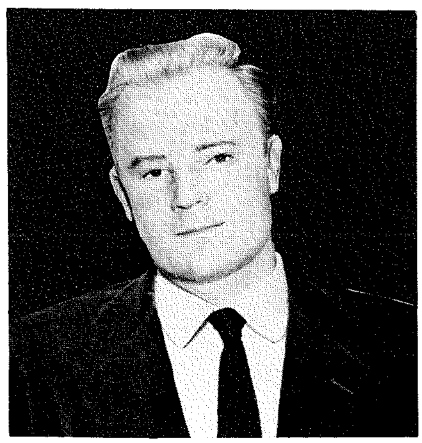
PAUL J. BURNS, covering Manufacturing Engineering, received a BS degree in EE and a BS degree in Business (Marketing) in 1952, attending Regis College and the University of Colorado. He joined RCA in 1952 as a Trainee, and was permanently assigned to the Marion Plant, November of that year. Mr. Burns is now in Process Engineering working on Exhaust problems. He is a member of the A.I.E.E. and Sigma Tau, and is a licensed "ham" (W9ZTR).

JAN DEGRAAD, covering Parts Plant Engineering, received a BS degree in Industrial Engineering from Oklahoma A&M in 1951. He joined RCA at Harrison the same year, later transferring to Marion as a Manufacturing Engineer. Mr. DeGraad has worked on presses, material inspection, specifications, product finishing and development projects.

Paul J. Burns



Jan De Graad



## THREE FELLOWSHIPS AWARDED TO RCA PRODUCT ENGINEERS

**MR. DAVID LOBEL,** ENGINEER CLASS B, ENGINEERING PRODUCTS DIVISION, has received an RCA Employee Fellowship at the Moore School of Electrical Engineering, University of Pennsylvania, in the academic year, 1955-1956.

Mr. Lobel was graduated second in his class from the Moore School in 1952, with a BS in EE. He is planning to work toward the MS in EE at the Moore School this Fall. The award was made to Mr. Lobel for his outstanding work on the Delta Computer of the Mod II Airborne System. He is a member of Eta Kappa Nu, Tau Beta Pi, IRE, AIEE, and the Philadelphia Engineers Club.

**MR. WHEELER JOHNSON,** MACHINE DESIGN ENGINEER, CLASS B, TUBE DIVISION, has been awarded the Employee Fellowship at M.I.T. in the academic year, 1955-1956.

Mr. Johnson received the BS in EE degree at Montana State College in 1950, and joined RCA Tube Division as a Draftsman Designer in Electrical Machine Design the same year. He was awarded the Employee Fellowship because of his conscientious, reliable and highly-productive work.

In September, 1954, Mr. Johnson was granted a leave of absence to attend M.I.T., where he has since been simultaneously engaged as Research Assistant and enrolled in a full schedule of courses leading to the degree of MS in EE. He plans to complete the degree requirements in June, 1956.

**MR. WILLIAM J. HANNAN,** ENGINEER CLASS B, THEATER AND INDUSTRIAL EQUIPMENT ENGINEERING, ENGINEERING PRODUCTS DIVISION, has been awarded an Employee Fellowship to continue graduate work in Electrical Engineering at the Polytechnic Institute of Brooklyn during the academic year, 1955-1956. Mr. Hannan received the MS in EE degree from the same Institute in June of this year under a previously awarded RCA sponsored scholarship.

In his work, Mr. Hannan contributed greatly to the first application of portable TV pick-ups. He developed the circuits for the TV-Eye low cost television pickup system introduced by RCA in 1953.

Mr. Hannan graduated with honors from RCA Institutes in 1951 and was employed immediately as a Student Engineer. He received his BS in EE degree at Drexel Evening College in 1954.

**NEW TECHNICAL PRODUCTS SHOWN AT NARTB CONVENTION . . .** A new type of color TV camera chain (TK-41), made possible by the RCA-developed all-in-one color signal processing amplifier. The new camera chain, principally because of the processing amplifier, represents a 25 per cent reduction of the price of color TV camera equipment.

The smallest, most economical high-power transmitter developed by RCA for UHF color and black-and-white TV broadcasting. A 25-kw model, the new transmitter will enable broadcasters to achieve million-watt ERP at minimum cost.

RCA's "Ampliphase" AM radio broadcast transmitter which requires half the space of comparable broadcasting equipment and reduces operating costs by 50 per cent.

RCA Color Effects Equipment which will enable broadcasters to originate color commercials, program titles, and station identification from black-and-white slides and artwork.

An RCA Universal Multiplexer (TP-15) which permits multiplexing of both single-V monochrome and 3-V color film camera chains so that the same projectors can be used for both color and monochrome film projection.

## EPD PRODUCT INSTALLATIONS

**150-MILE MICROWAVE SYSTEM COMPLETED IN UTAH; WILL BUILD SECOND . . .** The Engineering Products Division announced completion of a 150-mile microwave radio relay system for the Utah Power and Light Company and receipt of a contract for a second system, extending the new microwave network approximately 40 miles. The installation uses RCA CW-20A equipment to provide voice, telemetering, and supervisory control circuits connecting the utility's Terminal Substation with its four power plants. The second system will use the same equipment to add a fifth power plant to the network.

**RCA NEARS COMPLETION OF SECOND MEGAWATT STATION . . .** The second megawatt UHF television broadcast station in this country is nearing completion at KPTV, Portland, Ore. An RCA 25-kw transmitter has already been installed and tested, and with the raising of the high-gain pylon antenna, the station will vastly increase its broadcast coverage.

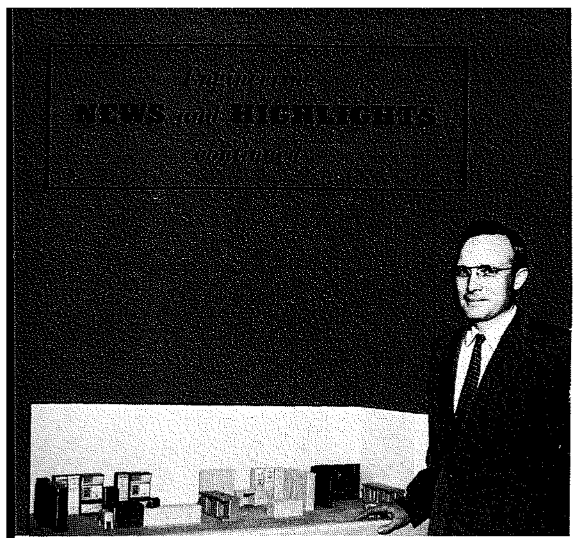
The first megawatt station is WBRE-TV, Wilkes-Barre, Pa., which went into operation in December, 1954 (see *Engineering the World's First 1,000 Kilowatt Television Station,* RCA ENGINEER, Vol. I, No. 1).

**FIFTH MICROWAVE SYSTEM COMPLETED FOR ARIZONA COMPANY . . .** Completion of a fifth microwave radio relay system which extends to more than 500 miles the microwave network now linking power stations of the Arizona Public Service Company, Phoenix, was announced late in June. The new system provides a 175-mile communications link between the power utility's installations at Phoenix and Yuma, Arizona. The Phoenix-Yuma link is inter-connected with the four previous RCA microwave installations.

## ENGINEERING TRAINING COMMITTEE

Members of the RCA Engineering Training Committee are shown above, after being welcomed to the Moorestown Engineering Plant by J. E. Love, Manager, Administration, Missile and Radar Engineering. They are, reading from left to right: R. L. Klem, Harrison; R. Haklisch, Camden; M. O. Pyle, Cherry Hill; F. A. Jordano, Lancaster; G. J. Honeyford, Moorestown; Miss B. A. Duval, Committee Chairman, Camden; J. F. Hirlinger, Harrison; T. J. Finan, Camden; J. E. Love, Moorestown; G. L. Dimmick, Camden; A. W. Tramel, Camden; P. R. Wakefield, Harrison; D. G. Garvin, Lancaster; Dr. L. Headrick, Lancaster; M. E. Shaw, Harrison; J. L. Cashman, Moorestown. Committee members not present are C. J. Boylan, Camden; J. T. Cimorelli, Camden; C. M. Sinnett, Cherry Hill; and A. M. Warner, Cherry Hill.

**ENGINEERING TRAINING COMMITTEE MEETS AT MOORESTOWN . . .** The RCA Engineering Training Committee held their latest meeting at the Moorestown Engineering Plant on May 12, 1955. The Training Committee, composed of Engineering and Training representatives from the various Product and Service Divisions, has been working on the development of a basic training program for new engineers. This program was completed by the committee at this meeting and is being circulated among Chief Engineers, Division Personnel Managers and local representatives for official approval.



H. W. Collar, Manager of Aviation Systems Engineering, is shown with a mock-up of Computer Room Equipment, planned for the Aviation Systems Section. These plans are part of the multi-million dollar expansion program currently under way at the Moorestown Engineering Plant.

**MOORESTOWN AVIATION SYSTEMS PLANS COMPUTER ROOM** . . . The equipment in the pictured mock-up comprise the computers which complement and supplement the systems engineer. The problem simulation on these computers is an important phase of systems engineering in the field of airborne electronics, integrating the airframe, armament, autopilot, radar, communications, etc.

The Aviation Systems Section makes the over-all plans and engineers the early study phase of a project. The information used as an input to these electronic devices includes the raw data and also the operations of functions of the new techniques found in laboratory and flight experiments. The equipment represented includes two types of analog computers and also data-handling devices which store information of magnetic tape.

Aviation Systems Engineering work at the RCA Moorestown Engineering Plant is carried on under the direction of H. W. Collar.

## ENGINEERING DATA AND CATALOGUES

**NEW TUBE DIVISION PUBLICATIONS . . .** BULLETIN—RCA-2N77 Junction Transistor for low-power audio applications where extreme stability is paramount (tentative data)

BULLETIN—RCA-2N104 Junction Transistor for low-power audio applications where extreme stability is paramount (tentative data)

BULLETIN—RCA-2N105 Junction Transistor for low-power audio applications where extreme stability is paramount (tentative data)

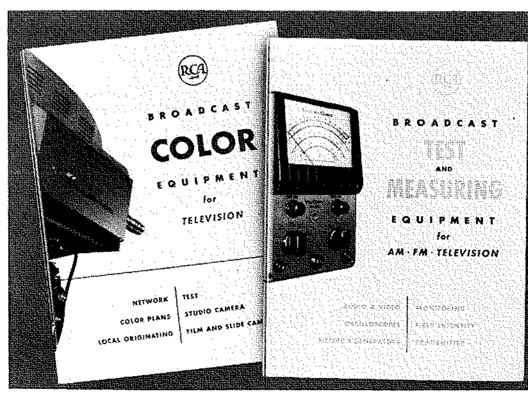
RCA SERVICE PARTS DIRECTORY SP-1035 contains circuit diagrams and parts lists for all 1954 RCA television receivers.

POWER AND GAS TUBES PG-101B a new technical catalogue.


**NEW MANUAL FOR MICROWAVE RADIO RELAY SYSTEMS** . . . A new 226-page service manual on wave propagation and other aspects of VHF and microwave radio relay systems has been prepared by the Government Service Engineering of the RCA Service Company, Inc. The publication, titled "Point-to-Point Radio Relay Systems—44 MC to 13,000 MC" was designed for use by electronics engineers, technicians and students, and is available from the Government Service Department, RCA Service Company at $2.00 each.

**REPLACEMENT GUIDE LISTS RCA DEFLECTION COMPONENTS FOR ALL MAKES TV RECEIVERS** . . . A new, up-to-the-minute, alphabetically listed catalog of the TV deflection components which RCA designs and manufactures for all makes of TV receivers was recently published by the RCA Tube Division. Entitled, "RCA TV Deflection Components Replacement Guide," this easy-to-read listing will help to determine quickly which RCA TV deflection component is needed for each replacement job.

**TWO CATALOGS ON TECHNICAL EQUIPMENT FOR BROADCAST STATIONS** . . . Two new catalogs, each about 100 pages, were recently announced by the Broadcast Marketing Section. Complete with technical descriptions, engineering specifications, curves, photos and data, these catalogs cover the following subjects: (1) Broadcast Test and Measuring Equipment for AM, FM and Television, and (2) Broadcast Color Equipment for Television Stations. Each book includes typical plans and layouts to assist Station Planning Engineers.




## COMMITTEE APPOINTMENTS

**EPD ENGINEERING . . .** D. P. BURKHART, Computer Engineering, has been appointed Vice Chairman, Executive Committee of the Professional Group on Electronic Computers, Phila. Section of IRE.

DANIEL HOCHMAN, Communications Engineering, has been elected Secretary, Professional Group on Microwave Theory and Techniques, Phila. Section of IRE.

R. L. MCCOLLAR, Airborne Fire Control Engineering, has been selected Chairman, Membership Committee of the Professional Group on Aeronautical and Navigational Electronics, Phila. Section of IRE.

L. S. BENSKY, General Engineering Development, has been elected Secretary, Executive Committee of the Professional Group on Electronic Computers, Phila. Section of IRE.

J. E. EISELEIN, Technical Adminstration, has been re-elected to serve on the Administrative Committee, Professional Group on Industrial Electronics, Phila. Section of IRE.

T. H. STORY, Surface Communications Engineering, has been elected Vice-Chairman of the Communications Group, Phila. Section of AIEE.

### TUBE DIVISION ENGINEERING

GEORGE M. ROSE, Manager, Advanced Development, Receiving Tube Operations Department, Tube Division, Harrison, N. J., has been appointed to the "Industry Advisory Committee" of Fairleigh Dickinson College, Rutherford, N. J.

### RECORD DIVISION ENGINEERING

DR. A. M. MAX, Manager, Chemical and Physical Laboratory, Record Engineering, Indianapolis Plant, was a delegate from the Indianapolis branch of the American Electroplaters Society to their national convention held in Cleveland, Ohio, during the week of June 20, 1955.

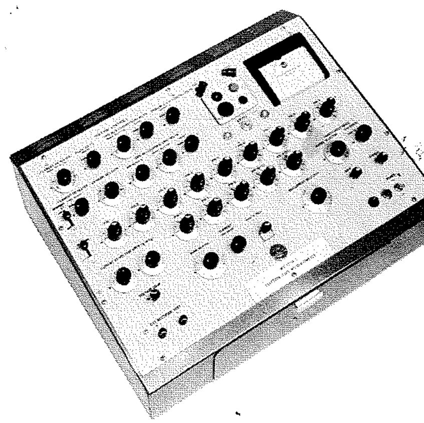
MR. M. L. WHITEHURST, also of the local chapter of the American Electroplaters Society, and also in attendance at the June 20 Convention in Cleveland, has been elected chairman of the Paper Committee. This will be a local project to present a paper on "Filter Media" at the 1956 National convention to be held in Washington, D. C.

**NEW 12-INCH HIGH-FIDELITY SPEAKER INTRODUCED BY TUBE DIV. . . .** The new speaker (RCA-502S1), with an exceptionally wide frequency response, embodies acoustical principles developed by Dr. Harry F. Olson, Director, Acoustical and Electromechanical Research Laboratory of the RCA Laboratories, Princeton, N. J. The speaker has a frequency response from 40 to 16,000 cps, an 8-ohm aluminum voice coil, and is rated at 12 watts. A specially curved cone is used to provide wide dispersion of sound. This response, usually found only in more expensive speakers results from a mechanically terminated cone and the use of high-efficiency low-mass mechanical elements throughout the electro-acoustical system.

**FOUR NEW AMPLIFIERS FOR USE WITH SCHOOL AND INDUSTRIAL SOUND SYSTEMS ANNOUNCED . . .** The new sound system amplifiers include a 30-watt type with inputs for four microphones and one phonograph (SA-32-A); a 15-watt type with inputs for two microphones and one phonograph (SA-15-A); and a 10-watt type with inputs for one microphone and phonograph (SA-10-C). All but the 10-watt type also provide two plug-in receptacles for loudspeaker connection.

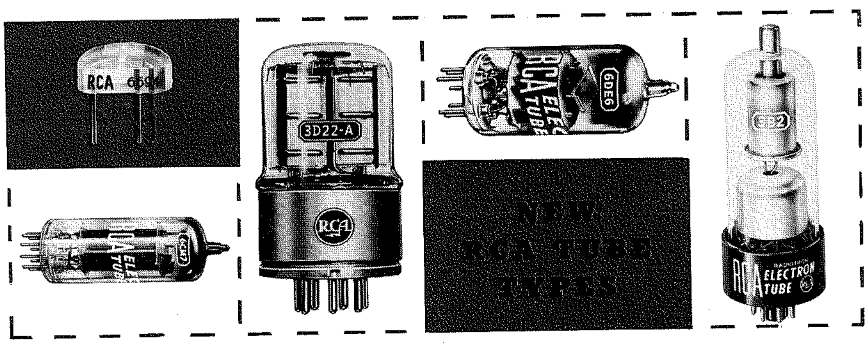
**NEW "LAB-TYPE" TUBE TESTER INTRODUCED BY RCA . . .** The instrument, called the WT-100A Electron Tube MicroMhoMeter, is intended primarily for production-line and laboratory tube testing of receiving and small industrial and transmitting tubes. In addition to the obvious advantages of checking tube characteristics at published ratings, the WT-100A can be set up to provide the operating voltages of a circuit of specific design. The performance of a tube under the desired voltage conditions thus can be quickly and accurately determined.

The MicroMhoMeter measures true transconductance, both control grid-to-plate ($G_m$) and suppressor-grid-to-plate; currents to all elements of tubes, except to the cathode, and the voltage drop across elec-



tron tubes, including gas types, dry-disc rectifiers, and crystal diodes.

The WT-100A measures transconductance with an accuracy of better than 5 per cent (maintained up to 100,000 micromhos in 6 ranges); permits the measurement of a-c heater currents (including series string tubes) at rated voltages; measured electrode currents up to 300 ma in 11 ranges, including an ultra-sensitive range of 0 to 3 ma; measures voltages up to 300 volts in 15 ranges. The WT-100A has an electronically protected burn-out proof meter and regulated power supplies for all voltages.




**RCA-6CM7** is a medium-mu dual triode for use as a vertical deflection oscillator and vertical deflection amplifier in television receivers. The tube contains two dissimilar units in one envelope, and has a 600-milliampere heater. Unit No. 1 is designed for use as a conventional blocking oscillator, and unit No. 2 is a high-perveance triode for use as a vertical deflection amplifier. The nine-pin basing arrangement facilitates use of the 6CM7 in printed circuits.

**RCA-6DE6** is a 7-pin miniature type sharp-cutoff pentode designed especially for use in the gain-controlled picture i-f stages of television receivers utilizing an i-f of 40 mc. The tube features a controlled grid No-1 voltage of —5.5 volts for a $G_m$ of 600 micromhos minimum, which permits the elimination of the agc amplifier in certain receiver designs. The 6DE6 has high $G_m$ combined with low capacitance values, providing high gain per stage.

**RCA-6694** is a very small cadmium-sulfide photoconductive cell of the head-on type designed especially for light applications where a single tiny photosensitive device is required. The cell features high luminous sensitivity, extremely low background noise, and signal output directly proportional to the intensity of the light falling upon the cell. It is useful for light-controlled relay applications, computer systems and is light meters for measuring the brightness of small luminous spots.

**RCA-3D22-A** is a sensitive four-electrode thyratron with indirectly heated cathode, designed for use in relay and grid-controlled rectifier applications. When used for d-c voltage control, two 3D22-A's in a full-wave circuit with resistive load are capable of handling up to 660 watts at a d-c output up to about 410 volts. When used for a-c voltage control, two of the tubes in a full-wave circuit are capable of handling up to 800 watts.

**RCA-3B2** is a double-ended, glass-octal type half-wave rectifier utilizing an indirectly heated cathode, for use in rectifying high-voltage pulses produced in the scanning systems of television receivers. The tube is rated to withstand a maximum peak inverse plate voltage of 35-kc (absolute), a peak plate current of 80 ma and a maximum average plate current of 1.1 ma.

RCA Report presented to engineers. Panel members, left to right: Harry Krieger, Jr., M. C. Batsel, and S. W. Cochran.

**ENGINEERING PRODUCTS DIVISION PANEL PRESENTS RCA REPORT . . .** Harry Krieger, Jr., Manager, Engineering Personnel, emceed the second annual panel presentation of the RCA Report to Engineering Employees on May 2nd. M. C. Batsel, Chief Engineer, discussed Company policy and answered questions of policy submitted by members of the audience. S. W. Cochran, Manager of Engineering Administration, interpreted the financial statistics as presented by the published report and as reflected in the questions submitted by the audience.

*Engineering*

## NEWS *and* HIGHLIGHTS

*continued*

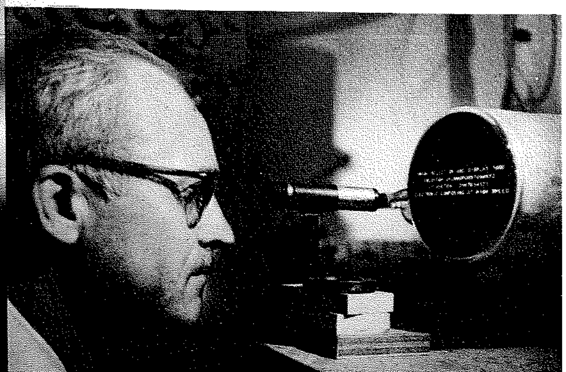
**RCA ENGINEERS ACTIVE AT DAYTON IRE . . .** Twelve RCA product engineers from Camden, Moorestown and Harrison Plants combined to present 11 engineering papers at the National Conference on Aeronautical Electronics at Dayton, Ohio, May 9, 10, and 11, 1955. This meeting, which is national in scope, is sponsored by the Dayton Section of IRE and the professional group on Aeronautical and Navigational Electronics.

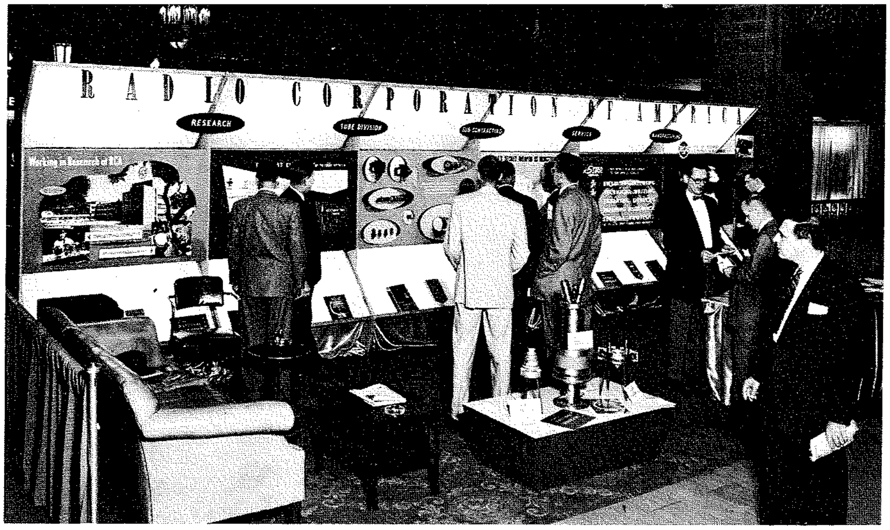
The 11 professional technical papers given by RCA product engineers covered a wide variety of subjects in the engineering field and are listed here with the participating engineer indicated. For summaries of these papers, see *"PEN AND PODIUM"* in this issue.

**PAPERS GIVEN BY RCA AT DAYTON IRE**

1. A New Packaging Design Well Suited to Automation
   D. H. Westwood (Moorestown)
2. Transistor Communications Receiver
   H. J. Woll (Camden)
3. Measuring, Assessing and Predicting Equipment Reliability
   C. M. Ryerson (Camden)
4. Field Support of Complex Airborne Electronic Equipment
   H. W. Brown, Jr. (Camden)
5. Analysis of Systems Containing Digital Computers. . E. Arthurs (Moorestown)
6. Feedback Control Systems Using Sampled Data
   L. E. Mertens (Moorestown)
7. Study of Noise Reduction by Feedback in Ultra-high Frequency Amplifiers
   A. B. Glenn (Camden)
8. Developmental Low Noise T-W Tubes for L, S and C-Band. . P. R. Wakefield and A. G. Hogg (Harrison)
9. A Developmental High Power Tunable X-Band Pulse Magnetron for Airborne Applications. . . W. F. Beltz (Harrison)
10. Pod-mounted Electronic Equipment Has Advantages
    H. A. Brelsford (Camden)
11. 8.5-15 CM. Plate Pulsed Reentrant Oscillator Circuits Using Pencil Triode Type 5893
    W. E. Babcock (Harrison)

**NEW TUBE TRANSLATES CODE INTO WORDS AND FIGURES . . .** Warren H. Bliss, RCA Laboratories, is shown inspecting resolution of letters and figures in the face of the new RCA electron-image tube which can translate coded information at rates up to 100,000 words a minute. The device is expected to find application in electronic message transmission and computing systems, and ultimately in general printing as an electronic means of typesetting.





RCA Display at Dayton IRE Show

## ENGINEERING MEETINGS AND CONVENTIONS

### *August-October, 1955*

**AUGUST 15-19**
*AIEE Pacific General Meeting*
*Butte, Montana*

**AUGUST 22-23**
*Symposium on Electronics and Automatic Production*
*(Sponsored by Stanford Research Institute and NICB, San Francisco)*

**AUGUST 24-SEPTEMBER 3**
*The National Radio Show*
*Earls Court, London, England*
*(Preview for overseas visitors August 23)*

**AUGUST 24-26**
*1955 WESCON*
*Civil Auditorium and Fairmount Hotel, San Francisco, California*

**AUGUST 26-28**
*Sixteenth Annual Summer Seminar*
*Emporium Section IRE*
*Emporium, Pa.*

**AUGUST 26-SEPTEMBER 4**
*Great German Radio, Gramophone and TV Exhibition*
*Dusseldorf, Germany*

**SEPTEMBER 12-16**
*Tenth Annual Instrument Conference and Exhibit, ISA*
*Shrine Exposition Hall*
*Los Angeles, Cal.*

**SEPTEMBER 14-16**
*1955 Annual Meeting of the Association for Computing Machinery*
*University of Pennsylvania*
*Philadelphia, Pa.*

**SEPTEMBER 17**
*Symposium on Automation*
*Cedar Rapids IRE*
*Cedar Rapids, Ia.*

**SEPTEMBER 19-20**
*Symposium on Electronic Automation*
*University of Pennsylvania*
*Philadelphia, Pa.*

**SEPTEMBER 26-27**
*RETMA Symposium, Electronics for Automation and Automation for Electronics*
*Philadelphia, Pa.*

**SEPTEMBER 28-29**
*Industrial Electronics Conference*
*AIRR*
*Rackham Memorial Auditorium*
*Detroit, Michigan*

**OCTOBER 3-5**
*National Electronics Conference*
*Hotel Sherman*
*Chicago, Illinois*

**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 Radio Fall Meeting*
*Hotel Syracuse*
*Syracuse, N. Y.*

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

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

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

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

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

# RCA ENGINEER EDITORIAL REPRESENTATIVES

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

## ENGINEERING PRODUCTS DIVISION

E. D. BLODGETT, *Chairman, Editorial Board*

**Editorial Representatives**

- J. A. BAUER, *Theater & Industrial Engineering, Camden, N. J.*
- J. BIEWENER, *Aviation Systems Development, Moorestown, N. J.*
- M. BOCCIARELLI, *Secretary, Editorial Board*
- T. T. N. BUCHER, *Surface Communications Engineering, Camden, N. J.*
- H. E. COSTON, *Engineering Administration, Standards & Services, Camden, N. J.*
- J. P. GILMORE, *Shoran & Specialties Engineering, Camden, N. J.*
- T. G. GREENE, *Missile & Radar Engineering, Moorestown, N. J.*
- W. K. HALSTEAD, *Computer Engineering, Camden, N. J.*
- H. KRIEGER, JR., *Engineering Personnel, Camden, N. J.*
- D. G. C. LUCK, *Aviation Electronics Engineering, Camden, N. J.*
- C. MCMORROW, *Aviation Engineering, Camden, N. J.*
- W. A. PATTERSON, *Aviation Engineering, Camden, N. J.*
- J. L. PETTUS, *"EPD" Engineering, Hollywood, Calif.*
- J. H. PRATT, *"EPD" Engineering, Los Angeles, Calif.*
- J. H. ROE, *Broadcast Studio, Antenna & Transmitter Engineering, Camden, N. J.*
- H. E. ROYS, *Optics, Sound & Special Engineering, Camden, N. J.*
- L. M. SEEBERGER, *General Engineering Development, Camden, N. J.*
- B. F. WHEELER, *Communications Engineering, Camden, N. J.*

## TUBE DIVISION

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

**Editorial Representatives**

- E. D. FLECKENSTEIN, *Cathode Ray & Power Tubes, Lancaster, Pa.*
- D. G. GARVIN, *Color Kinescopes, Lancaster, Pa.*
- A. E. HOGGETT, *Receiving Tubes, Cincinnati, Ohio*
- R. L. KLEM, *Receiving Tubes, Harrison, N. J.*
- J. KOFF, *Receiving Tubes, Woodbridge, N. J.*
- P. M. LUFKIN, *Electronic Components, Findlay, Ohio*
- E. E. MOORE, *Electronic Components, Camden, N. J.*
- J. W. RITCEY, *Semi-Conductors, Harrison, N. J.*
- M. N. SLATER, *Black & White Kinescopes, Marion, Ind.*
- L. H. URDANG, *Receiving Tubes, Indianapolis, Ind.*

## RCA VICTOR TELEVISION DIVISION

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

**Editorial Representatives**

- R. D. FLOOD, *Color TV Engineering, Cherry Hill, N. J.*
- F. KSIAZEK, *Black & White TV Engineering, Cherry Hill, N. J.*
- R. W. SONNENFELDT, *Advanced Development Engineering, Cherry Hill, N. J.*
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