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VOL. 2, NO. 2 • **AUG -SEPT., 1956**

RCA ENGINEER

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

OBJECTIVES

To disseminate to RCA engineers technical information of professional value.

●

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

●

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

●

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

●

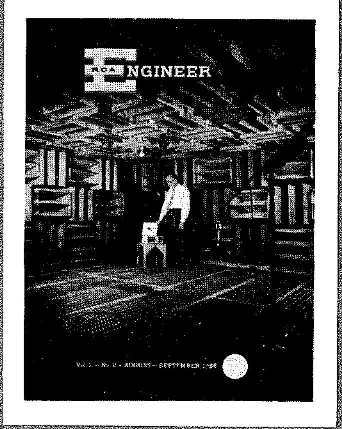
To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.

●

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

●

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



OUR COVER

Our cover this issue shows the interior of one of the Anechoic Chambers at Cherry Hill. A small, portable receiver is shown as it would be set up for acoustic measurements. S. V. Perry has just completed making adjustments to the instrument. The measurements are made by means of a microphone in the room and electrical equipment located outside the room. See "The Anechoic Chambers at Cherry Hill" by M. S. Corrington, R. L. Libbey and S. V. Perry in this issue.

TEAMWORK IN ENGINEERING

Probably the reason the word "teamwork" is used so widely is because it has so much meaning. In Electronics engineering, teamwork is particularly significant, since it can mean the difference between technical leadership and mediocrity!

Steady progress depends upon the ability of engineers and scientists to apply complex technical knowledge to the design of practical new products and creation of new services. This requires the combined talents of entire groups of RCA engineers on a broad scale, representing various company locations. To solve a particular design problem, the engineer may find it necessary to utilize a wide variety of technical information involving several allied activities. For example, the engineer working mainly on the electrical design considerations of a product may discover that successful completion of his work depends upon the mechanical design of a new device or the development of a new component or material.

Therefore, close contact or "teamwork" with engineers in other activities is essential. It is a good way for the engineer to initiate and stimulate ideas which will be helpful in solving his particular design problem.

At RCA, engineering teamwork is being fostered in many ways. Technical lectures, courses and seminars provide methods of "pooling" abilities. Engineering group meetings, technical society meetings, personal contacts, letters and technical reports are other ways of furthering team work. Another method is in the publication of information in technical journals for the benefit of all other engineers. An avenue for accomplishing this is through the pages of the *RCA ENGINEER!*

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HOW TO GET YOUR IDEA ACCEPTED

An engineer is an individual who adapts materials and energy to practical human use. As such he must have a consuming interest in solving practical problems, and a consuming curiosity about the workings of inanimate objects. It is perhaps this same mental drive which makes some engineers technically competent, and yet poor investments for their employers.

As a group, engineers are people with an oversized "bump of curiosity." They are driven by a desire to know the answers. Having found the answers, however, the matter becomes routine; they tend to lose interest, and turn to other unsolved problems. It is an occupational hazard of the engineer that there is always another unsolved problem pressing for his attention. Under these conditions it is not surprising that a substantial portion of engineering progress remains buried in notebooks, or obscure files. Why pursue the matter further when the answer has been found? Got to keep moving . . . There's work to be done. . . .

To further bedevil the engineer is the fact that some problems are "catastrophes," while others are only "routine." Work started on a lesser project is apt to be dropped during an all-out effort to save the ship. Such projects are relegated to "fill-in" status, to be worked on in those slack periods which never come. Eventually they are forgotten. It is unfortunate that the sum total of forgotten little problems may have as much effect on an enterprise as one of the catastrophes for which they were forgotten.

Finally, there is the natural human tendency to feel that what is important to one's self is important to others. When a man has been wrestling with a tricky problem, and he finds what appears to be the answer, he is somewhat taken aback if others cannot seem to muster enthusiasm comparable to his own. After several such experiences, the engineer may begin to doubt himelf or his superiors, and that is the beginning of real trouble.

By **ROBERT A. BERGMAN**

Tube Division
Marion, Indiana

In short then, it may be said that because of the unpredictable nature of engineering work, and because of the variable work-load, effort is wasted. At times, this situation leads to disappointments for both the employer and the engineer.

ONE BITE AT A TIME

An answer to the handling of the "little" problems is for the engineer to plug steadily away at each one until he solves it, or meets diminishing returns, or until the matter becomes obsolete. He must not question the importance of a problem once he has started to work on it. It is difficult to know what "unimportant" problems of today will be the big ones of tomorrow. If a problem is important enough to work on at all, it is important enough to finish. The completion of a problem may mean writing a report to be read by the proper people; it may mean circulating a Proposal for Change, or ordering a certain piece of equipment. It may even mean writing a report saying that the idea investigated was not feasible; in any case, some conclusion should be reached and acted upon. A problem should never be shelved until it has left the engineer's notebook in some form. Only then should the engineer's attention be given to additional problems.

HUMAN RELATIONS

The fact that the engineer's primary interests lie with energy, materials, and ideas, sometimes tends to put him at a disadvantage in his dealings with people. For example, having pursued a series of tests to a successful conclusion, he may feel that the matter is now self-evident. It seems to be an imposition when people expect him to defend his ideas. Actually, the converse is true: it is the man with the new ideas who is to some extent imposing upon those who must take the trouble to study his proposals, and arrive at their own conclusions. They must change their ideas, and relinquish the security of the old tested method by going out on a limb for the new proposal. When considered in this way, it becomes clear that the burden of broadcasting facts and creating a receptive audience for his idea rests squarely upon the originator.

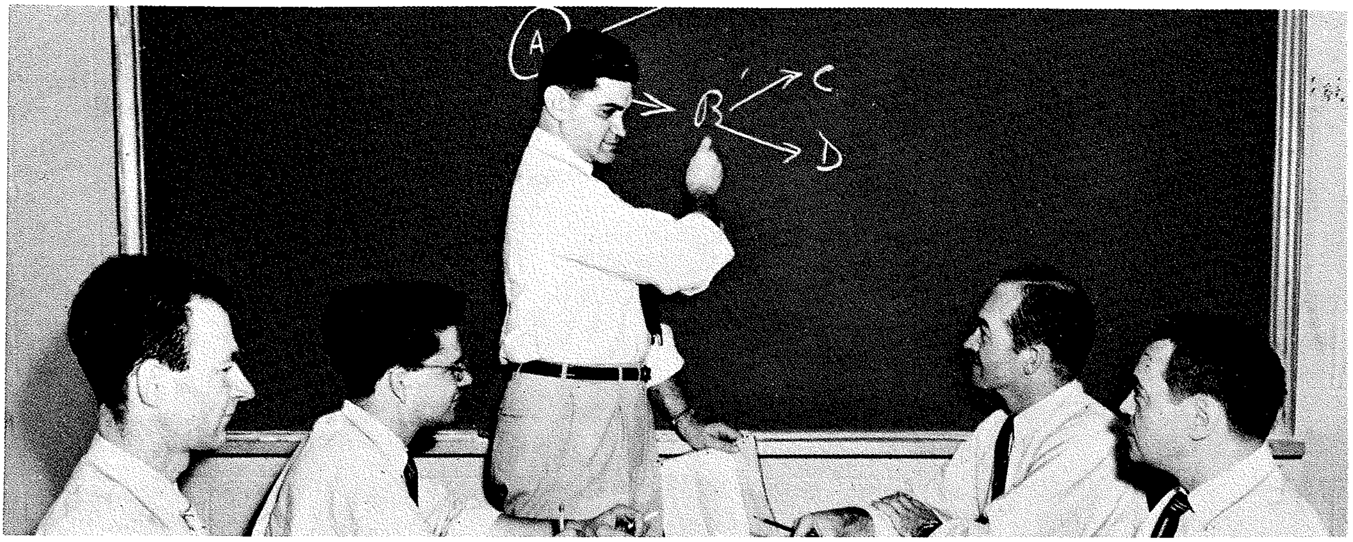
SELLING OUR IDEAS

It is a rather safe bet that a supervisor will be strongly motivated by most of the following considerations:

a. Reluctance to slow down or stop a production line.
b. Reluctance to change any current procedure which apparently is satisfactory.
c. Eagerness to achieve cost reductions and to prevent cost increases.

ROBERT A. BERGMAN received the B.S. degree in Chemistry from Queens College, N. Y. in 1944, and has taken graduate courses at Brooklyn College, N. Y. During the war, he served as an aerial photographic officer. From 1947 to 1950, he was employed at the Brooklyn Naval Ship Yard as an analytical chemist. From 1950 to 1955, he held the position of supervisory inspector of the Pittsburgh area for the Army Chemical Corps. He joined the Tube Division of the Radio Corporation of America in Marion, Indiana in 1955, and is presently a member of the newly formed Phosphor Development activity of the Black-and-White Kinescope Operations Department.

Mr. Bergman is a member of the American Chemical Society, the American Society for Quality Control, and the Biological Photographic Association.



The author is shown at the blackboard during the presentation of an idea to a group of engineers who are, left to right: John Peters, Albert P. Vermette, Joseph C. Dobie and Tom Hudgins.

d. Keen desire for quality improvement.
e. His knowledge of what the competition is doing.
f. Company policies.
g. Timeliness of the idea.
h. His opinion of the person trying to convince him.

An engineer and the merit of the idea he is proposing must meet the test of all these factors and perhaps more, before convincing anyone.

How can we, who innocently happened upon what we think is a good idea, prevent it from being lost in the merry-go-round of daily business?

First, be very sure that the idea is as good and as important as it looks. Would its adoption create problems elsewhere in the organization? Can we write down some good reasons why the idea is an improvement in terms of money, quality, safety, or competitive position? These reasons should not be merely opinions, but should be backed by convincing evidence. One excellent way to deflate unworthy ideas is to subject them to the friendly criticism of fellow workers. A small, informal discussion group can point out flaws in one's reasoning, or gaps in one's data with disconcerting ease. If the idea survives this treatment, it probably has merit. Do not neglect the contributions which can be made by one's supervisor, the boss. He should be consulted throughout the development of the idea for criticisms and suggestions. When the idea comes back to him in finished form, it will reflect his mature judgment and experience, and will stand a much better chance of success. However, we are not ready to make our move. We, who have lived intimately with this project are convinced that it is a wonderful idea. The boss does not yet know all those little details which served to convince us. So we DON'T CALL UP OUR BOSS!

We gather together all the facts, with any data, prints, models, sketches or samples which may be needed to illustrate our case quickly and clearly.

CALL UP THE BOSS!

Now, we mentally review the presentation, the data; make sure that all the demonstrations will work as expected, and that the evidence indicates what we think it does. Then CALL UP THE BOSS.

In calling, try to arrange for a definite time. In this way we will not have to make a hurried or an interrupted presentation of our case, and the boss' attention will not be distracted by ringing telephones, other callers, or the pressure of his business. The essential point is to secure full and uninterrupted attention for the necessary period. The boss' work too is full of big sized and little sized problems, and if a bigger one comes along while he is listening to us, ours might become lost in the shuffle.

We now make our presentation as we have planned it, always allowing for the problems our boss will have with HIS boss if he OK's our proposal. Provide him with plenty of good reasons why he should want to see it accomplished. We are not likely to have more success in selling our idea than he thinks he will have higher up.

Suppose it is not our own boss who must be convinced; any industrial manager will be strongly motivated by most of the same principles: cost reduction, quality improvement, sales appeal, safety. In the case when one must convince people outside of the immediate "family," the reasons given must be particularly convincing, direct, and well documented, since these people are less likely to be able to fill in any gaps in our presentation.

THE ULTIMATE INGREDIENT

The final ingredient in selling ideas, as in selling anything else, is to be sold oneself. The true beliefs of the speaker will show through his presentation, and cannot fail to have a great influence upon the listener. Therefore, if an engineer is truly convinced of the merit of the idea he is selling, he need only tell others why he is convinced, and show the evidence. If his conviction is justified from the evidence, no reasonable man can fail to share it.

Whether management with its knowledge of sales objectives, competitive position, and all the other factors involved in making innovations, sees fit to adopt the new idea, is now out of the hands of the engineer. He has made it known to the people who can act upon it. If adopted, he stands ready to see his idea into practice; if not, he can feel that he has done his job, and may turn to that next unsolved problem which he has been aching to tackle. . . .

THE A-F ANECHOIC[1] CHAMBERS AT CHERRY HILL

by **MURLAN S. CORRINGTON and ROBERT L. LIBBEY**
RCA Victor Television Division
and
SYDNEY V. PERRY
RCA Victor Radio and "Victrola" Division
Cherry Hill, N. J.

When acoustical measurements are made on sound waves, any reflections or echoes due to nearby objects will change the sound field and cause errors in the results. Echo-free measurements can be obtained in a large, unobstructed, outdoor field. However, unwanted sounds from airplanes, birds, or automobiles often make accurate outdoor data difficult to obtain. Wind and inclement weather may hamper or prevent the work. To eliminate these difficulties of outdoor measurements, it is necessary to approximate ideal free-field conditions in a special room. The extent to which such a room simulates actual free-field conditions depends upon its size, construction, and acoustical treatment.

WALLS MUST ABSORB THE SOUND

A large room with sound-absorbing walls is desirable for an anechoic chamber. As the size of the room is decreased, the path difference between the direct and reflected waves decreases and the two waves become more nearly equal in intensity. This causes larger errors due to the addition and subtraction of the reflected wave.

In a small room, acoustical treatment can be used to make the room approximate the conditions of free space. The only limitation is that enough acoustical absorption be used on the walls. The action of acoustical absorbing material can be analyzed using transmission-line theory. Air can be thought of as a transmission line for sound. In the case of an open field, this air transmission line is infinitely long and there are no reflections. In an anechoic chamber the transmission line becomes finite in length. If the proper kind and amount of material can be used to match the impedance and terminate the line, no reflections will occur.

OUTSIDE NOISES EXCLUDED

Construction of an anechoic chamber must also provide isolation from external mechanical vibration and air-borne noise. If the chamber is placed in a building where other activities are going on, there may be considerable unwanted noise and vibration. Air-borne noise can be excluded by the use of heavy, non-porous masonry construction. Double walls provide additional isolation by giving a "room within a room." The inner room can be completely suspended upon springs to prevent the transmission of external mechanical vibrations.

Isolation must also be considered when installing signal cables, power, lighting, and air conditioning. The air conditioning duct may permit unwanted sound to enter if it is not properly designed. It must be well damped to prevent the entire duct from resonating as a pipe. The air passage in the duct must also be treated acoustically to prevent the inflowing air from causing noise.

An anechoic chamber must be accessible and convenient. It must be relatively easy to move large television or "Victrola" cabinets in and out of the room. It should be possible to place microphones anywhere in the room without undue effort or risk of damage. It is often difficult to provide this accessibility and still keep the isolation of the inner chamber.

CHAMBERS ARE ON SECOND FLOOR

Most sound rooms are mounted on solid foundations which are deep in the ground. At Cherry Hill it was necessary to build the rooms on the second floor of a large building, with very limited headroom between the concrete floor and ceiling slabs. It was necessary to isolate against mechanical vibrations in the building, and to design for the greatest possible headroom within the chamber. Two rooms were built, one for the Television Division and one for the Radio and "Victrola" Division.

DOUBLE-SHELL CONSTRUCTION

Both anechoic chambers are of the double-shell construction, as shown by Figs. 1 and 2. The outer shell of each

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[1] A sound measuring room is usually referred to as an anechoic chamber. The word "anechoic" is from the Greek an-echoic and refers to the fact that sound reflections or echoes in these rooms have been nearly eliminated.

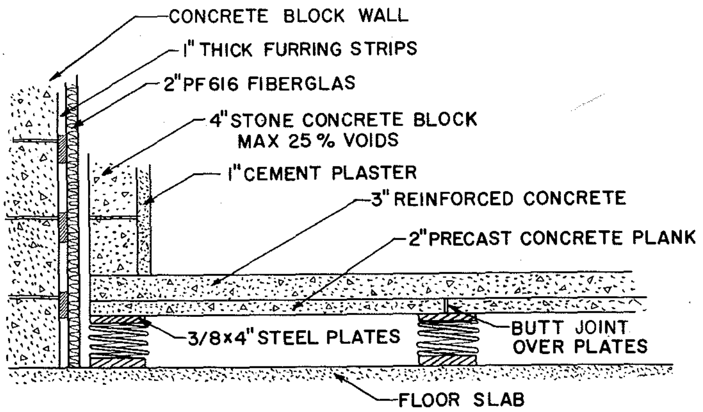

Fig. 1—Details of Floor Construction

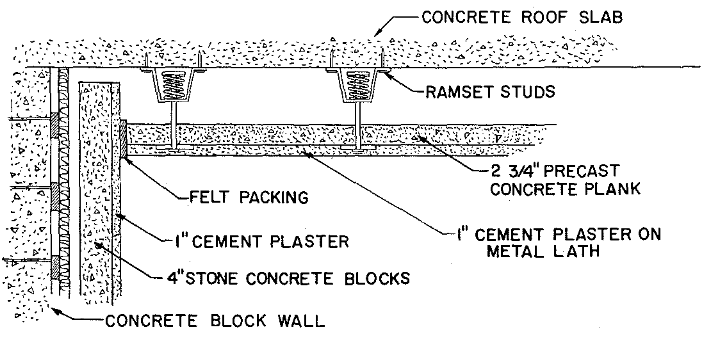

Fig. 2—Details of Ceiling Construction

consists of four concrete block walls which stand on the concrete floor slab of the building, and extend to the concrete roof slab. Air leakage through the mortar joints and blocks is sealed off by a one-inch-thick non-porous coating of cement plaster on the inner surfaces.

The inner surfaces of the outer walls and the roof slab are lined with two inches of Fiberglas PF615[2] mounted on and spaced from the wall by one-inch-thick furring strips. This lining is used to absorb whatever sound may get into the space between walls. This reduces the sound transmission to the inner wall.

INNER SHELL MOUNTED ON SPRINGS

The inner shell of each chamber is a complete masonry box isolated from the outer shell and from the building by steel springs, as shown by Figs. 1 and 2. The spring details are shown by Figs. 3(a) and 3(b).

The springs reduce the transmission of mechanical vibrations from the building into the walls of the inner shell, and thence into the air inside the inner chamber. These springs, when loaded by the completed room, each have a static deflection of one-half inch, thereby giving the structure a natural frequency of mechanical vibration of 4.4 cycles per second in the vertical direction. The theoretical maximum reduction of vibration which can be produced by this system in the audible range is 26 db at 20 cps, and increases 12 db per octave at higher frequencies.

This amount of isolation is attained if the damping is zero. In order to approach this theoretical maximum isolation no resistive (or frictional) damping was employed in the spring suspension system. Such a system could build up excessive amplitudes of motion at frequencies near its natural resonance (in this case, between 3 cps and 6 cps) if subjected to sufficiently great and prolonged exciting forces. In this case it was assumed that no such forces would exist; an assumption that has so far been verified by experience.

SPRING DETAILS

The side walls and the floor of the inner chamber are all supported as a unit by one set of compression springs located under the floor, as shown in Figs. 1 and 3(b). Each spring unit is made of one-half-inch spring-steel rod wound into a helix of four inches outer diameter. There are suitable metal end caps at each end of the helix, and a one-quarter inch thick rubber pad under the lower end cap. The rubber pad reduces the transmission of unwanted high frequencies through the spring and thence into the floor slab. The overall loaded height of these units is 3¼ inches. These spring units carry a working load of 625 pounds each. The floor and ceiling springs were designed and manufactured for the job by Robinson Aviation Inc. of Teterboro, New Jersey.

The four-inch outer diameter of the spring helix was chosen to give good mechanical stability horizontally, and to give the completed structure approximately the same natural period horizontally that it has vertically.

In the anechoic room used by the Television Division the weight of the floor slab is supported by 45 of these spring units spaced uniformly approximately 38 inches (center-to-center) under its entire area. The weight of the side walls is supported by 57 more of these units spaced approximately 15 inches apart under the floor slab around its outer edge. Each row of springs is bolted to a steel bar ⅜ by 4 inches laid flat, to properly distribute the load into the concrete slab.

The Radio and "Victrola" Division room is slightly larger, and additional springs were used for the added weight.

FLOOR SLAB AND WALLS

The floor slab is a three-inch-thick layer of reinforced concrete poured over two-inch-thick precast concrete planks, laid on the steel bars. This design facilitated construction since no wood forms were required under the concrete to support it during the setting period. The side walls are of concrete block and mortar construction, lined with a one-inch layer of cement plaster to seal off all leakage through the mortar or blocks. The total weight of the floor slab and walls is about 32 tons.

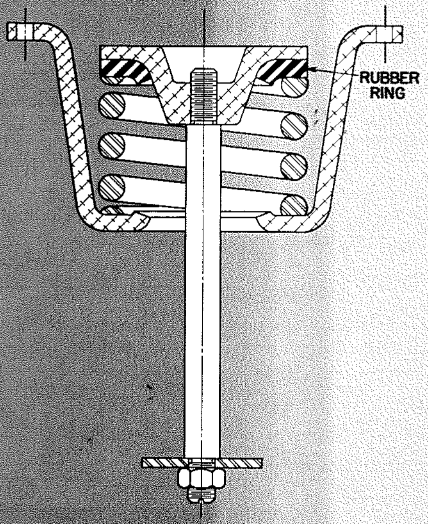

Fig. 3(a)—Ceiling Spring

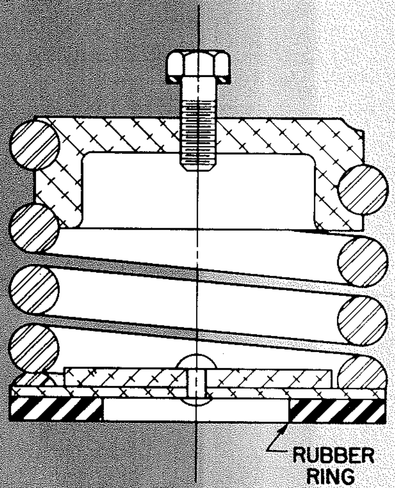

Fig. 3(b)—Floor Spring

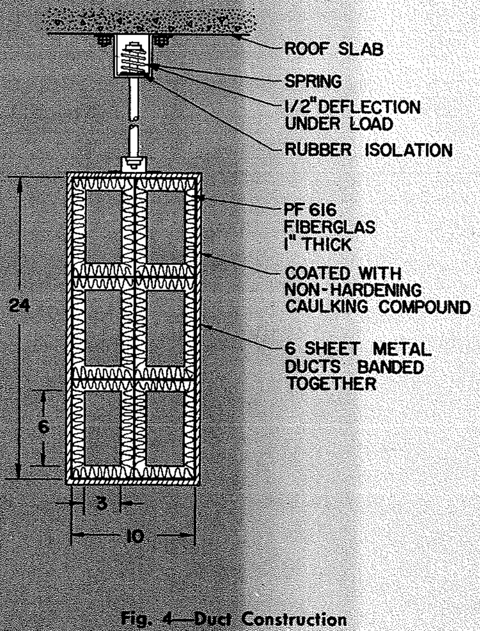

Fig. 4—Duct Construction

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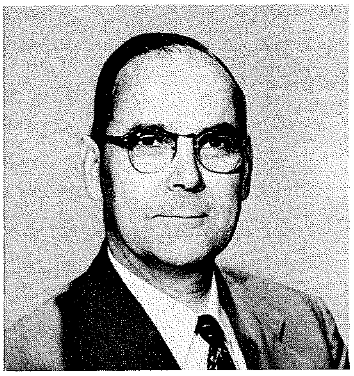
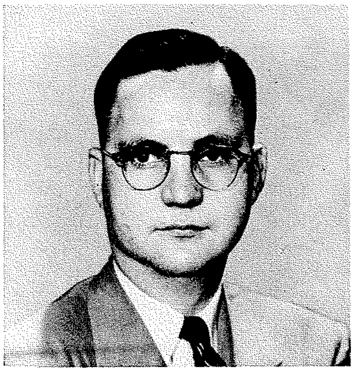
[2] Manufactured by Owens-Corning Fiberglas Corp.

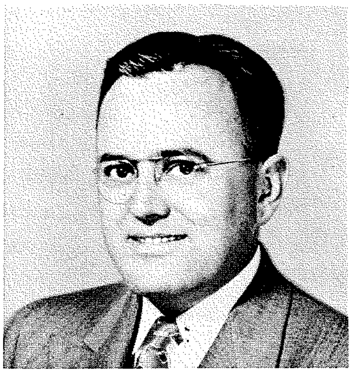


SYDNEY V. PERRY, a native of England, was graduated from Queens University at Kingston, Ontario, Canada in 1923. He immediately joined the RCA organization through the then affiliated Westinghouse Company at East Pittsburgh, Pennsylvania. Mr. Perry has been in loud speaker and acoustic work since 1925. He is a member of I.R.E. and has several patents to his credit.

Since 1938 Mr. Perry has been concerned chiefly with the over-all audio and acoustic performance of radios, phonographs, and television instruments. He developed the "Golden Throat" tone system which included the correlation of amplifier, controls, loud speaker, and cabinet. More recently he developed the "Panoramic Sound System." He is now engaged in loud speaker and acoustic work in Radio & "Victrola" Division.



ROBERT L. LIBBEY received his B.S. in E.E. from the University of Wyoming in 1950 and a Master's Degree in Speech and Dramatics two years later. As an undergraduate and graduate student he was Supervisor of Radio at the University of Wyoming; Chief Engineer of radio station KOWB, Laramie, Wyoming; and Chief Engineer of radio station KCVO, Missoula, Montana. In 1952 Mr. Libbey joined RCA as a specialized trainee. Since the completion of his training program he has been a member of the Advanced Development Section of the RCA Victor Television Division, where he has worked on magnetic recording and miniature transistor circuits. He is now engaged in audio and acoustic development and is responsible for the acoustic approval of all TV receivers. Mr. Libbey is a member of I.R.E.



MURLAN S. CORRINGTON received the B.S. Degree in E.E. in 1934 from the South Dakota School of Mines and Technology, and the M.S. Degree in 1936 from Ohio State University. From 1935 to 1937 he was a graduate assistant in the Physics Department of Ohio State University. In 1937 he joined the Rochester Institute of Technology where he taught mathematics, mechanics, and related subjects. Since 1942 Mr. Corrington has been engaged in mathematical engineering in the Advanced Development Section of the RCA Victor Television Division. He is presently manager of Audio, Acoustics, and Antennas for the Section. Mr. Corrington is a member of Sigma Pi Sigma, the Acoustical Society of America, the Society for Industrial and Applied Mathematics, and a Fellow of I.R.E. He holds many national offices in I.R.E. and is Chairman of Philadelphia Section. He has written many technical papers in the fields of audio, FM and circuit theory. He is the author of two textbooks.

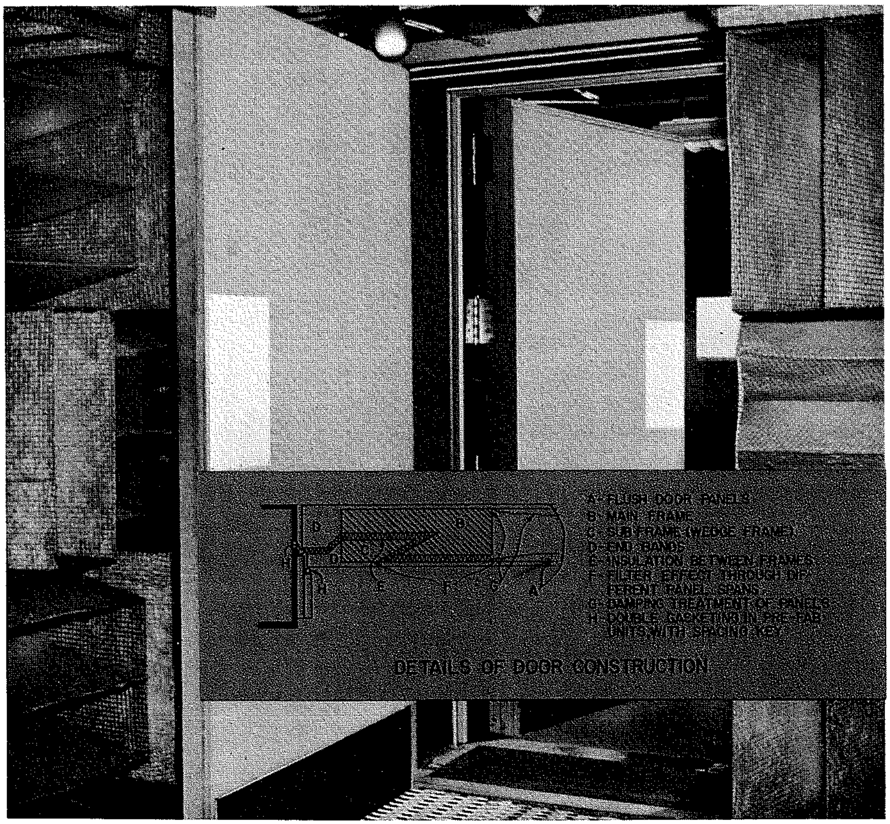


Fig. 5—A view from the interior of the TV Division Anechoic Chamber showing the double-door, soundproof construction which employs a dead-air space in between (total depth of doors and air space is about 2 feet). Inset is a sketch showing details of door construction.

CEILING DETAILS

The ceiling of the TV Division room is very similar in construction to the floor slab, and is illustrated in Fig. 2. It does not rest on top of the side walls as in ordinary construction, but is suspended from the roof slab by 45 steel spring units uniformly spaced over the entire ceiling area (each carrying 300 pounds). This avoids deep wall-to-wall beams, saving greatly needed head room. There is a one-half inch space all around between the suspended ceiling and the walls which is packed tightly with felt to reduce sound leakage. The total weight of the ceiling (including the internal acoustical treatment), is about 7 tons.

ROOM DIMENSIONS

The floor of the inner chamber is $8\frac{7}{8}$ inches above the floor slab of the building, and the lower surface of the ceiling is $7\frac{1}{4}$ inches below the roof slab of the building. The inside head room before installation of the acoustic treatment was almost 9′2″. This is felt to be very good, since

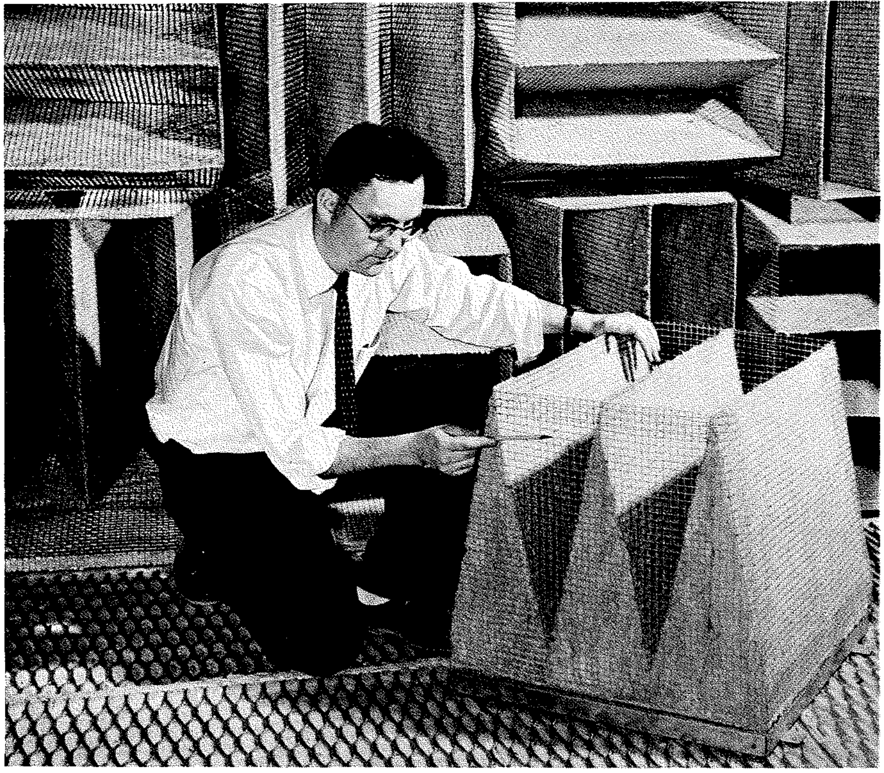


Fig. 6—Robert Libbey of the Advanced Development Section is pointing to a cube-shaped, Fiberglas wedge unit like those used in the construction of the TV Division Anechoic Chamber. About 200 such units (approx. 2′ x 2′ x 2′) were used.

the head room of the building is only 10′6″. The floor dimensions of this room (before acoustic treatment) were 21′9″ x 20′1″.

The anechoic chamber used by the Radio and "Victrola" Division is similar in construction to the room described above, but differs in floor dimensions which are 21′7″ x 24′7″.

AIR CONDITIONING SYSTEM

The ventilation system was designed to supply an adequate volume of air at sufficiently low velocity to prevent wind noise, through a duct system designed for minimum leakage of noise from outside sources. Conditioned air from the distribution system of the building is brought into each anechoic chamber through a relatively long (14 feet) multitubular duct or plenum chamber, as illustrated in Fig. 4. Each tube of this duct is completely lined with one-inch-thick Fiberglas, PF616, held in place by metal clips and by wire screen on the inside of the Fiberglas.

The group of tubes is held together with metal bands on the outside. The entire unit and suspension is completely coated with a nonhardening caulking compound applied irregularly to break up and damp out any panel resonances. The entire assembly is suspended from the building roof slab by steel spring and rubber "isolators" designed to have one-half inch deflection under load, the same as the inner chamber and its ceiling.

The duct assembly is located in the space between walls, and passes through the outer wall through a felt-lined opening. It is connected to the air distribution duct system of the building through a neoprene flexible connection to prevent the direct conduction of outside noises through the metal ductwork. The inner end of the duct opens into the inner chamber through a felt-lined opening, located near one corner of the chamber, diagonally opposite from the doorway. The exhaust is through the doorway, which is kept open at all times, except when measurements are in process. When the door is closed, the air flow is automatically stopped during measurements. This system has proved to be quite adequate in actual operation.

SOUNDPROOF DOORS

The doors of the inner and outer chambers were designed and built for these rooms by the Munchhausen Soundproofing Company, Inc., of New York. They are shown in the photograph of Fig. 5, and their cross section is illustrated in the sketch. They are of wood-frame and flush-panel construction, so made that the inside panel and frame and the outside panel and frame are separated from each other by a layer of felt. The inner and outer panels are held together by a dove-tail construction so that no nails or other fasteners pass through the felt from one panel to the other.

When closed, the side and top leakage is sealed off by closely fitting double-gaskets of highly compliant and resilient material. The bottom is closed by two felt "drop seals" which drop when the door is closed and raise up when it is opened. Each door is closed by an ordinary door check. As a safety precaution there is no latch or lock. The inner door is rated at 35 db attenuation, and the outer door at 45 db attenuation.

WEDGE DESIGN

The internal acoustical treatment of the walls and ceiling consists of Fiberglas wedges designed in accord with the curves of Beranek and Sleeper,[3] and made by The Eckel Corporation, Cambridge, Mass. The wedges were designed to absorb nearly all energy above 125 cps. Below this point the absorption decreases with frequency. Because of headroom limitations, the wedges were built in cubes two feet on a side as shown by the photograph of Fig. 6. Each one consists of an angle-iron base with lugs for fastening to the furring strips behind them. Each wedge is covered with one-half-inch mesh hardware cloth as shown. The completed room, with wedges in place, is shown by Fig. 7 and by the front cover.

FLOOR COVERING

The available head room in the rooms prevented the use of wedges on the floor. This, of course, limited both the absorption of low frequencies and the isolation from external noise and vibrations. However, by careful design it is believed that optimum results were obtained from the available space.

Several types of PF Fiberglas were measured in a four-inch acoustical transmission line to determine the absorption and the acoustical impedance. A study of the impedance as a function of frequency indicated that the maximum absorption for a layer 5 inches thick was obtained by using

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[3] L. L. Beranek and H. P. Sleeper, Jr., The Design and Construction of Anechoic Sound Chambers, Jour. Acoust. Soc. Amer., vol. 18, pp. 140-150; July, 1946.

1 inch of PF613 on the concrete floor covered with 1 inch of PF616, followed by 1 inch of PF613 and 2 inches of PF616. An expanded metal grating was used as a walk above the Fiberglas.

PERFORMANCE OF THE ANECHOIC CHAMBERS

The performance of an anechoic chamber is dependent upon the way it is used. In the low-frequency region reflections may produce standing waves and the intensity of these standing waves will change from one part of the room to another. Likewise, the effect of the reflections depends upon the size, number, and spacing of the sound sources. The anechoic chambers described herein are used to check instruments with several sound sources (loud speakers) as often as they are used to check on a single source in a large baffle.

INVERSE-DISTANCE LAW

If the room is free from reflections, the sound pressure from a simple point source will decrease inversely with the distance from the source. That is, the pressure will decrease two to one (or six decibels) each time the distance from source to microphone is doubled. Any deviation from the inverse-distance law gives an indication of the performance of the room at the frequency of the signal.

Fig. 7 shows the performance of the room as measured with a twelve-inch loudspeaker in a small box. This is an accurate copy of a normalized set of curves taken in the Television Division anechoic chamber. They have been shifted the proper amount to allow for the inverse-distance law. For a point source in a perfect room the curves should coincide. At the low-frequency end the results are within 2½ decibels of ideal. In the mid-frequency range the accuracy is very good. At high frequencies the deviations are due to the changing plane of the source.

Often it is impossible to establish the exact plane of the source at high frequencies. For instance, for a twelve-inch extended-range loud speaker several parts of the cone may be radiating if the frequency is above 10,000 cps.[4] In this case, the *exact* source of sound may move with frequency. Thus, it might appear that the inverse relationship is not holding.

CONCLUSIONS

Two anechoic chambers have been built at Cherry Hill on the second floor of the Engineering Building. They are so well isolated from the rest of the building that the ambient noise is too low to measure on the most-sensitive scale of a General Radio Sound Level Meter. They are completely air conditioned and are well suited to acoustical research and development work on radio and television receivers.

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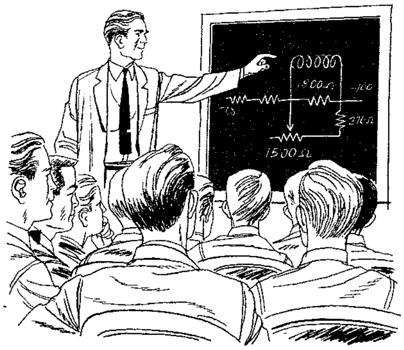
[4] Murlan S. Corrington and Marshall C. Kidd, Amplitude and Phase Measurements on Loudspeaker Cones, Proc. IRE, vol. 39, no. 9. pp. 1021-1026; Sept. 1951.

Fig. 7—Curves showing the variation of Sound Pressure with distance are printed over a photo which shows wedges and floor of TV Division's Anechoic Room. R. L. Libbey (left) and M. S. Corrington are adjusting the distance of the microphone from a TV receiver in preparation for acoustic measurements.

PROFESSIONAL TRAINING AT RCA

Editor's Note: This article gives a brief description of four distinct programs organized for the further training of RCA engineers and engineering students. It serves as an introduction to more detailed articles on training programs planned for later publication.



by **R. C. GIES**
Engineering Training
Defense Electronic Products
Camden, N. J.

The chief asset of any organization is its people. This is particularly true in an industry which depends so heavily upon creative ideas. RCA, recognizing the need to attract and fully utilize talented engineering personnel, has an extensive training program to aid the professional growth of all its engineers.

SPECIALIZED TRAINING PROGRAM

To help engineering students to bridge the gap between the college campus and the complex framework of modern industry, RCA's College Relations Section contacts interested students in colleges and universities throughout the United States. Career opportunities are discussed and the individual's qualifications matched with needs for engineering manpower. Successful candidates are eligible, upon graduation, for the *Specialized Training Program.* The purpose of this program is to aid recent college graduates to find work for which they are best suited and in which they can be prepared for positions of greater skill and responsibility within the Company. To accomplish this, each trainee is given four five-week assignments to different activities. During these rotating assignments, experienced counselors in the various engineering activities continue the careful individual guidance begun during selection. The assignments acquaint trainees with engineering operations of different departments and help to determine the best positions for trainees based upon RCA needs, and abilities and preferences.

TRAINING FOR NEW ENGINEERS

Once assigned to a particular activity, the second phase of the Specialized Training Program consists of more specific assignments designed to integrate the trainee into the activity and to make him a productive member of the engineering team. New engineers employed out of industry (and Specialized Trainees in the second phase of their program) receive training support in the form of *RCA's Training Program for New Engineers.*

This new program for training engineers has at its purpose the effective utilization of the new engineer. During the engineer's first year, his supervisor conducts a series of job introduction discussions covering such information as the engineer's responsibilities, procedures in obtaining needed equipment and services, need for good record keeping and filing, reference material pertaining to engineering and manufacturing standards, the product line economic situation and future development and opportunity for the professional engineer. To aid him in his relationships with others, instruction in human relations is offered during this period by the Training Manager or a designated representative. In addition, a series of sessions designed to acquaint the new engineer with other activities and procedures with which he will be in contact is scheduled. Completing the program are sessions on problem solving, report writing, business, and personal growth.

RCA TUITION LOAN AND REFUND PLAN

Although the Program for New Engineers is expected to provide the answers to many training needs, there are other training opportunities for those who desire further self-development. The *RCA Tuition Loan and Refund Plan* is designed to encourage employees to prepare for positions of greater responsibility within the Company by taking appropriate courses at an approved educational institution or correspondence schools.

Tuition loans are offered, if desired, and participating employees are granted a tuition refund upon successful completion of a course. In the Camden area, for example, such schools as the University of Pennsylvania, Temple University and Drexel Institute of Technology offer a variety of courses of interest to engineers. There are many employees seeking Bachelor's, Master's or Ph.D. degrees through the plan, although a degree goal is not necessary to take courses which increase the engineer's qualifications.

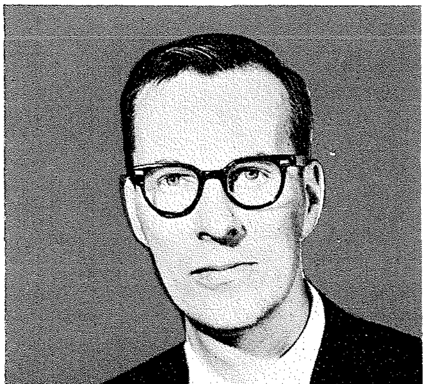
THE TECHNICAL PROGRAM

Another popular program conducted outside of working hours is the Technical Program. This program supplements courses available through local universities. Specialized technical training is conducted using RCA facilities and instructors. Such subjects as Transistor Circuit Fundamentals, Engineering Data Analysis, Random Processes and Communication Theory, and Engineering Accounting and Finance are currently being offered.

SUMMARY

The training programs summarized so far—The Specialized Training Program, The Training Program for New Engineers, The Tuition Loan and Refund Plan, and The Technical Program—are basic programs designed to assure all engineers the opportunity for planned training to increase personal effectiveness and to prepare for advancement. Supervisory and management courses are also offered to aid the supervisor in his many responsibilities. The goal is to provide facilities for career training which parallel and promote the individual's professional development as a member of RCA.

RICHARD C. GIES, Training Specialist, received his B.S. degree in Education from Rutgers University and has taken graduate work at Rutgers and the University of Pennsylvania. He joined RCA in January 1956. Mr. Gies served 1943-46 and 1950-52 in the U. S. Navy in the fields of gunnery, radar, fighter direction, radio and communications. From 1947 until he joined RCA, Mr. Gies was with the Insurance Company of North America, where he was Senior Fire Insurance Instructor in the Education and Employment Department.



THE RCA AVQ-10 COMMERCIAL AIRLINE WEATHER RADAR

Photo Courtesy United Air Lines

Editor's Note: Weather Radar is a comparative newcomer as a navigational aid to commercial air travel. Commercial acceptance of RCA weather radar was fully realized in the latter part of May, 1956, when, at San Remo, Italy, the Ninth Technical Conference of the International Air Transport Association (IATA) turned out with a rousing vote of confidence for world acceptance of RCA AVQ-10 equipment.

The IATA conference was attended by approximately 300 delegates, representing the world's leading airlines, airframe manufacturers, military and civil aviation bodies and aviation electronics manufacturers. Among the conclusions the delegates took away from the conference were:

1. That weather radar was highly desirable, if not mandatory.
2. That RCA equipment was the best on the market and consequently was the most widely used.

From the Chairman's Summary of Discussion, Committee B-1, the following is excerpted regarding weather radar in general:

"Tangible advantages which seemed . . . to accrue from the equipment were—avoidance of delays due to thunderstorms; avoidance of detours; lessening of maintenance due to hail, lightning and structural damage due to turbulence.

"On the intangible side . . . passenger reassurance; crew tranquility of spirit; advertising value, etc."

The excellence of engineering that went into the RCA weather radar is attested to by comments of users in strongly urging more widespread use, confidence in the reliability of the RCA products, and in the quantity of orders placed with RCA.

In the article following this, W. F. Beltz and R. W. Kissinger tell the design story on the RCA-6521 magnetron, which is the heart of this equipment. We are proud to publicize another engineering teamwork story that has led to RCA leadership in a new field of electronics.

By: **A. W. VOSE**
West Coast Engineering
Defense Electronic Products
Los Angeles, Cal.

THE turbulence associated with storm clouds of the cumulo-nimbus variety has long been recognized by our commercial airlines as a serious danger to air travel. With the ever increasing speeds of modern aircraft this danger is sure to increase.

WORLD WAR II

The display of weather echoes by radar came about quite accidentally as an unintentional by-product of military radar equipments which were designed for bombing and navigation purposes near the start of World War II. When it was discovered that radar could see water droplets about as well as it picked up ground targets, meteorologists were quick to recognize the enormous potentials of this new instrument as a weather observing and forecasting tool.

TWA TESTS

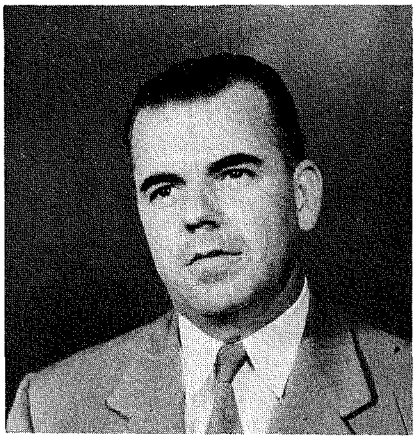
Near the end of World War II considerable interest was focused on the possibility of installing cockpit radar in airline planes for storm avoidance purposes. Trans World Airlines in late 1945 and 1946 conducted tests with an airborne set built especially for them by Bell Laboratories and Western Electric from components taken from war surplus equipment used by the military. While the immediate results of this project were somewhat disappointing, the TWA group was enthusiastic over the possibilities, and recommended that future airborne search radars should be developed specifically for storm avoidance.

AAL PROJECT

American Airlines, operating under a Navy contract, was another pioneering airline to conduct a major project looking into the application of airborne radar. The American group did some excellent work in correlating radar pictures with IFR[1] penetrations of actual thunderstorm conditions, including the development of a highly practical application of the principle of providing a second rainfall rate contour for the purpose of painting in the heavy rain cores of storms. This attachment was first known as Iso Echo Contour Circuitry, but has gradually been shortened to the simple term "Contour." This project was also credited with developing the principle of correlating heavy thunderstorm turbulence with sharp-edged radar echoes, possibly the greatest contribution of all in the development history of airborne weather avoidance radar.

WEAKNESSES OF WARTIME EQUIPMENT

In spite of the early post-war enthusiasm, it soon became evident that there was a major obstacle standing in the way of immediate adoption of airborne radar by the airlines. This was the unsatisfactory nature of the available equipment which had been built for military use and primarily for purposes other than storm avoidance. The equipment was heavy, it was subject to frequent breakdowns and—because it operated on a wavelength of 3.2 cm—it could not see



AUBREY W. VOSE, Staff Engineer on the staff of J. C. Smith, West Coast Electronic Products Engineering, DEP, attended RCA Institutes, New York, from 1937 to 1939. He started work at Westinghouse Electric Corporation, Baltimore, in 1940, on Test Equipment design and maintenance. He joined the engineering department at Westinghouse in 1942 as a design engineer on units of radar systems. In 1946 Mr. Vose became a partner of Allison Associates, Los Angeles, where he designed search radar for aircraft and acted as consultant on guided missile circuitry and theoretical study and design specifications for an optimum radar system for detection and location of schnorkling submarines.

In 1948 Mr. Vose formed the partnership of Suffield-Vose and under contract to the Houston Corporation set up production test for their radar system. He then was employed by the Houston Corporation as Chief Engineer. He joined RCA Los Angeles Engineering as Administrator of Systems Activities in 1950.

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[1] Instrument Flight Rules—"blind flying" regulations

through local heavy rain to show more distant storms. In short, the 3.2 cm radar was a useful piece of equipment for detouring storm areas, but appeared to be undependable for penetrating corridors in lines of thunderstorms on the airway.

ATA-ARINC SPECIFICATIONS

It was not until May 1, 1952 that the Air Transport Association came face to face with the problem by taking positive steps to break the bottleneck. On that date a group of interested ATA members drew up a set of ten operational requirements which was then submitted to the Airlines Electronic Engineering Committee with orders to convert the requirements into electrical characteristics. The most critical of these requirements was the one pertaining to attenuation of the radar beam by heavy rain, stating that;

> "The equipment must be capable of penetrating and displaying at short range rainfall rates of 60 mm/hr. to a depth of 15 miles."

THE McGILL STUDY

This ATA-ARINC[2] requirement practically ruled out consideration of 3.2 cm as the wavelength for the standard airline radar in the United States by virtue of its well-known attenuation characteristics at lesser rainfall rates. To make doubly certain on this point, however, ATA and ARINC contracted with McGill University to carry out a theoretical study to find the most practical wavelength for airline radar. The McGill study, produced by Drs. J. S. Marshall and Walter Hitschfield, contained the following conclusion:

> "That an operating wavelength of 5.5 cm will provide optimum performance for weather mapping radar from the standpoint of providing maximum sensitivity with minimum attenuation of signal in heavy rain."

RCA-UAL C BAND EVALUATION

Shortly after the ARINC specifications were announced United Airlines contracted with RCA to build a breadboard prototype C band radar to verify these requirements under actual flight conditions. Design of this prototype was begun at the West Coast Electronic Products Department in February of 1953 and resulted in installation of the equipment in a UAL DC-3 cargoliner on May 29th of the same year. Through the summer of 1953 this equipment was subjected to a series of 40 flight tests in thunderstorms over the Western Plains. When these tests demonstrated that C band radar would successfully meet all of the specifications, ARINC Characteristic #529 was finalized and entitled "5.5 cm Weather Penetration Airborne Radar."

AVQ-10 PROGRAM

Upon adoption and approval of ARINC Characteristic #529 by the Airlines Electronic Engineering Committee February 5, 1954 the West Coast Electronic Products Department undertook the design and manufacture of the AVQ-10 Weather Penetration Radar. The program called for completion of the first engineering model in October and delivery of the first of a series of eight flyable consignment models to the airlines for evaluation purposes in early January 1955. The first production equipments were scheduled to roll off the end of the line in June of 1955. It is gratifying to realize that the combined efforts of everyone involved not only allowed fulfillment of these three objectives, but have resulted in RCA becoming the leading producer of commercial airline radar equipment today with hundreds of AVQ-10's being installed on most of the major foreign and domestic airlines.

SPECIAL DESIGN CONSIDERATIONS

The requirements set forth in ARINC Characteristic #529 made necessary many new design concepts not encountered in previous airborne radar equipment, which was all of military origin. Such things as standardized major unit form factors, plug-in radar rack mounting, un-pressurized operation, greatly increased reliability requirements, reduced volume and weight requirements, all combined to create new problems.

C BAND MAGNETRON

One of the problems encountered in the design of the AVQ-10 was the development of a suitable magnetron. No tube was available having the necessary frequency range, power output and size factor. Tube reliability and life expectance with which the airlines had become accustomed was also entirely out of the question when applied to magnetrons of the military variety, even had one been available. As a result, the RCA Microwave Tube Division at Harrison, New Jersey under-

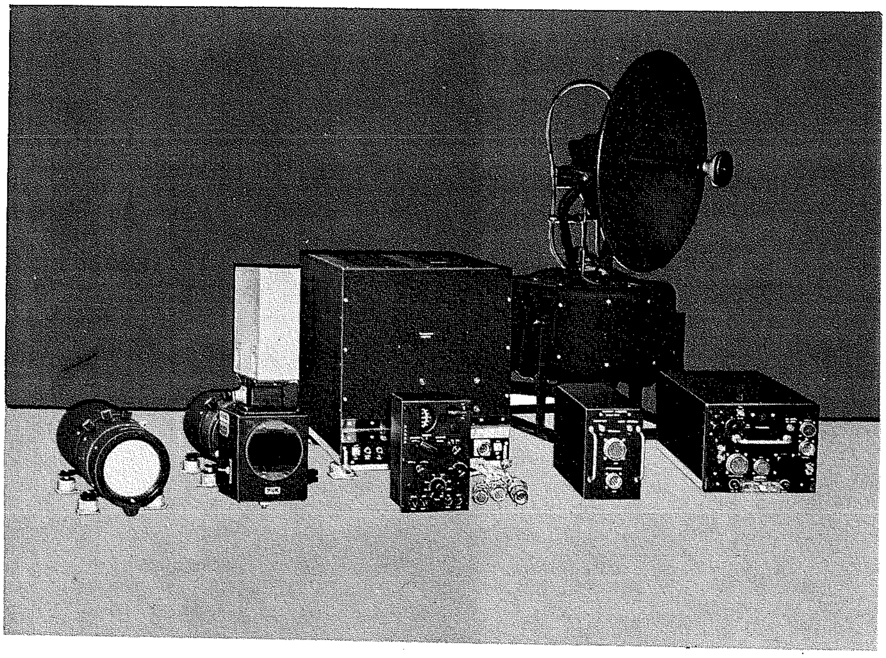

Fig. 1—RCA-UAL C Band Evaluation Equipment.

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[2] ARINC—Aeronautical Radio, Incorporated. An industry-wide engineering association.

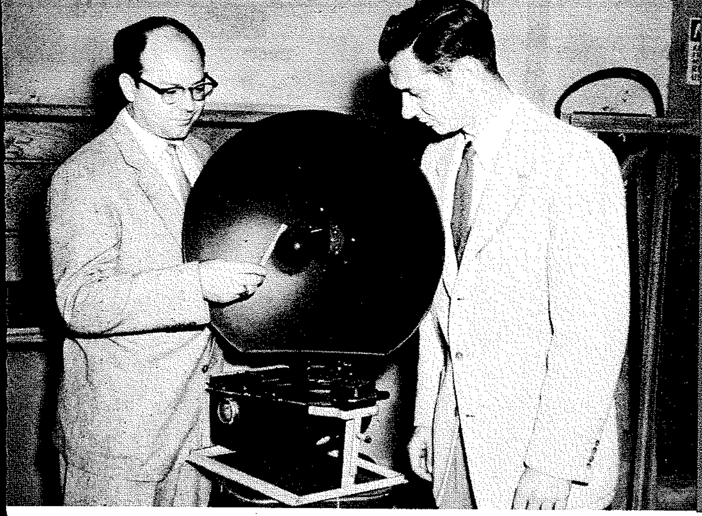

Fig. 2—D. Clark (left) and W. Perry discuss the feed system of the AVQ-10 Antenna. Mr. Clark was responsible for the mechanical design of the antenna, and Mr. Perry designed the complete radio-frequency transmission system.

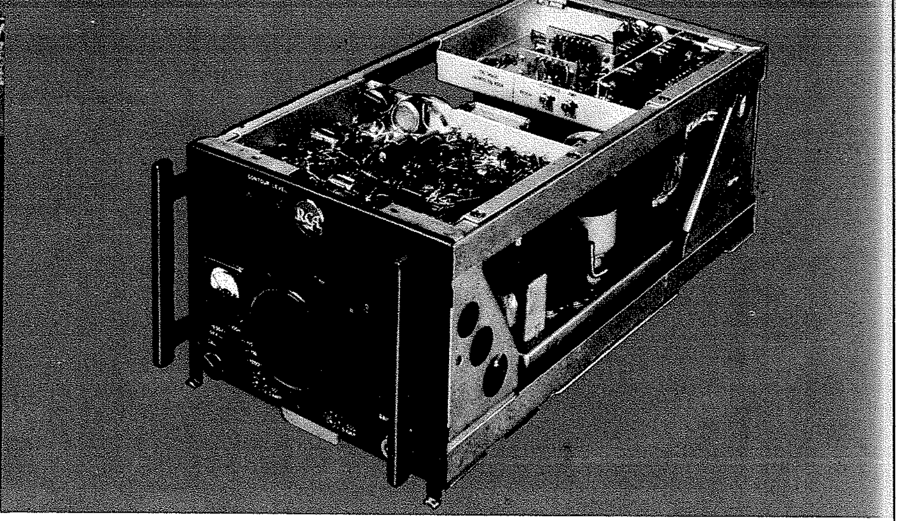

Fig. 3—AVQ-10 Accessory Unit, internal view.

took the development of a suitable C Band Magnetron. This tube, the 6521, was designed with long life and reliability of primary consideration and its record to date indicates the design goal of 2000 hours minimum life to be a reality.

ISO-ECHO CONTOUR CIRCUITRY

Results obtained during the RCA-UAL C Band Evaluation in 1953 had verified earlier work done by American Airlines that there was a definite correlation between turbulence and the sharp-edged radar echoes, ie: a sharp rainfall gradient (sharp-edged echo) is associated with severe turbulence. Contour circuitry has been incorporated into the AVQ-10 video system to make this phenomenon readily detectable to the operator. While an experienced operator can usually distinguish a less-dangerous target by its soft and fuzzy appearance on the cathode ray tube screen, the "Contour" function provides a more definite means of selection. This is done by showing two contours, one corresponding to the minimum detectable signal level and the other corresponding to a predetermined signal amplitude above this level. The first contour is defined by the outline of the target on the cathode ray tube while the second corresponds to the edge of the "hole" left when signals above the predetermined level are inverted. The separation between the contours indicates the rainfall gradient; the less the separation, the greater the rainfall gradient.

PACKAGING

The equipment is divided into five main units:

- Antenna
- Receiver Transmitter
- Accessory Unit
- Indicator
- Control Panel

All units except the Antenna are intended for installation in the pressurized cabin of the aircraft and are themselves unpressurized, with an upper limit of 16,000 ft. in altitude for satisfactory operation. Pressurization of the antenna and aircraft waveguide system is required and is provided by allowing air from the pressurized cabin to bleed into the waveguide system. The Receiver Transmitter and Accessory Unit are designed in standard 1ATR[3] size form factors for radio rack mounting with internal blowers to provide for adequate cooling.

ANTENNA

The Antenna system provides for any one of three parabolic reflector sizes: 22 inch, 30 inch and 34 inch with their respective feeds. This assembly sweeps continuously through 360° in azimuth once every four seconds, providing a beam of energy 7°, 4.5° or 4.0° wide, depending on the reflector used. Provision is made for tilting the reflector and feed assembly within the limits of 10° above and 15° below horizontal with the degree of selection determined by the Tilt Control on the Control Panel.

The Antenna is "line of sight" stabilized in both pitch and roll using for reference, voltages from the vertical gyro in the aircraft Autopilot system. Stabilization accuracy is ±2° up to ±20° excursion with additional excursion limits up to ±30° at reduced accuracy.

RECEIVER TRANSMITTER

The Receiver Transmitter is a 1ATR size case containing all the r-f circuits together with master trigger generator, i-f pre-amplifier, auto-

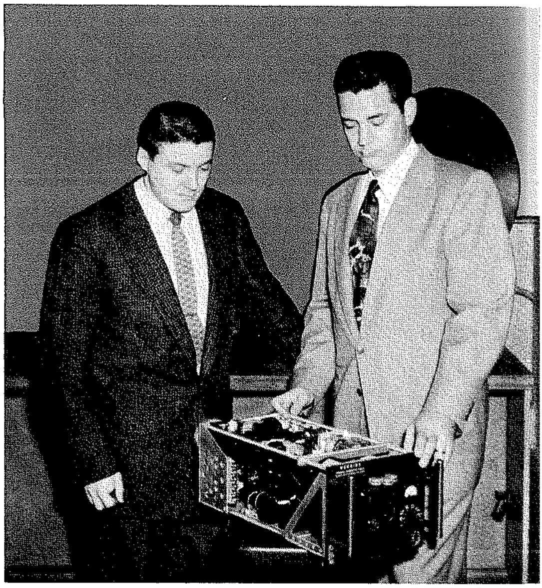

Fig. 4—N. Bingham (left) and L. Hutchison examine a production model AVQ-10 Receiver/Transmitter. Mr. Hutchison had overall responsibility for mechanical design of the R/T, Indicator and Control Panel. Mr. Bingham did detail design on the R/T.

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[3] Standard Air Transport Radio Size.

matic frequency control circuits and modulator. The transmitter section uses the 6521 5.5 cm magnetron feeding into a duplexer and directional coupler. It provides a minimum peak power output of 75 KW. The magnetron is pulsed at the line-frequency rate of 400 pps by a hydrogen thyratron delay line type AC resonant-charging modulator producing a 2 microsecond pulse. The thyratron is triggered by a pulse produced by a magnetic trigger generator operating from and synchronized to the 400 cycle supply line frequency. The magnetic trigger generator also provides timing pulses for the rest of the equipment.

The receiver section of the mixer-duplexer contains three crystals coupled to a common klystron local oscillator. In one crystal the local oscillator signal is mixed with a small portion of the magnetron output and the difference frequency is fed to the Automatic Frequency Control Unit. The output of this unit controls the frequency of the local oscillator to maintain the i-f at 60 mc in spite of drift in magnetron and local oscillator frequencies.

The second and third crystals are part of a balanced mixer assembly, the output of which is fed to the i-f preamplifier which has a bandwidth of 1.0 mc and a noise figure of 2.5 db. The overall noise figure of the complete system is approximately 12 db.

The i-f Pre-Amplifier and Automatic Frequency Control Unit are constructed as separate units which plug into the mixer-duplexer assembly.

ACCESSORY UNIT

The accessory unit is also a 1ATR size case containing all the timing circuits, stabilization circuits and low voltage power supply, plus i-f and Video amplifier circuits.

The Stabilization and Timer chassis are of the removable hinged type for easy maintenance. All wiring and components parts face the exterior of the unit and are immediately accessible upon removal of the dust cover. The stabilization section of the unit contains two similar roll and pitch amplifiers plus a tilt channel which provides the necessary signals to the antenna for roll and pitch stabilization and tilt control. The timer section contains the sweep generator, range mark generator, sensitivity time control circuits, iso-echo contour and

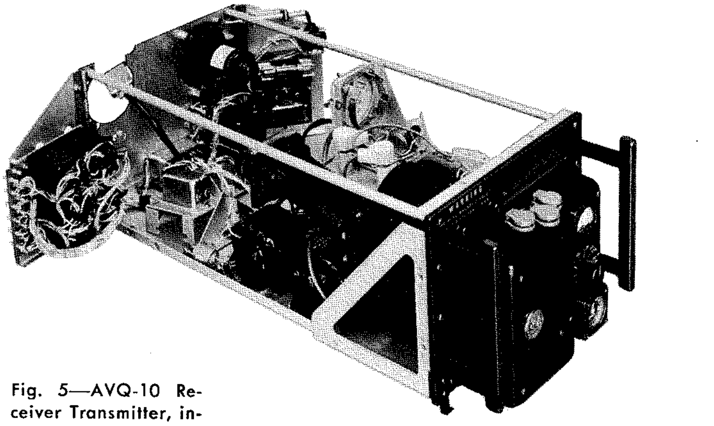


Fig. 5—AVQ-10 Receiver Transmitter, internal view.

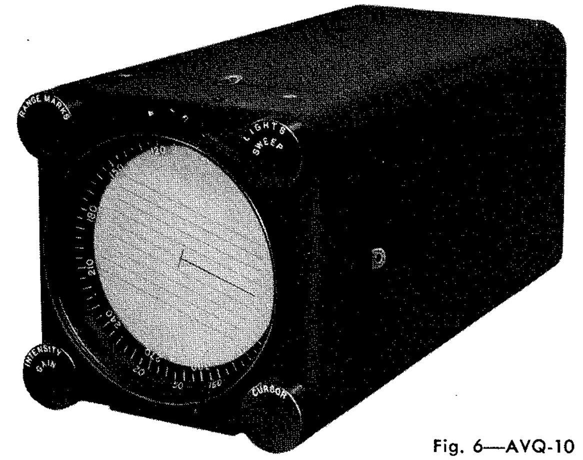


Fig. 6—AVQ-10 Indicator, external view.

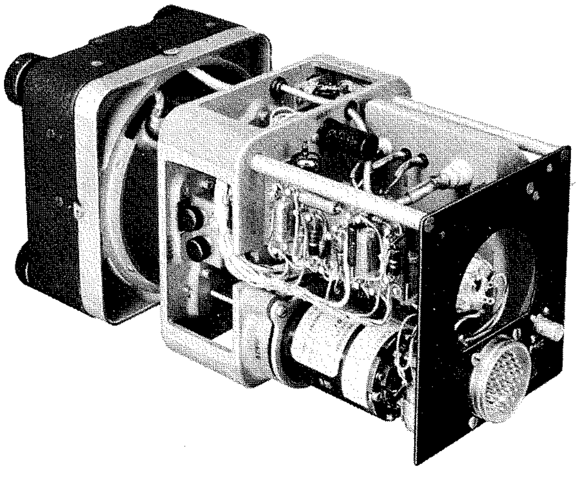


Fig. 7—AVQ-10 Indicator, internal view.

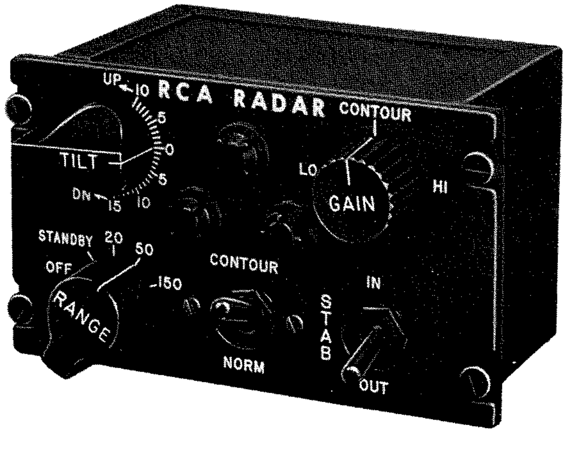


Fig. 8—AVQ-10 Control Panel.

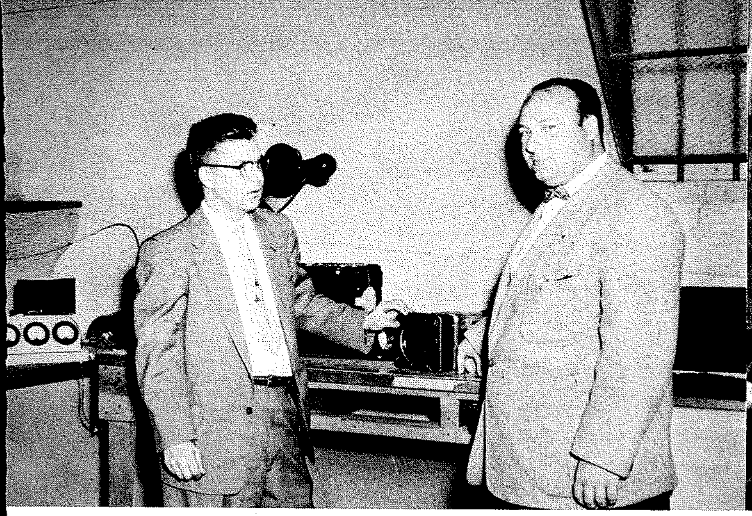


Fig. 9—C. J. Monroe (left) and M. Franco discuss the progress of system life tests. Mr. Monroe is Leader of the AVQ-10 group. Mr. Franco was responsible for the design of the Accessory Unit containing the i-f, video, antenna stabilization and power supply circuits.

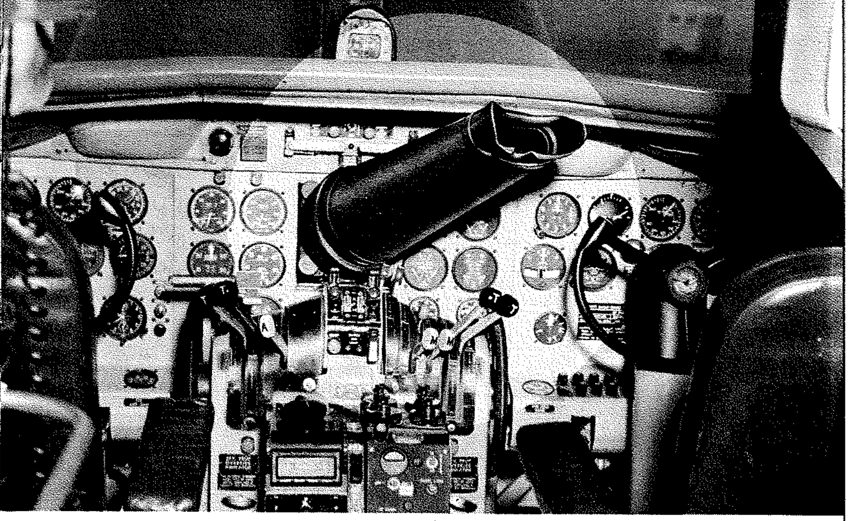


Fig. 10—Typical AVQ-10 Indicator Installation, Convair 340 Cockpit.

video circuits. Three ranges are provided of 20, 50 and 150 nautical miles with corresponding range mark intervals of 5, 10 and 25 miles.

INDICATOR

The Indicator contains a 5 inch cathode ray tube plus sweep and video amplifiers. The anode potential of 8,000 volts is obtained from a sealed high voltage supply located in the Indicator. Sweep rotation is of the mechanical type with the sweep deflection coil driven by a torque synchro slaved to a corresponding unit in the antenna. Controls are provided at each corner of the Indicator face for Sweep Intensity, Range Mark Amplitude, Cursor Rotation and Cursor Lighting.

CONTROL PANEL

Many styles of radar controls are used with the AVQ-10 system, some designed by RCA to meet the operator's specifications, and others fabricated by the airlines themselves to meet certain requirements in regard to available space and odd-shaped form factors. The Control Panel shown is typical and provides for the five basic operating functions of antenna tilt control, receiver gain control, range selection, stabilization selection and iso-echo contour selection. The remaining controls used in the normal operation of the radar are located on the face of the Indicator.

GENERAL CHARACTERISTICS

The following is a general summary of the characteristics of the AVQ-10 Weather Penetration Radar.

System—5 Major Units

Weight—120 lbs (major units less shockmounts)

Tubes—total of 51 tubes including TR and ATR tubes

Frequency—5400 ± 20 mc

RF Power—75 KW minimum peak power output

Pulse—2 microsecond duration

Pulse Rate—400 pps synchronized to line frequency

Ranges—20, 50, 150 nautical miles

Range Marks—5, 10, 25 miles spacing

Stabilization—Line of sight stabilized to ±2° accuracy up to ±20° total excursion

Antenna Beam—7°, 4.5°, 4°—depending on reflector used

Power—850 watts at 115 volt 400 cycles, plus 30 watts at 28 volts dc

Display—Centered or offset 5 inch PPI

FUTURE OF THE AVQ-10

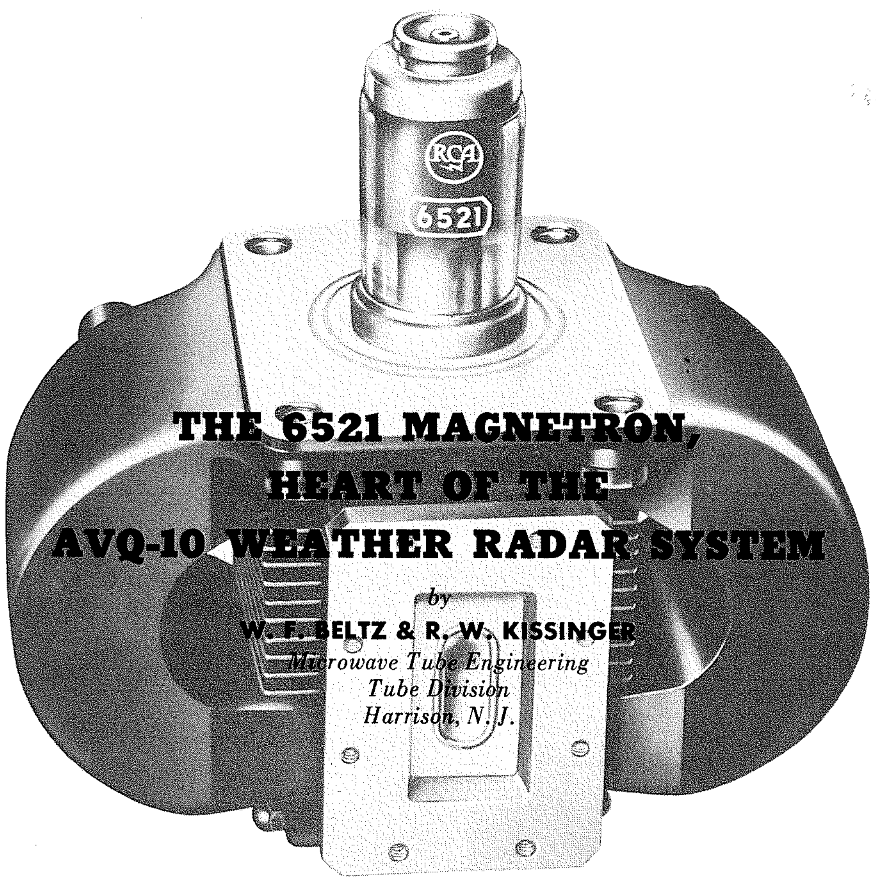
Upwards of 400 AVQ-10 Weather Penetration Radars have been produced as of this writing. Equipments are installed and in daily use on such airlines as United, American, Pan American, Trans World Airlines and Continental Airlines. By 1957, equipments will also be in use on foreign airlines including BOAC, Sabena, SAS and Swiss Air.

A continuing product improvement program for the AVQ-10 will help to keep RCA the leader in commercial airline radar equipment. Improvements planned include a direct view storage tube indicator bright enough for daylight viewing in the cockpit without a hood as well as refinements in design to increase reliability and reduce size and weight.

Fig. 11—Typical AVQ-10 Antenna Installation, Convair 340.

THE 6521 MAGNETRON, HEART OF THE AVQ-10 WEATHER RADAR SYSTEM

by
W. F. BELTZ & R. W. KISSINGER
Microwave Tube Engineering
Tube Division
Harrison, N.J.



Because there is no such thing as a "universal" magnetron, any application which has a unique aspect about it requires a unique magnetron design. A tube designed to meet the tight requirements of size and weight in a missile application, for instance, would not be a wise choice for ground-based radar, where high power and long life might be dominant factors. Unfortunately, magnetrons have earned a reputation of being rather short-lived, unreliable tubes which are tolerated simply because there is nothing better to use. Part of this reputation is a result of under-designing the magnetron to reduce size and weight, and part is due to the frequent misapplication of the tubes by equipment designers not familiar with the special properties of magnetrons.

MAGNETRON CHARACTERISTICS

A magnetron is a self-contained oscillator characterized by relatively high efficiency, high power capabilities, and small physical size. It combines all the circuitry inside its vacuum envelope. Fig. 1 shows a cross-sectional drawing of a typical magnetron. Although there are a wide variety of types of magnetron anodes, this discussion will be limited to the vane-type structure used in the 6521 and shown in the drawing. The vanes arranged around the anode circle are uniformly spaced, and each pair of adjacent vanes forms a resonator cavity. Because adjacent resonators are quite close, they couple together, forming a closed ring of electrically resonant structures. The basic frequency of oscillation is related to the physical dimensions of the resonator structure. Because a capacitance exists between vane tips, and because the path from one vane tip to the next (as measured around the anode) forms an inductive element, it is apparent that electrical resonance can be expected at some very high frequency.

Electrons are provided by the cathode of the magnetron, which is axially centered with respect to the anode interaction space, as shown in Fig. 1. Because the cathode is operated at a different potential from the anode, it is supported outside the tube body by a concentric glass insulator called the input sleeve. Normally, a magnetron is operated with the anode grounded and the cathode at a high negative potential.

Outside the magnetron is a magnet structure (usually a permanent magnet) which provides a magnetic field parallel to the cathode axis. When the cathode is heated and the anode voltage applied, electrons are drawn from the cathode toward the anode. Because of the magnetic field, however, these electrons follow spiral paths, as shown in Fig. 1. Many electrons, after spiraling away from the cathode, are forced back to it with considerable energy. These "back bombardment" electrons liberate more electrons from the cathode, adding to the total number of available electrons, but increasing the cathode temperature.

When the magnetron is oscillating, the electrons spiraling from the cathode are formed into "bunches" which, in turn, form "spokes" that go from cathode to anode. Some electrons tend to drop behind their spoke, while others tend to lead it. Because, in oscillation, the electrical phase shift from one vane to its neighbor is usually π radians, forward-going electrons are retarded, and slow electrons are accelerated. This focusing action maintains the nature of the spoke.

An electron normally loses energy to the field as it crosses the space from cathode to anode. Consequently, the input energy is transformed into r-f energy and useful oscillation is maintained.

Because alternate vanes should be of the same phase, it is useful to strap them together electrically. This strapping is accomplished by the use of small circular metal rings, called vane straps, which are brazed to alternate vanes.

In normal magnetron operation, there is an electrical phase shift of π radians between neighboring anode vanes. This mode of operation is called, logically, the "π-mode". However, other field configurations are not uncommon in the magnetron anode. Despite the fact that straps are used to insure a π-mode field configuration, it is possible for a different field pattern to build up during a pulse and be maintained. The possible variations of field pattern follow certain principles and, in general, differ from the desired π-mode in that they are less efficient, have a higher frequency, require different anode voltages, and may cause the magnetron to arc internally. Altogether, they are a nuisance.

The operation of a magnetron in any but the desired mode is called "moding". A measure of this moding is the tube's "mode stability". Various applications require different degrees of magnetron mode stability, and the degree required is of concern to both the tube designer and the equipment designer. For example, there would be little reason to spend development dollars in the production of a very stable magnetron if it were to be used to fry ham. On the other hand, there would be ample reason to justify the development expense if the tube were to be used in a moving-target-indicator type of radar.

The energy in the magnetron is coupled out by a slot in the back of one of the resonators, and passes through an output window to the external waveguide and thence to its destination. The output window acts as a vacuum barrier, and also as a window to pass the r-f output. For a given frequency (or band of frequencies), it is possible to design a rectangular metal "iris" that is electrically resonant and, therefore, passes energy readily to the external system. The addition of a window of dielectric vacuum-barrier ceramic to this metal frame provides the essentials of an output structure for the magnetron.

Obviously, there are many factors influencing magnetron design, and some of them are mutually restrictive. Consequently, there can be no happy reconciliation of the laws of physics which would result in a "universal" magnetron.

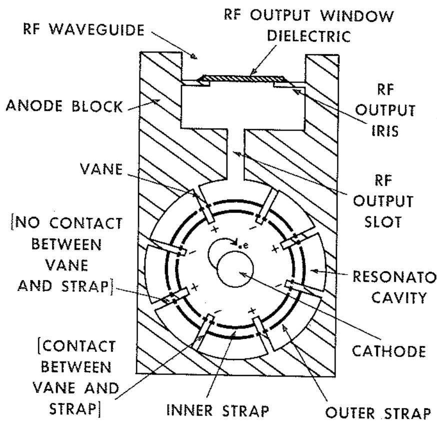


Fig. 1—Typical vane-type magnetron anode.

FEATURES OF THE 6521

The RCA-6521 "weather radar" magnetron was developed to fill the need for a reliable, long-life magnetron whose size and weight were of secondary importance. Throughout the development, close liaison was maintained between the Tube Division engineers in Harrison and the equipment engineers in Camden and the West Coast. In this way, it was possible to provide an environment for the magnetrons in the AVQ-10 Weather Radar System which would enhance reliability under the most adverse conditions of flight.

The tube-design engineers believed that the greatest deterrent to good life performance was the operation of magnetron cathodes at excessive current densities. In the design of the 6521, the interaction space was scaled from the RCA-4J50, a 3-centimeter fixed-frequency magnetron. In general, when a magnetron is scaled down for lower frequencies, the number of resonators is reduced to decrease the magnetic-field requirement and, consequently, the magnet weight. In this case, however, the number was not changed. As a result, the 6521 has larger anode and cathode diameters which, in turn, permit lower cathode-current density and anode-dissipation density. Fig. 2 shows a cutaway view of the 6521 as described below.

ANODE:

The 6521 uses a vane-type anode which contributes to a simple, rugged unit. Cooling is accomplished by forced-air flow over the external anode radiator fins. Because it would be possible for the air-flow system to fail during some critical period of radar operation, the anode structure is rather massive. This large size insures that a magnetron "catastrophic failure" will be unlikely even if the cooling flow of air should be lacking for average flight durations.

CATHODE:

The 6521 cathode is a sintered-nickel, oxide-impregnated type. The cathode support structure is also massive to minimize the deteriorating effects of electron "back-bombardment" heating of the cathode. The massive structure provides greater mechanical support against vibration and sagging, but also minimizes cathode temperature variations which may result from input-power changes. Three getters integrally mounted in the cathode assembly maintain a very high vacuum during both shelf storage and operation of the 6521. This aspect is of importance in a field-stocked, long-life tube, because spare-tube shelf-storage time may be considerable. Incorporation of these getters may well account for arc-free performance when the tube is put into service. See Fig. 3.

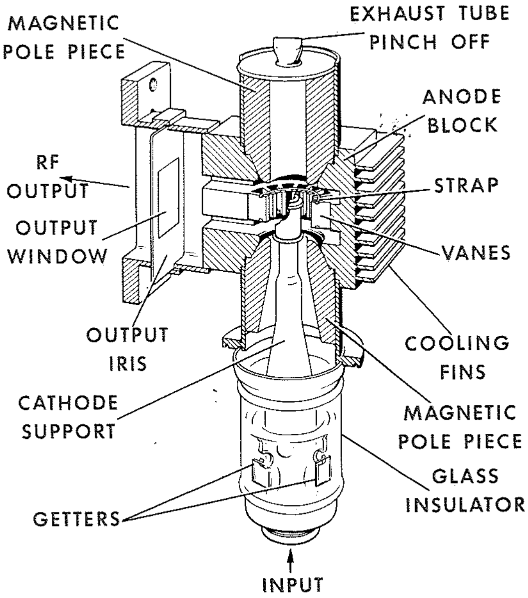


Fig. 2—Cutaway view of the RCA-6521 magnetron.

HEATER:

A double-helical heater is used in the 6521 to prevent electromechanical resonances and heater modulation. This heater is also important to long life and greater reliability of performance.

The heater-voltage-reduction schedule for the 6521 is shown in Table I. Only small reductions in heater voltage are recommended. Moreover, tests show that tube performance does not deteriorate when no reduction is made over rather considerable periods of operation. This characteristic is significant in terms of dependability.

OUTPUT WINDOW:

Although most airliners are pressurized, and the waveguide system is also pressurized, it is possible that the aircraft and system may lose pressure, particularly during severe storm conditions. For this reason, the RCA-6521 is designed to operate in a normal fashion in unpressurized equipment up to altitudes greater than 16,000 feet. This requirement imposes problems in the design of the output window because the combined effects of low pressure and high pulse power are conducive to window breakdown.

Because of space limitations, a circular output window was not considered feasible. Instead, a simple rectangular resonant iris window was developed. Although early developmental tubes used a glass window, the combined effects of dielectric loading and small physical dimensions caused this type of window structure to break down at altitudes of less than 16,000 feet. The ceramic-to-metal output window structure now used meets the altitude specification readily, and is superior to the glass-to-metal construction in terms of fabrication.

The voltage rating of the glass cathode input sleeve also meets the altitude requirement. Even in the event of momentary breakdown of either the input sleeve or the output window, it is probable that no major damage would be suffered by the tube.

MODE STABILITY:

Good magnetron mode stability is important to the AVQ-10 Weather Radar System. If the magnetron should operate in an improper mode during a pulse, no echo information could possibly be presented on the pilot's PPI scope, because the magnetron output would be at the wrong frequency. As a result, the pilot would observe a "missing line" from what otherwise might be a solid mass of storm-area information. Although the amount of target information missed would be quite small, the sporadic lack of lines on the PPI screen would be disturbing to the pilot. It is possible that such operation would cause him to doubt the advisability of continued navigation by weather radar.

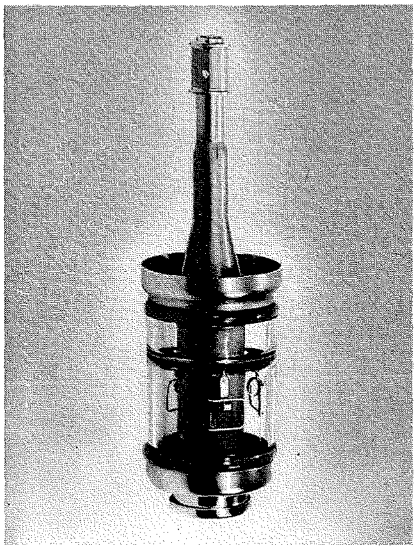


Fig. 3—Complete cathode assembly.

One of the techniques employed by the tube designers to improve mode stability is a "discontinuous" type of vane strapping. The discontinuities in the tube straps are in the form of distortions of the normal circular metal strap rings. Although the field configuration of the desired mode of oscillation is not disturbed by these interruptions, the field patterns of the unwanted modes are disturbed in such a way that the ability of the magnetron to support oscillation in the undesired, higher-frequency modes is greatly reduced. Many design experiments were conducted to optimize the type of strap configuration, its relative position in the anode geometry, and its physical shape.

Because the oscillations at the undesired mode are greatly affected by the degree to which they are coupled to any dissipative load, it is important that the system present an environment to the magnetron which will extract higher-mode energy, or, more accurately, load these modes in a way that tends to prevent their build-up.

The application engineers determined that the mode stability of the 6521 was greatly influenced by the relative electrical position of the radar duplexer. A duplexer is a device which permits the use of only one antenna for both transmitting and receiving purposes. Experiments were performed to determine the best position for the duplexer, i.e., the position in which the unwanted modes have the least tendency to build up oscillations. Because the electrical characteristics of the 6521 are substantially the same from tube to tube, incorporation of the optimum duplexer position in the radar equipment insures best mode stability in the original 6521 supplied with the equipment, and also in subsequent replacement tubes.

MAGNETS AND MOUNTING:

An unimportant detail to the tube designer and manufacturer can often produce problems of emergency proportions to the tube user. Such a detail is the relative polarity of the magnets used on a magnetron. If the magnets are randomly polarized north or south from one tube to the next, fatal calibration errors of navigational magnetic equipment could easily result when the tubes are used in airborne service. Because the magnets of the 6521 are always of the same relative polarity, only a minimal effect is exerted on the plane's magnetic compass when a tube is changed.

WILLIS F. BELTZ received a B.S. degree in Electrical Engineering from Purdue University in 1950 and an M.S. degree from Stevens Institute of Technology in 1954. He joined the Radio Corporation of America in 1950 as a specialized trainee, and in 1951 was assigned to the Microwave Tube Engineering activity of the Tube Division in Harrison, N. J. as an application and test engineer. From 1953 to 1956 he was a project engineer in charge of magnetron product design and development. He is now manager of Microwave Quality Control.

Mr. Beltz is a senior member of the Institute of Radio Engineers and a member of Eta Kappa Nu and Tau Beta Pi.

ROBERT W. KISSINGER received an A.B. degree in Physics and Mathematics from Gettysburg College in 1948. He was then employed by Pennsylvania State University as an Instructor in Physics and subsequently as a Research Associate in the Ionosphere Research Laboratory. Between these two positions, he spent a year with the RCA Tube Division in Lancaster, Pa. as a development engineer on black-and-white kinescopes. In 1952, he was with the Sperry Gyroscope Company for about 6 months, after which he rejoined RCA as a sales engineer in the International Division. Since 1954, he has been a member of the Microwave Tube Engineering activity of the RCA Tube Division at Harrison, N. J.

Because aircraft service is usually synonymous with vibration, mounting arrangements designed into the 6521 allow it to be held either by bosses cast into the magnet coating, or by the mounting flange on the top of the tube, or by both. This design allows the tube to be mounted in two planes.

PERFORMANCE OF THE 6521

The results of coordinated design and application engineering, together with close liaison with the equipment designer, have been highly profitable. In life tests, 6521 tubes have operated for more than 2000 hours under severe conditions of cycling before failure. Measurements have been made of variations during life of several of the more important parameters of the 6521. It is interesting to note that mode stability remained essentially constant throughout life, the change in frequency being less than 1.5 megacycles per second. The tubes were still in satisfactory condition when removed from test after more than 2000 hours. One of the very early developmental tubes operated satisfactorily for more than 3400 hours before failure. These life tests are conducted on a cycled basis, i.e., the tube is operated for 45 minutes after a 5-minute warm-up period, and is then switched off for the remaining 10 minutes of each hour of test. Such cycling is considered to be representative of the frequent "on-off" nature of flight service, and particularly of the extensive, brief pre-flight checks.

The final result of the 6521 development program is a packaged (that is, with magnets attached to each tube), 12-pound tube which delivers a peak pulse power output of 85 kilowatts at a frequency of 5400 megacycles per second. The peak anode voltage is 15 kilovolts at a peak anode current of 13.5 amperes. Additional typical operating conditions are given in Table II. Operation is not limited specifically to these conditions, of course, but is defined within a spread of values because many aircraft systems have poor voltage and frequency regulation.

The specified maximum voltage-standing-wave ratio (which is a measure of impedance mismatches) into which the tube should operate for reliable service is 1.5 to 1. Under these conditions, the "missing lines" will be less than 0.25 per cent.

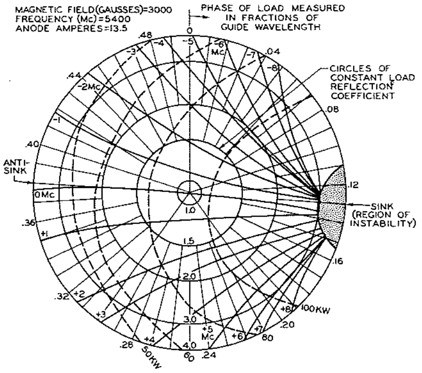


Fig. 4—Rieke diagram for the RCA-6521.

The Rieke diagram shown in Fig. 4 relates power and frequency for the 6521 as the load is varied with constant input conditions. Very extensive testing has been done with regard to the VSWR into which the tube operates. Although operation is specified to be within the circle representing a mismatch of 1.5 to 1, no appreciable deterioration of the weather information mapped by the system is evident when the tube operates into a very substantial reflective load. This feature is of vast importance in airline service because reliability of safety equipment under unusual conditions is absolutely imperative. Fig. 5 shows a typical performance chart for the "weather radar" magnetron. This chart shows changes of input parameters with constant load conditions. The tube has an efficiency (ratio of output power to input power) of 51 per cent at its recommended operating point.

The RCA-6521 "weather radar" magnetron is, admittedly, not a "universal" tube. It is a tube designed to fill a particular and important need, a tube which will perform well in commercial air service, where dependability under adverse circumstances is a "must" and where long life is imperative.

ACKNOWLEDGMENT

The successful conclusion of the 6521 magnetron development program was due only to the cooperative effort of many people, both in the Harrison Microwave Engineering activity and in other activties. The authors wish to extend their thanks to each of these persons.

TABLE I

HEATER-VOLTAGE REDUCTION SCHEDULE

(Warmup Time—4 Minutes)

Average Power Input—Watts	Heater Volts	Percent Reduction
up to 90	10.0	0
90 to 130	9.9	1
130 to 180	9.5	5
180 to 220	9.1	9
220 to 256	8.9	11

TABLE II

RCA-6521 TYPICAL OPERATING CONDITIONS

Heater Voltage (See Table I)	9.5 Volts
Peak Anode Voltage	15 Kilovolts
Peak Anode Current	13.5 Amperes
Pulse Repetition Rate	400 pps
Duty Factor	0.0008
Pulse Width	2 usec
Frequency	5400 ± 20 Mc
RF Bandwidth (Maximum)	1.5 Mc
Peak Power Output	85 Kilowatts
Pulling Figure	5.5 Mc
Missing Pulses (Maximum)	0.25 percent
Efficiency	50 percent
Voltage Standing-wave Ratio (Maximum)	1.05
Thermal Factor	0.15 Mc/°C

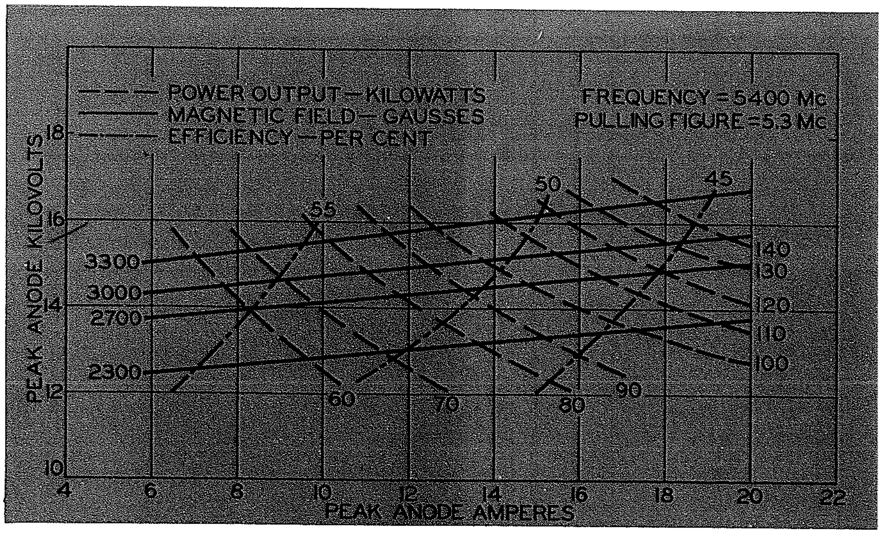
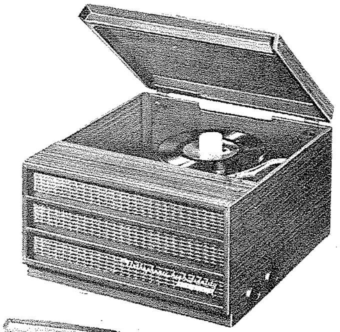
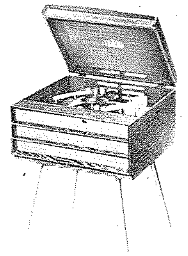


Fig. 5—Performance chart for the RCA-6521.

SOME PRACTICAL ASPECTS OF HIGH-FIDELITY DESIGN





By **ROY S. FINE**

RCA Victor Radio
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Most engineers appreciate the fact that high fidelity is a subject of much controversy and such discussions usually hinge on the particular preference of an individual. The particular desires of one person can be satisfied by custom designing equipment to suit specific listening tastes. From an economic standpoint, however, such deluxe high-fidelity systems are not usually within the means of the average listener nor are they ideally suited to acoustical properties existing in the average home.

This article is intended entirely as an informative treatment of the problems involved in the design of practical, economical, high-fidelity instruments for the home, rather than an advanced treatise on the art of high-fidelity. The high-fidelity considerations discussed in this paper not only include the design problems involved in striking an ideal compromise but in giving consideration to all the stages which combine to make up the high-fidelity system from "records to loudspeaker."

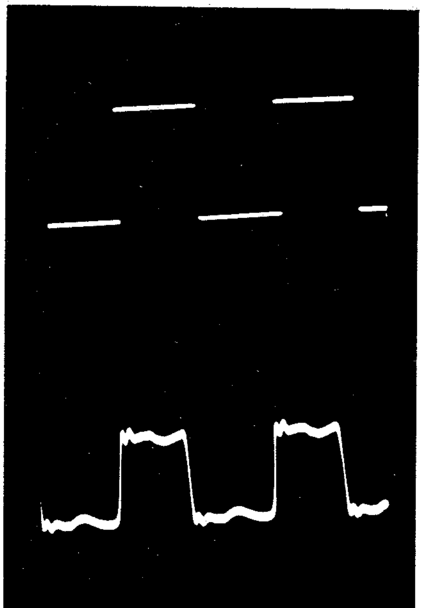
The primary objective of any design of a high-fidelity system should be concerned with the quality of sound reaching the ears of the listener; the method of reaching this objective is incidental. Concern over the quality of the individual components comprising a system should be dictated by the extent to which they affect the overall sound and not necessarily by figures of merit relating to the particular components. Naturally, any system is made of components which must be treated individually, keeping in mind the above mentioned statements.

Both components and systems will be considered and it is assumed that the reader is familiar with the basic principles of voice and music reproduction. The components in which we are interested are records, pickups, record players, preamplifiers, tuners, tape recorders, power amplifiers, and loudspeaker systems.

RECORDS

At the present time there are two commonly used record types: disc and tape. The current high quality level of both media has been instrumental in increasing the interest in obtaining good reproducing equipment. Concomitantly, adherence to the same recording frequency characteristic standard by all major disc record companies has produced much greater uniformity of reproduction from record to record. As is well known, RCA introduced and began using the "New Orthophonic" recording characteristic in 1952. By 1954, all major companies adopted it under either of the terms "Record Industries Association of America" (RIAA) or "National Association of Radio and Television Broadcasters" (NARTB). Of course, microphone placement, room acoustics, and instrumentation in the original recording session vary, but in general most present day records show a marked degree of uniformity of performance. Furthermore, they have extremely low distortion, wide-frequency range, and good signal-to-noise ratio.

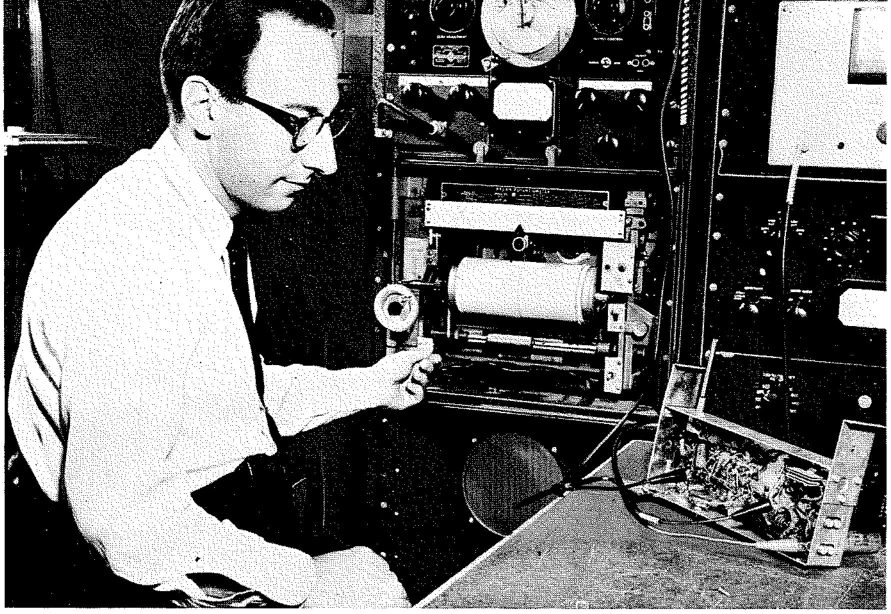
1000 cycle square wave response of a good high fidelity pickup versus an ideal response from a square wave generator. The slight raggedness of the pickup response from the record is probably due to the inability of the recording stylus to cut a clean square wave in the recording medium.



Concerning tape records, there is an NARTB recording characteristic for tape and it is used by most companies making pre-recorded tapes. The superiority of tape records over disc records, however, has been generally exaggerated. The one marked advantage of tape is the lack of deterioration with use, but the notion of better signal-to-noise ratio is a misconception. One major pre-recorded tape manufacturer claims only equal signal-to-noise ratio on tapes and new discs. It should be borne in mind that these statements are made with respect to duplicated tape records and not to an original recording made on virgin tape, in which case the noise is somewhat lower.

PICKUPS

The four basic types of pickups in use today are magnetic, crystal, ceramic and capacity. It is emphasized that with proper design, a high fidelity phonograph pickup can be made



The author is shown using Automatic Frequency Response Tracing Equipment on a tape recorder chassis. The development work on each set produced requires literally dozens of such curves, finally resulting in a composite product, each component of which is matched to all others. Thus permanent performance records of each stage of design are on hand for future reference and as tools for use in the design of subsequent instruments.

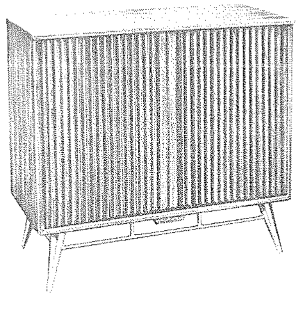
from any of the above types, and that the much maligned Rochelle salt crystal is not inherently a low-fidelity device. It's true that a crystal pickup is more subject to variations and deterioration due to high temperature and humidity, but this has not been the basis for criticism. A crystal pickup can be designed to have wide range (0-20 kc), smooth response, good tracking capabilities, low-distortion, and low noise if its designer specifically attempts to obtain these qualities. Generally in practice, high-output voltage and low cost have received prime consideration necessitating a sacrifice in other attributes more closely associated with high-fidelity requirements. Also, the temperature and humidity effects can be minimized to the extent that satisfactory performance can be maintained for years in most parts of the United States and many other countries.

The prime reason for the unsavory reputation held by crystal pickups is simply that good high-fidelity designs have not been available on the market, but ordinary ones have. The same story is true, to a lesser extent, of ceramic pickups, except that the temperature and humidity effects are negligible. Some efforts have been made to produce a design suitable for high-fidelity application.

The situation is a little different when it comes to magnetic type pickups. There have been many good designs available for several years, but this is true primarily because they have been designed specifically for high-fidelity applications. As a matter of fact, some of these pickups enjoy a reputation not completely deserved. One magnetic type which has a reputation as a good high-fidelity device, actually is deficient in the extreme high-frequency range. Another type, sold in considerable quantity, has low compliance and results in poor tracking and high-needle talk.

Because of the foregoing it is unfair to judge the merit of a phonograph pickup for a high-fidelity application only on the basis of its principle of operation, i.e., whether it is magnetic, crystal, etc. On the other hand, on the basis of pickups currently available, the magnetic designs in general are superior to crystal and ceramic types.

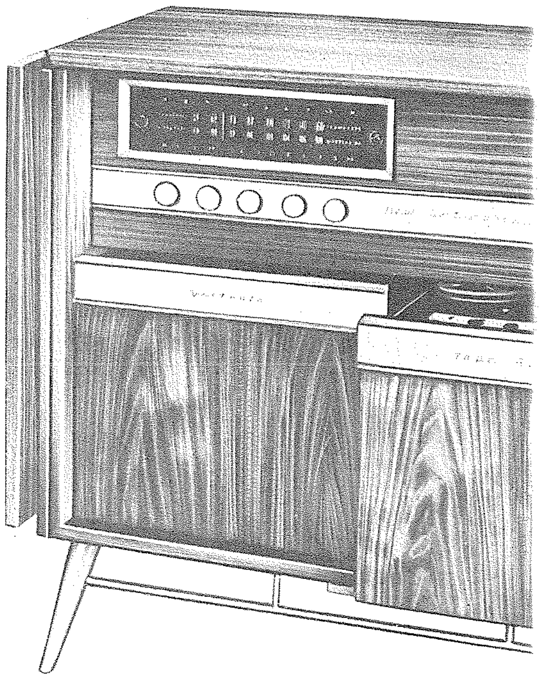
Pickup stylii also receive a large share of attention from those interested in high fidelity. The three types in use today are osmium, sapphire, and diamond, with the last considered far superior to the others. Assuming that the shape of the stylus is initially correct, the most important aspect of its quality is its ability to maintain that shape with use. Because it is the softest material, osmium has the shortest usable life and is used only where low cost is of primary importance. Sapphire is somewhat more expensive and considerably more satisfactory; and of course diamond stylii show the smallest amount of wear with time. However, this picture is not a black and white one; the use of diamonds does not necessarily imply high quality stylii. Diamond being an extremely hard material is correspondingly difficult to shape and grind to a smooth finish. It has been found that some diamond stylii are so rough that a record can be ruined with 25 plays by them.



These rough diamonds, incidentally, represent products that are actually for sale as diamond stylii pickups. Furthermore, although satisfactorily ground diamonds are available, the best is not as smooth as the sapphire versions available from the same sources. Although diamond stylii, when right, are unquestionably superior, sapphires are capable of giving many hours of playing time before damage is done to the record or distortion is heard. In short, a sapphire stylus definitely has a useful application in high fidelity work, especially since replacement is easily effected.

RECORD PLAYERS

Two types of record players are used in high-fidelity work; record chang-



ers, and manual transcription type players. The latter are generally preferable, where cost and the lack of operating convenience is not prohibitive, for several reasons; (1) lack of changer mechanism makes instrument more dependable; (2) turntable flywheel effect more easily achieved; (3) permits use of better tone arm and bearing; and (4) lack of changer mechanism allows less needle force to be used.

In general, therefore, manual transcription type players are preferable primarily because they represent an easier engineering design job. This does not mean that no record changers are available which perform satisfactorily. Conversely, many manual players have performance very much inferior to the best changers, even though the makers claim otherwise.

However, most record players in use today are of the changer type and a brief discussion of these follows. In general, it is desirable to have as simple a mechanism as possible and one which requires a minimum of torque from the motor to operate and cycle. To minimize rumble, motor shafts, turntable rims, and idlers are ground to smooth concentricity. Motors are also dynamically balanced. Weight added to the periphery of the turntable helps, and of course reduces flutter and wow. Further, if motor excitation is kept to a minimum, 120 cycle torque pulses, a factor in rumble, will be minimized. The use of a four-pole four-coil motor is not an absolute requirement in a high fidelity changer, but since the hum field is considerably less than that of a two-pole two-coil motor, the hum induced in a magnetic pickup is lower in the four-pole type.

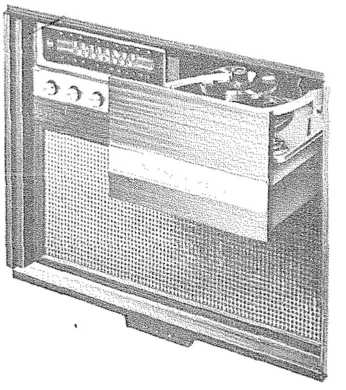
PREAMPLIFIERS

Preamplifiers may or may not be contained on the same chassis as a power amplifier, but problems involved in making them separate or integrated are minor. The most satisfactory preamplifiers are those which give necessary flexibility with a minimum of complexity in operation and circuitry. When designing a completely integrated instrument, it is not necessary to make a preamplifier as versatile as if it were a separate component since most of its associated equipment is provided and matched. However, some versatility of input signal selection and control is necessary. For example, in an instrument having am/fm radio and phonograph services, an input for a tape recorder and/or television sound is generally sufficient. Of course on less expensive sets where a-c/d-c circuits are used on phonograph only instruments, it is generally advisable to omit provisions for external attachments because of additional cost and engineering problems, such as hum, Underwriters' Laboratories approval, etc.

One feature often found on high fidelity instruments is a record equalization selector switch, considered to be of prime importance by many. It has been found, however, that the differences involved in changing from one characteristic to another are, on listening, relatively minor; much smaller, for example, than the differences due to microphone placement, recording techniques, and record manufacture from one record to another within the same equalization pattern of a single manufacturer. Further, the general overall effect achieved by equalization switching can be almost exactly accomplished by slight adjustment of the tone controls. Therefore, it is felt that a single playback characteristic is completely satisfactory and the characteristic should be the "New Orthophonic" which is very nearly an average of most other characteristics. At this writing about all record companies are using it, either under the above name or as "RIAA" or "NARTB" equalization characteristics; they are identical.

The subject of volume controls versus loudness controls is of interest in our consideration. A volume control is one which changes level uniformly at all frequencies; a loudness control varies the frequency response with level setting.

It is the feeling here, that a loudness control is desirable in a composite instrument since the manufacturer has control of the frequency response at average listening levels. However, experience has shown that loudness controls closely approximating the action dictated by the Fletcher-Munson curves are grossly inadequate, the changes at room listening levels being insignificant to most listeners. Satisfactory loudness sensations are obtained with considerably more increase of bass response at decreasing settings of the control. Also, the Fletcher-Munson information indicates that no compensation is necessary at high frequencies, the distance between curves being generally constant. However, some designers find it desirable to incorporate some high frequency boost with reduction in loudness control setting to overcome the masking effects of room and other extraneous noises.



An adequate tone control system is a necessity in a high fidelity preamplifier with separate continuously variable bass and treble controls being mandatory. However, it is felt that graph type precision is not a requirement if satisfactory action is observed on listening. Adequate boost and cut, and uniform action are the important factors, but the elaborate circuits required to give ideally precise action do not justify themselves on the basis of listening tests.

If a preamplifier has a monitor output for making tape recordings, it should be ahead of both volume and tone controls so that it can be maintained flat regardless of the shaping required to meet particular listening requirements at the time the recording is made.

A phonograph preamplifier presents an opportunity for a very interesting application of transistors: the first amplifier stage. This is a case where transistors are much superior to tubes and their use can be justified entirely by the exceptional performance obtainable. Of course, low noise units are required, but hum problems are solved virtually automatically. The cost of low noise transistors for first stage use is very little higher than tubes designed for the same application and is not considered a prime factor. Undoubtedly the use of transistors will become almost universal in high grade preamplifiers, resulting in a general improvement in performance.

TUNERS

The subject of radio tuners will be dealt with only superficially here since they are themselves subject to a lengthy and involved discourse. It is taken for granted that fm services are capable of full high fidelity performance and am radio can be made quite capable of giving enhanced performance. Generally the requirements dictate broadening the i-f response, inclusion of a 10 kc "Whistle" filter and full attention paid to a design capable of minimum distortion.

Although fm is quite capable of providing optimum high fidelity performance, full satisfaction from use of a tuner can be obtained only if certain features are provided. An accurate indication of tuning is a necessity. The combination of a tuning eye or meter and automatic frequency control is unbeatable; very satisfactory results are obtained with an indicator and good temperature compensation of the local oscillator. AFC alone is somewhat less satisfactory since distortion occurs at extremes of the lock-in range even though the station is brought in strongly.

The usual quality factors in general radio performance are of course mandatory: good sensitivity, selectivity, signal to noise ratio, capture ratio, limiting, AVC, etc., as well as good audio frequency response and low distortion.

TAPE RECORDERS

Tape recorders, too, are a subject worthy of lengthy and involved discussion, and will be dealt with here only inasmuch as they affect high fidelity reproduction. All but the most expensive recorders leave something to be desired for high fidelity performance, indicating that the return for costly improvements is small, however necessary. Good frequency response at this time is readily obtainable; it is simply a question of adequate design. At present, there are specifications for playback response outlined by the NARTB for a tape speed of 15 inches per second. This specified response curve has been adopted for 7½ inches per second by RCA and other manufacturers of pre-recorded tape. It is therefore essential that the playback system of any high fidelity recorder conform to this curve, and the degree of conformity is considered to be an important figure of merit factor in the evaluation of such a machine. It is understood that the output voltage for application to a preamplifier be flat from a frequency tape such as RCA test tape 12-5-61T. On a complete tape reproducer, the playback compensation should be adjusted for the best acoustic output from the loudspeaker system.

The recording characteristic of a recorder should be adjusted so that a composite frequency response measurement, i.e., a tape made and played back on the same machine, is flat from a flat input signal.

Good signal-to-noise ratio is another extremely important factor in tape recorder performance, and judging from the performance of even high quality machines it is not easily achieved. Two types of noise are generally prevalent; hum and "white noise."

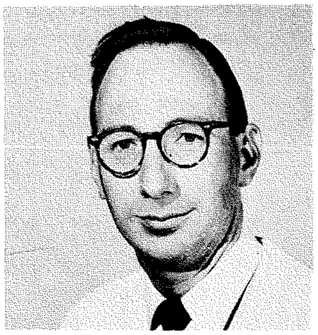
Hum can be minimized to inaudibility by good design. Some factors here are adequate shielding of heads and reduction to a minimum of the hum induced in first or first and second stages of the playback amplifier, generally achieved by using transistors, or d-c on the tube heaters.

White noise elimination is more of a problem and comes from (a) transistors, (b) tubes, and (c) the tape itself.

It is generally minimized not by good design of the amplifier itself, but by proper selection of the best components available especially tubes and/or transistors, resistors, and the tape itself. Care must also be taken in the engineering design to prevent switching and other transients from magnetizing the heads, a factor which also gives rise to noise. In all deference to existing designs however, it must be pointed out that where a single tube or transistor phonograph preamplifier stage is generally required, from two to four tubes or transistors are necessary to amplify the head output signal to the same level.

The third important factor in tape recorder performance is flutter and wow, and good results are obtained

ROY S. FINE graduated from Brown University with a degree of Bachelor of Science in Engineering in 1944. He spent three years in the Signal Corps, with the majority of this time at the Signal Corps Engineering Laboratories, Ft. Monmouth, working on radar and microwave communications. Mr. Fine joined RCA as a student engineer in 1946 and worked in the Advanced Development Section of RCA Victor Home Instruments Division until 1951. He then transferred to the Radio and "Victrola" section and is now working on product design of high fidelity instruments and tape recorders.



primarily by precision machining of mechanical parts. Care must also be taken to insure that irregularities in reel motion are not transmitted to the tape as it travels over the head.

In general, the problems of good tape recorder performance have not been successfully solved especially in inexpensive machines, but it is definitely felt that good engineering application by a company with sufficient resources can soon bring about a much improved product.

POWER AMPLIFIERS

In the overall picture of high-fidelity equipment, power amplifiers are probably the strongest link in the chain. It is relatively easy to design and build a good amplifier. The problems then become those of economy versus performance. The performance factor most often associated with the quality of a power amplifier is power output versus distortion. Some requirement and specifications have gotten beyond all reason currently. The industry apparently forgets that it is the distortion at normal listening levels which is important. It is felt here, that if the harmonic distortion is kept below 2% at 10 watts output from 30 to 15000 cycles, any amplifier will perform satisfactorily with any combination of components and that the limiting factor in the performance of such a system will never be the amplifier.

It is true, of course, that higher powered units will more completely insure good performance. Although some feel that an increase of two to one in the rated power output of an amplifier makes a tremendous improvement, they are perfectly willing to ignore loudspeaker sensitivity differences which can easily be in the order of three decibels, and can effectively result in cutting the power output of the amplifier in half. It is recognized, however, that a brute force amplifier design job is perhaps the safest course, and that the technological progress of other components still has a goal to attain. Another aspect of amplifier and/or system design that is often overdone is the meticulous attention to matching of load to amplifier, especially when done on the basis of a specified loudspeaker impedance. Since the impedance of a speaker is not constant and is normally specified at the frequency of lowest impedance within its working range, the amplifier invariably works into a properly matched load only at that one point; there is a mismatch at all other frequencies. In a good amplifier, therefore, a load variation of as much as four to one should not materially affect distortion. The closer the amplifier is to being a constant voltage source, the better it is in this respect.

With respect to overall amplifier design, it is felt that the methods of obtaining the desired results are unimportant; it makes little difference if triodes, tetrodes or pentodes are used, if and how much feedback is used, etc. The important parameters such as frequency response, intermodulation and harmonic distortion, output impedance, input sensitivity, damping factor, noise level, etc., will determine the performance results obtainable.

LOUDSPEAKER SYSTEMS

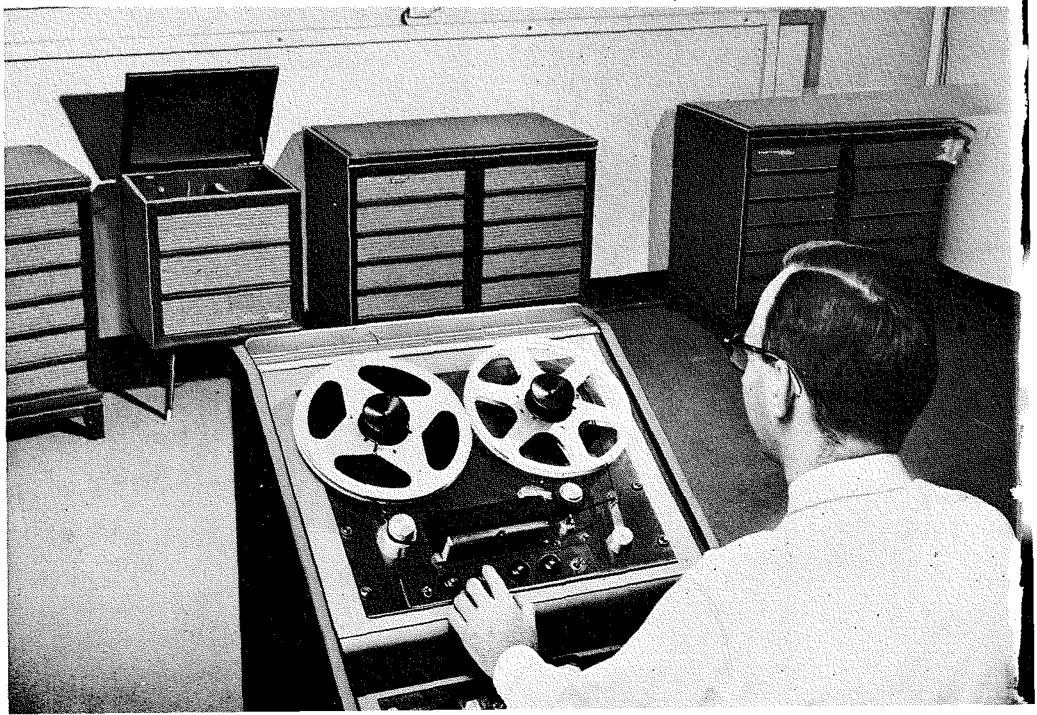
The design and construction of loudspeaker systems is again a very complex subject; in fact engineering careers are built around such acoustic work alone. In designing a good high fidelity instrument, it should be emphasized that, besides a sound background of acoustic engineering, elaborate and expensive anechoic chambers (sound rooms) and complex test equipment are necessary.

For example, a good loudspeaker and a good cabinet cannot always be combined to provide good results. Further improvements can invariably be made after the two are combined. Small changes may be measured although not heard, but the cumulative effect of several such small increments of improved performance can make startling differences upon listening to the system.

The quality of sound from a high-fidelity system can be almost entirely dependent upon the performance of its loudspeaker system. The so called "presence" invariably stems from the speakers, and lack of "presence" can make an otherwise excellent system quite unsatisfactory from a listener's point of view. The same is true of the distribution pattern within the listening area. Since high fidelity loudspeaker systems are invariably placed against a wall or in a corner, it is desirable to have adequate sound distribution over a large arc in front of the speaker. It is felt that any steps to achieve uniform distribution of sound behind the instrument are unncessary.

Many persons are unaware that the cabinet affects chiefly the low frequency end of the audio spectrum. Tweeters and mid-range speakers may

Special tapes have been made to test loudspeakers. The author is shown using recordings of tone bursts to test the transient response of several loudspeakers. Other tapes contain specially selected passages, such as organ music, for testing low frequency response, and cymbals and triangles for use in high frequency tests.



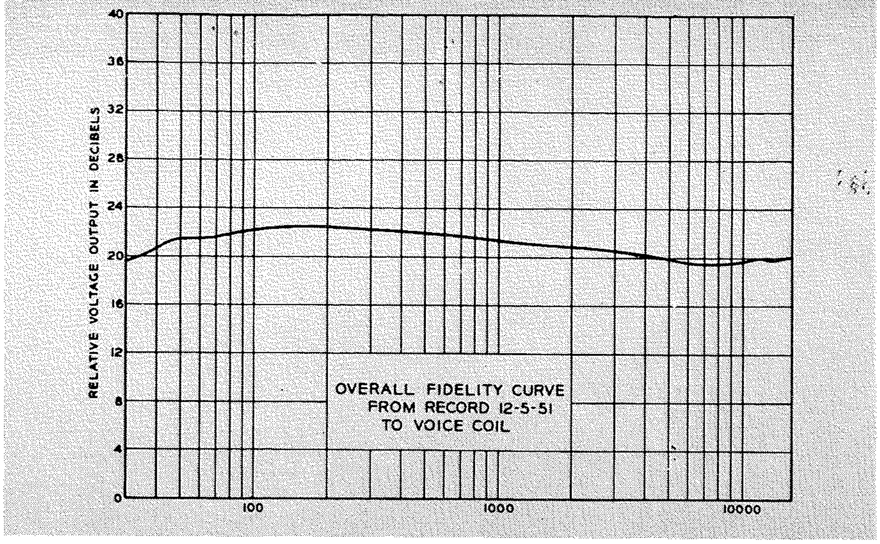
be placed at any convenient location and do not have to be within the confines of the speaker enclosure. The problems of directivity are also frequency sensitive; the distribution angle is somewhat inversely proportional to frequency and is dependent on the size and shape of the radiator.

There are more problems in matching a loudspeaker to a system than the one of impedance matching. It is well known that most speakers do not have absolutely flat frequency response, and irregularities can many times be compensated in the amplifier. One method of compensation commonly used, with small enclosures, is to tilt up the low and high frequency ends of the amplifier to a considerable degree to compensate for speaker system deficiencies in these regions. Of course, the speaker itself should have certain characteristics to make this compensation possible; it should be capable of sufficiently large excursions with low frequencies and should have a gradually sloping high frequency roll-off rather than sharp cut off.

It is also possible to compensate for deficiencies in the "presence" region by choosing a phonograph pickup with a broad but low amplitude resonance rise over this region.

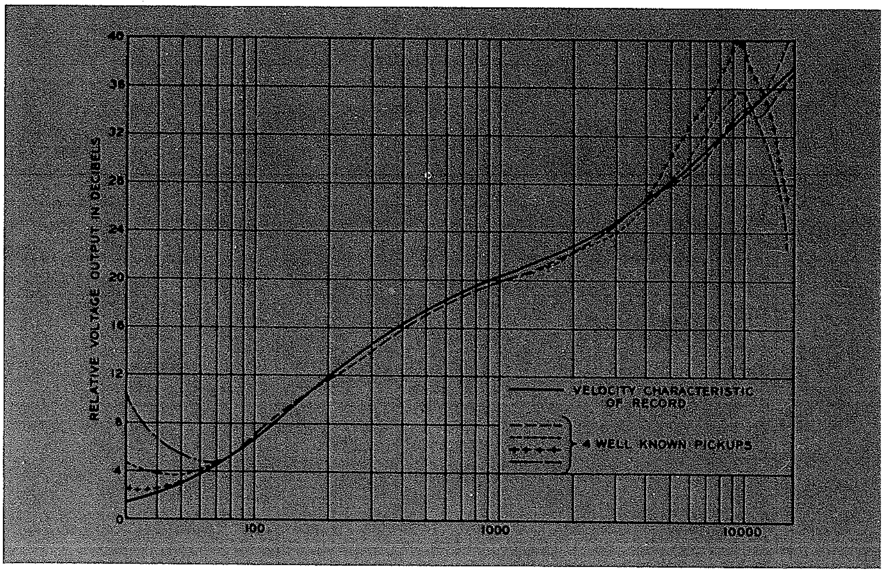
GENERAL

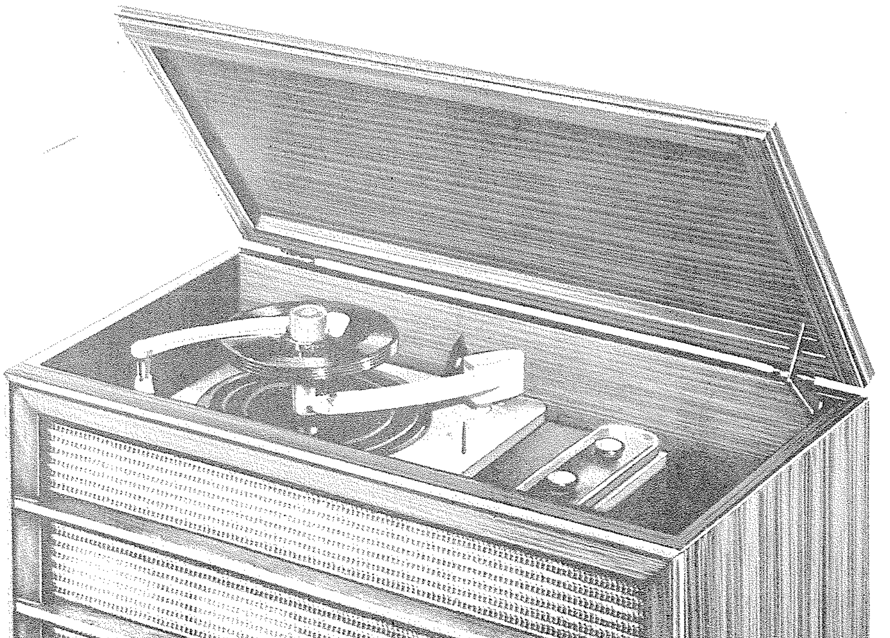
In order to design a good high fidelity system, it is necessary to have not only a thorough background of knowledge, but extensive and complex test equipment. Part of this test equipment is the environment, i.e., a sound room and a listening room. The final results are the impressions that a listening panel observes on an evaluation of the overall system from signal source to acoustic output. In building a composite system for sale to the general public, an average must be attained. Conversely, a system being built for an individual must please only one person; an infinitely easier job since there is no average individual, only an average group. It is imperative to have correlation between electro-acoustic measurements and the results of listening tests. Only then, can a composite system be satisfactorily designed to meet the requirements necessary for sale to the discriminating general public.



Above: Actual response curve of a high fidelity instrument from record to voice coil. This response is considered excellent and experience has proven that such a curve is rare in high fidelity installations and instruments.

Below: Response of four well known magnetic pickups with good reputations for high fidelity performance. Note the high frequency response deviations, with two pickups rapidly falling off above 10 kc. One of the other units is such that tone arm resonance produces a pronounced low frequency peak. Therefore, only one pickup in this group is considered to be capable of excellent frequency response in the tone arm in which they were tested. In spite of the apparent shortcomings of some of these pickups, proper compensation can enhance their performance.





ULTRA-MINIATURE PERSONALIZED RADIO EQUIPMENT

By
HARRY J. LAIMING
Surface Communications Engineering
Defense Electronic Products
Camden, N. J.

EVER since the initial development of radio for communication, men with imagination have been looking forward to the day when a radio communication device would be made available to everyone. At last, a personal radio transceiver for furnishing this final link to communication trunk lines is close at hand. This device will be small enough to fit into a man's coat pocket or a woman's purse.

SIGNIFICANT PROGRESS MADE IN COMPONENTS

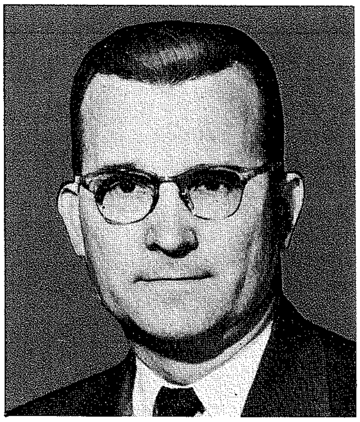
RCA has recognized this important need right from the start and, consequently, for years has directed the necessary effort for achieving its fulfillment. The major break-through in this field has come about as a result of rapid development of semiconductor devices such as transistors and of ferro-magnetics. These devices have moved in a relatively few years from the laboratory to actual production applications. The low-power requirements of transistors have made practical the utilization of numerous compact low voltage power sources. These include mercury cells, thermocouples, photo-cells and numerous other voltage generating devices.

Progress also has been made in the necessary circuit component elements such as low-voltage capacitors, resistors, coils, and transformers. These improvements have been attained in large measure through the utilization of new materials and techniques.

SMALL SIZE FOR MILITARY OR "PERSONAL"

Since the personal communication set will be closely associated with the user, its size and configuration will play an important role in its acceptance in military applications as well as in civilian use. For example, package sizes such as a pack of cigarettes, a cigarette lighter, or a wrist watch have proved acceptable models for size and shape to many users. No doubt this acceptance will continue.

In military applications, incorporation of such communication equipment as a part of existing paraphernalia may prove very attractive. The primary requirement of a soldier is to provide the necessary combat performance. In light of the fact that he is normally burdened with an appreciable complement of soldiering equipment, the addition of a radio set, by necessity, must meet the following rigorous requirements: reliable performance, small size, light weight, optimum simplicity of operation, minimum care in handling and use, water-tightness, concealment and protection so as to avoid interference with his normal function as a soldier.



HARRY J. LAIMING graduated from Drexel Institute of Technology in 1934 with degree of B. S. in M. E. and joined RCA in 1935. Since then he has been closely associated in the engineering department with design and development of numerous well known mobile radio communication equipment for the Armed Services. In these equipments the state of the art in compactness, weight and performance has always been pressed. Consequently, Mr. Laiming's interest in miniaturization and utilization of new techniques at all times has been very keen.

In 1946 he was made Engineering Staff Assistant, in 1951 Leader, in 1953 Manager of Communications and Sonar, and in 1956 Manager of Communications and Military T.V. Mr. Laiming is a Senior Member of American Society of Mechanical Engineers, IRE, and a registered professional engineer in the State of New Jersey.

MILITARY "HELMET" MODELS APPROACH WRIST-WATCH SIZE

Work done to date has made it apparent that personalized radio communication sets will fit into areas such as helmets. We are currently developing such equipment for the U. S. Signal Corps, designated AN/PRC-34. Antennas must be included as a part of the device since protruding antennas certainly would be objectionable. Needless to say, in all cases, these radio sets preferably should be self-contained with necessary power pack. Sizes of these equipments are such as to enable them to be fitted into wrist-watch size packages, part of a rifle, a pocket or cartridge belt.

Even though the civilian user may not subject equipment to quite the same degree of abuse that can be expected under combat conditions, still a personalized radio set must have sufficient ruggedness to withstand continued rough handling far beyond that encountered by the normal popular miniature radio set. This equipment in all cases must provide trouble-free, reliable performance.

"PERSONALIZED" SETS DEVELOPED

In order to develop radio equipments fulfilling the foregoing objectives, intensive applied development has been directed to the construction of numerous representative examples of personalized type radio sets. These include a complete medium-frequency chassis utilizing four transistors and necessary complement of circuit components. This complete unit occupies a volume no greater than that of an average man's wrist watch and provides adequate sensitivity to operate at signal levels found in a normal metropolitan area.

In a package no larger than an average size pack of cigarettes it has has been possible in UMR-1 to incorporate a complex FM crystal-controlled radio receiver utilizing 10

A group of transistorized, ultra-miniature sets contrasted with a current model of the AN/PRC-10A ("Walkie-talkie") transmitter-receiver developed by RCA for the U. S. Signal Corps. This model (approx. 25 lbs.) employs sub-miniature tubes and is about half the size of its predecessor which employed miniature tubes and weighed nearly 50 lbs. The group of ultra-miniature equipments points to the direction in which transistorized sets will go in size. Equipments are l. to r.: 50 MC, F-M crystal-controlled radio receivers, transistorized A-M radio transmitter, and A-M radio receiver. All are single-channel, crystal-controlled, completely self-contained unit.

The transistorized A-M broadcast receiver with cover removed, to expose speaker, enclosed ferrite antenna, special tuner covering 540 to 1600 kc, and necessary battery, giving 100 hours of continuous operation.

Edward A. Bennett, Surface Communications engineer is demonstrating the small size of ultra-miniature, transistorized, transceivers and receivers for commercial and military use. Nearby is the present standard army helmet similar to the one in which PRC-34 communication equipment will be housed.

transistors and 2 diodes. The battery drain of this equipment is only 100 milliwatts thereby permitting battery life well in excess of sixty hours with a self-contained battery. This receiver operates effectively up to a distance of one mile with the signal received from a one-watt FM Transmitter, AN/PRC-10 (the well-known Korean War Veteran's Walkie-Talkie).

UMRT-1 FM TRANSCEIVER

Comprising nine transistors, two diodes, two tubes and other necessary circuit components, a complete crystal-controlled FM transceiver, UMRT-1 has been encased in the space normally occupied by a can of tobacco. Almost half of the volume in this case is consumed by the battery, the relatively large size of which was principally due to power requirements of the two tubes. With the continued progress in transistors, elimination of the tubes is already assured for this type of application.

Performance characteristics are essentially as follows:

General

Frequency Range	47-52 mc
Frequency Control	Crystal
Communication Range	One-quarter mile
No. of Transistors	9
No. of Tubes	2
Overall Dimensions	6¼ x 3-1/16 x 1¼
Weight	2 pounds
Battery Life	24 hours

Receiver Section

Sensitivity	5 microvolts for 10 db S/N
Selectivity	75 kc at 6 db 400 kc at 60 db
Image Rejection	30 db
A-F Output	5 milliwatts (max.)
A-F Distortion	1% at 1 milliwatt
A-F Response	–3 db at 200 cycles –8 db at 5000 cycles
No. of Transistors	9
Battery Drain	100 milliwatts

Transmitter Section

R-F Power Output	75 milliwatts
Frequency Deviation	15 kc
Frequency Stability	.02%
Spurious Output Attenuation	–40 db
A-F Response	–3.5 db at 300 cycles +2.0 db at 10,000 cycles
A-F Distortion	3%
No. of Tubes	2
Battery Drain	950 milliwatts

FAVORABLY ACCEPTED BY ARMED SERVICES

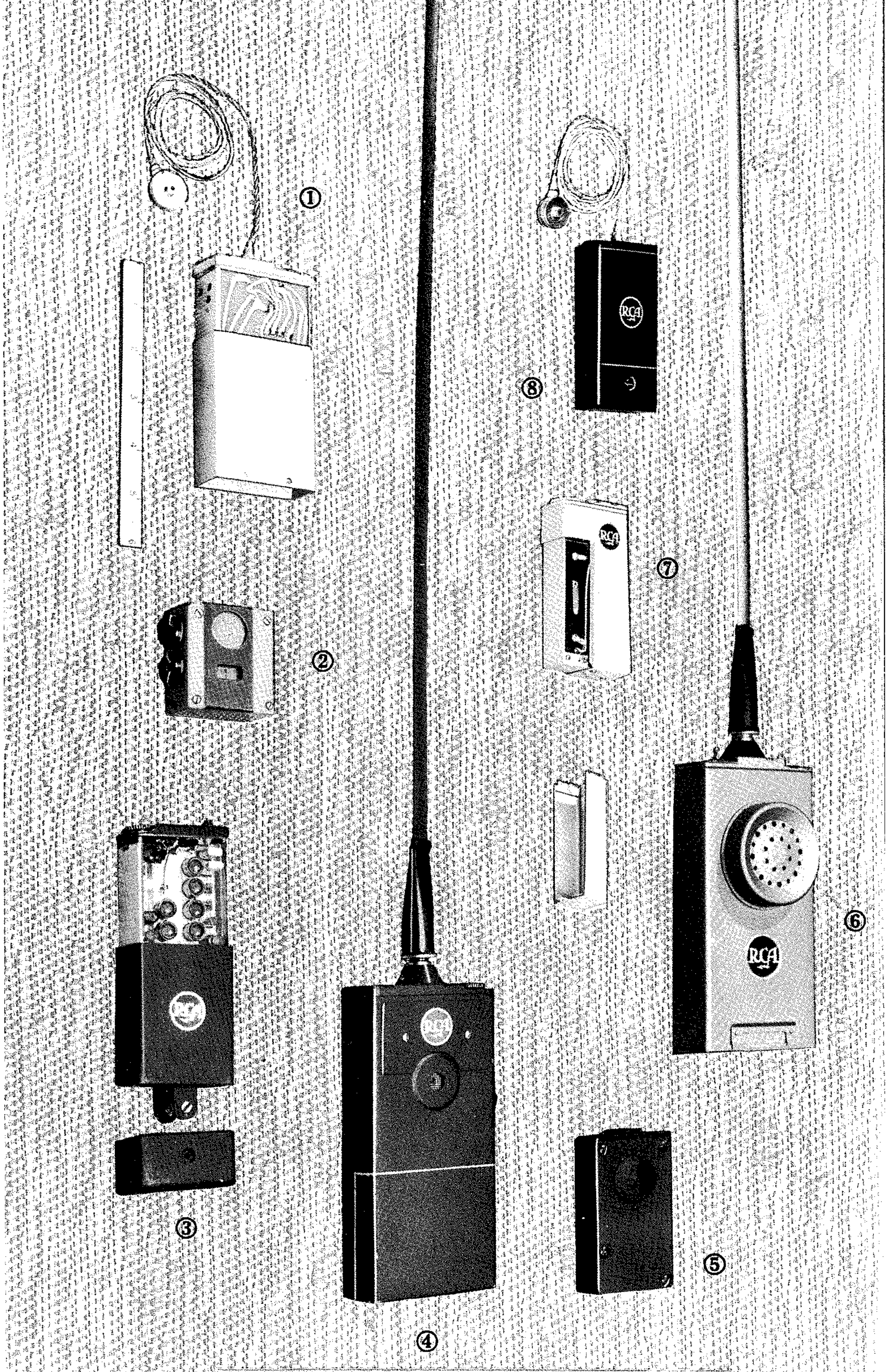
Sets such as those described above have been demonstrated from coast to coast to various Armed Service organizations. Some of the Services have procured limited quantities of these equipments and conducted their own tests. This has included squad operational tests at Fort Carson, Colorado, and Fort Huachuca, Arizona. In all cases tremendous interest and enthusiasm were generated for this type of equipment.

The newer radio sets in no way represent the ultimate in this field but merely illustrate that it is possible to attain good performance in space allotments that heretofore have been considered totally inadequate. As circuit developments continue and new techniques are brought forth the development and product design of more sophisticated systems will ensue.

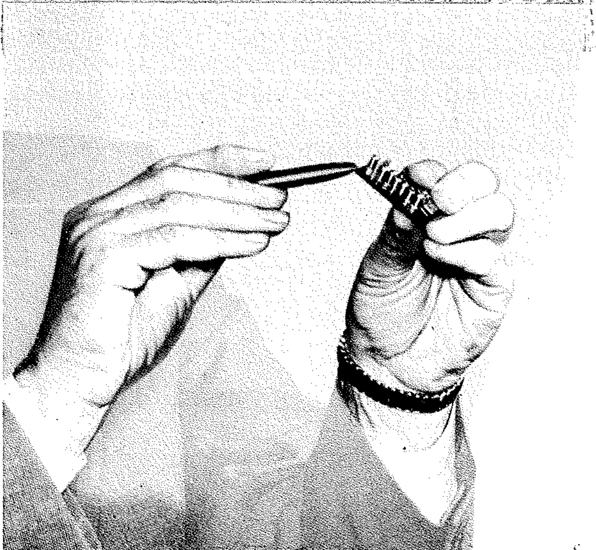
The basic structure of a transistor indicates high reliability potential. This has already in some cases fulfilled our anticipations in comparison with conventional vacuum tubes. Furthermore, the associated components are also able to provide higher reliability than their predecessors in view of low operating voltages and temperatures. Hence, highly compact design is possible without excessive heat rise. This type of design helps to provide more rugged structures capable of withstanding extreme shocks successfully. These compact units lend themselves to encapsulation by hermetic sealing or potting techniques, thereby preventing failures due to the effects of humidity.

ULTRA-MINIATURE SET FOR FUTURE

The ultra-miniature product area will undoubtedly help to bring automation to its anticipated level of application. This is particularly true in light of the fact that production volume of these devices will fully justify elaborate, refined automation assembly and test techniques. Public acceptance of the ultra-miniature line will be materially enhanced through cost reductions which will come about through full utilization of automation possibilities.



Shown above is a group of ultra-miniature radio sets designed by the Surface Communications Engineering section. All units are transistorized, and completely self-contained, including required batteries and antennas. They are identified as follows: (1) 50 MC, F-M crystal-controlled, modularized radio receiver, (2) Complete, tunable a-m radio receiver, (3) 55 MC, F-M crystal-controlled radio receiver (partially open to show construction), (4) 47 MC, F-M crystal-controlled radio transceiver (early military type), (5) Single-channel, crystal-controlled a-m radio receiver, (6) 50 MC, F-M crystal-controlled, radio transceiver designed with special microphone for NBC, (7) 45 MC, F-M crystal-controlled radio receiver (battery cover removed) and (8) 55 MC, F-M crystal-controlled radio receiver.



A complete transistorized A-M radio receiver chassis is comparable in size to an average fountain pen.

ULTRA-MINIATURE PERSONALIZED RADIO

—continued

To take full advantage of machine capabilities it will be necessary to modify the conventional concept of component configuration in order that most effective machine uses can be made and resulting product be of desired size and component density. Work in this direction has shown that far more complex communication devices may be incorporated in the sizes of the relatively simplified units described previously. Through standardization of specialized components a tremendous saving will be realized. Automatic tests for components, sub-modules and modules can be incorporated as a part of automatic fabrication and assembly machines. This will provide exact control of material fitting into the over-all automatic assembly positions. Over-all final tests can also be provided giving quantative and qualitative test data and records for each equipment.

LARGE MILITARY AND COMMERCIAL MARKET

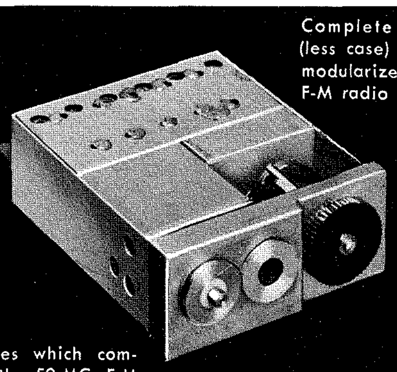
There is no doubt that a tremendous market is awaiting these ultra-miniature devices. In some cases such radio sets will be specially tailored to the need; in other cases standard types of units may be acceptable. In military applications alone, with the need for high dispersal due to modern warfare, radio communication even down to squad level will become an accepted fact. With rapid movement of military units, a constant contact must be maintained with all key personnel; wireless type of communication devices will help to provide the necessary flexibility. With reductions in military strength during cold war, close control of dispersed outposts will become vital. These ultra-miniature radio devices will offer a tremendous aid to various security units such as military police, sentries, protective guards, etc. One can easily visualize the convenience and improvement of operational efficiency resulting from the use of personalized communication equipment in installations such as guided-missile sites, air bases, maintenance bases, fire control operations, and disaster area. Another important type of application for which a great need exists is that of paging, alerting and selectively calling, in ground and shipboard installations.

In the commercial field potential applications are equally numerous and many new ones will be generated through the availability of these equipments. In this field, price reduction will have a very pronounced effect on sales potential.

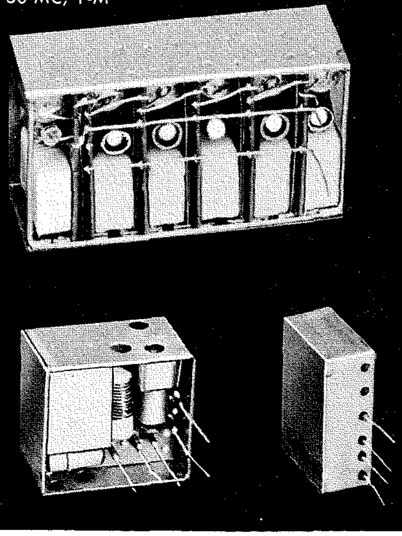
CONCLUSION

In view of the almost fantastic possibilities that such equipment offers in communications, it fully deserves the creative effort currently being directed toward its ultimate fulfillment. Such effort will overcome the remaining technical problems standing in the way of fullest utilization. There is no question that ultimately devices of this type will play a major part in our every day existence.

Sadao Okafuji, Surface Communication Engineer shown performing a test on a complete ultra-miniature, transistorized F-M radio receiver which utilizes modularized construction. Note the size relationship of test probe and receiver.



Complete assembly (less case) showing a modularized, 50 MC, F-M radio receiver.



Modules which comprise the 50-MC, F-M receiver.

COLLECTOR-CHARACTERISTIC CURVE TRACER FOR TRANSISTORS

By
A. L. CLELAND
Tube Division
Radio Corporation of America
Harrison, N. J.

THIS ARTICLE describes a curve tracer used to obtain quantitative information on characteristics of junction and point-contact transistors. Although this test set is not a precision instrument, the cathode-ray oscilloscope can be calibrated so that the accuracy of the visual representation is approximately 15 per cent. A curve tracer of this type can be used in production testing to discover discontinuities in the collector characteristic.

Information is presented in this article on the use of this curve tracer for both point contact and junction transistors, although it appears that the point contact transistor is rapidly becoming obsolete because of critical production problems and the continuing improvement in the high frequency performance of junction transistors.

INTRODUCTION

In most cases, the collector-characteristic curves of a point-contact switching transistor indicate whether the unit has the proper characteristics for large-signal applications. Probably the most significant regions of this characteristic are the so-called "knee" and the saturation region, as shown in Fig. 1a. A sharply defined "knee," which indicates that the emitter-input characteristic of the transistor is also sharply defined, is necessary for satisfactory switching operation. The collector characteristics of two transistors are shown in Fig. 1a, and their corresponding emitter-input characteristics in Fig. 1b. Unit A has the required characteristic curve for switching service, but unit B, having a poorly defined knee, would not work well in this application. The amount of collector current which flows when the emitter current is zero is also very important in switching applications because it determines the magnitude of the negative base bias required when the unit is used as a conventional non-linear amplifier.

More information can be obtained on junction type transistors when the collector characteristic is plotted as a function of the base current rather than the emitter current, i.e. when the transistor is used in the base-input (common-emitter) rather than the emitter-input (common base) connection. In the base-input circuit, the ratio of collector current to base current is high. The relation of this ratio, α_{cb}, to the ratio of collector current to emitter current, α_{ce}, of the emitter-input circuit is given by the following equation:

$$\alpha_{cb} = \frac{\alpha_{ce}}{1\text{-}\alpha_{ce}}.$$

The use of the base-input connection, therefore, facilitates the evaluation of the transistor characteristics because an extremely small change in α_{ce} causes a large change in α_{cb}, especially when the value of α_{ce} is very close to unity. In many cases, the value of α_{ce} decreases slightly with increasing emitter current, causing the value of α_{cb} to decrease very rapidly. The relationship of emitter current and base current to collector current in the base-input circuit is shown in Table 1 and in Fig. 2. It should be pointed out that the data shown include extreme cases to emphasize the relationship between α_{ce} and α_{cb}. In class B amplifiers, which operate at high peak current, the use of a base-input connection may cause the output to be greatly distorted because α_{ce} decreases at high current levels. This decrease in α_{ce} is compensated to some extent by a decrease in the input impedance of the circuit which permits larger base currents to flow for the same increment of signal voltage at the higher voltage levels. The $I_b = 0$ curve is also quite important in class B amplifiers because of the power which is wasted while the transistor is idling and the effects of this current on "cross-over" distortion.

AARON L. CLELAND received the B.S. degree in Electrical Engineering from Kansas State College in 1951. He joined the Radio Corporation of America in 1951 as a Specialized Trainee and, after completion of the training program, was assigned to the Receiving-Tube Application Engineering Laboratory of the Tube Division in Harrison, N. J. His work has been concerned principally with the development of circuit applications for both tubes and transistors. At present, he is an applications engineer in the Semiconductor Division.

TRANSISTOR TEST CIRCUIT

The collector-characteristic curve tracer is designed so that the collector characteristic of a transistor can be viewed directly on the face of a cathode-ray oscilloscope. The voltage between collector and base of the transistor produces a horizontal deflection; the collector current produces a proportional vertical deflection. Fig. 3 shows the test circuit used for transistors made with n-type germanium operating in the common-base or emitter-input connection. The constant-current bias supply for the emitter, shown at the left of Fig. 3, consists of a battery which is shunted by a potentiometer so that a voltage potential variable from zero to full battery voltage can be applied to the series emitter resistance, R_1. R_1 must be large as compared to the sum of the transistor input impedances and the ohmic resistance of the potentiometer so that variations in the transistor or the potentiometer will be small in comparison with the over-all circuit resistance.

The basic sweep circuit for the collector and the deflection circuits for the cathode-ray oscilloscope are shown at the right of Fig. 3 for n-type transistors. The negative-going half-sine-wave sweep voltage is applied to the

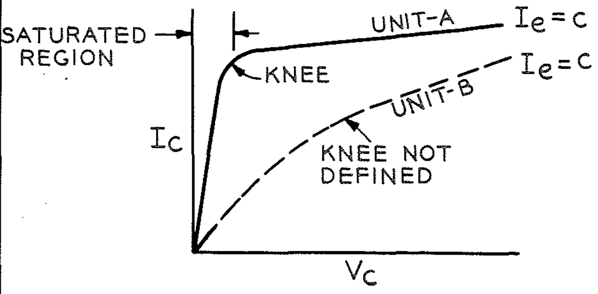


Fig. 1a—Collector Characteristics with I_e as constant showing sharp and poor "knee."

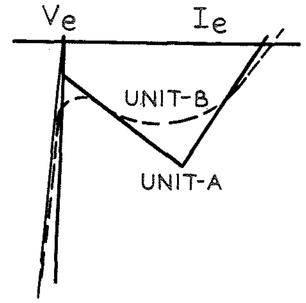


Fig. 1b—Emitter input characteristic of units in Fig. 1a.

collector of the transistor. T_1 is a variable auto-transformer, and has the function of varying the magnitude of the voltage applied to the rectifier; and thus the magnitude of the sweep voltage.

A p-n-p junction transistor used in a common-emitter or base-input circuit requires a negative collector sweep voltage and a negative base-current in the order of zero to 200 microamperes. For n-p-n transistors in common-emitter circuits, voltages of opposite polarity but of the same order of magnitude are required. A point-contact transistor can not be used or measured in the common-emitter circuit because its amplification factor, α_{ce}, is greater than unity and produces sufficient feedback to cause oscillation or "run away." If a point-contact transistor were placed in such a circuit, it would undoubtedly be damaged, if not destroyed.

COMPLETE TEST SET

Fig. 4 shows the complete circuit of the test set. In this circuit both p-type and n-type junction transistors can be measured in either common-emitter or common-base circuits and point-contact transistors can be measured in common-base circuits. Switch #1 controls the polarity of the emitter-voltage supply, and switch #2 the polarity of the meter. Switch #3 shunts the emitter when common-base circuits are to be used, and switch #4 selects the desired circuit (i.e. common-base or common-emitter) for the transistor. Switch #5 chooses the proper polarity for the sweep supply. Switches #1 through #5 are ganged. Diode D_1, which passes only the positive cycle, applies the output voltage V_1 across the 10,000-ohm resistor, R_4, which is grounded through the 10-ohm resistor, R_3. This arrangement produces a half-sine-wave voltage on the collector of the transistor, the peak magnitude of which can be controlled by the auto transformer T_1, and the polarity chosen by switch #5. R_3 must be small in comparison with the other impedance parameters so that the voltage wave-form applied to the vertical plates of the scope will not deviate appreciably from the wave shape of the collector current which develops it. The horizontal axis of the trace observed on the oscilloscope, therefore, is proportional to the collector voltage and the vertical axis is proportional to the collector current.

POLARITIES FOR P-TYPE AND N-TYPE TRANSISTORS

If the test set is used for both p-type and n-type transistors, consideration must be given to the polarities of the bias supply and the sweep voltage. A transistor using n-type germanium (either a p-n-p junction unit or an n-type point-contact unit) requires a negative sweep voltage and a positive emitter current in the common-base circuit, and a negative sweep and negative bias for the common emitter connection. P-type transistors require sweep and bias of the opposite polarity as shown for n-types. A bias current of zero to 2 milliamperes is sufficient in most cases for both junction and point-contact types. The switch positions corresponding to the available circuits are tabulated in Fig. 4.

OPERATION

Switch positions #1 and #2 accommodate either junction or point-contact transistors in the common-base circuit, the two positions being used for n-type and p-type units, respectively. In both positions, the collector current, I_c, is measured as a function of the collector voltage, E_c, at a constant value of emitter current, I_e. Positions #4 and #5 accommodate p-n-p and n-p-n junction transistors, respectively, in the common-emitter circuit. In these positions, collector voltage is measured as a function of collector current at constant base current, I_b.

Fig. 5 illustrates the traces observed on the face of the oscilloscope. It should be noted that the curve from a p-type transistor (shown dotted) will be inverted from that of an n-type unless an external switch is installed to reverse the plates of the scope.

The recommended test procedure is as follows:

1. The collector sweep voltage, controlled by the Variac, is reduced to zero before the unit is inserted in the socket.
2. The desired bias is then obtained by adjustment of potentiometer R_1.
3. The collector sweep voltage is now applied by adjustment of the Variac.
4. All voltages are reduced to zero when the transistor is being inserted or removed from the socket.

CONSTRUCTION

Although the half-wave voltage applied to the collector has a relatively low frequency (60 cps), the collector current for the applied sweep voltage is effectively a square wave as shown in Fig. 6. The current rises sharply as the sweep voltage increases until the "knee" value is reached, remains relatively constant until the same value is reached on the decreasing portion of the sweep cycle, and then drops rapidly to zero.

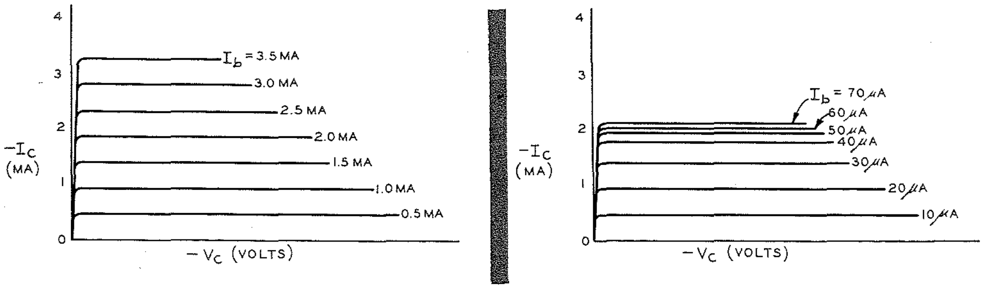


Fig. 2—Junction collector characteristics showing the effect of α_{ce} fall off.

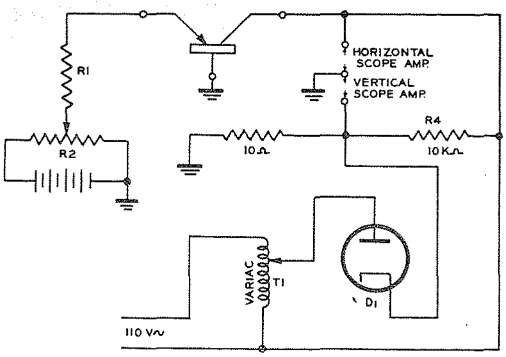


Fig. 3—Circuit diagram of simple curve tracer for transistors of the N-type used in the common-base connection.

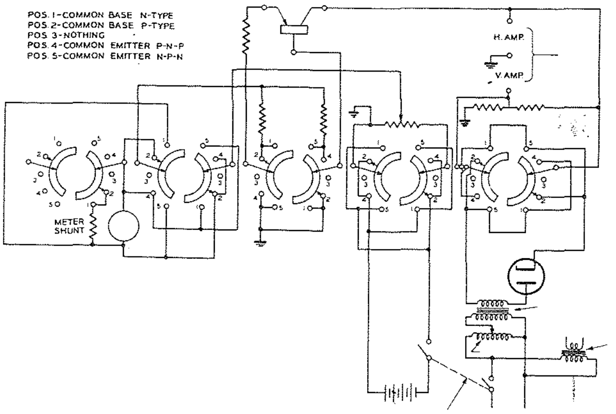
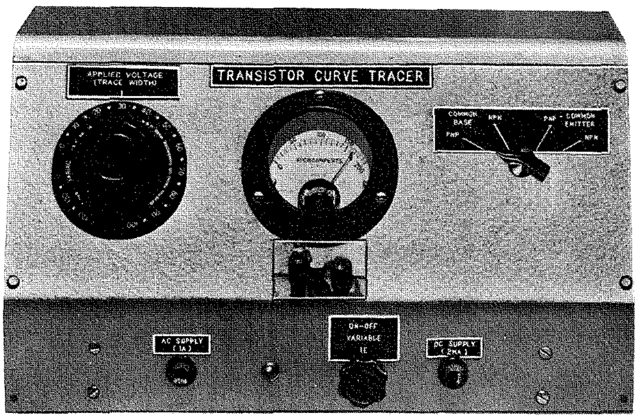


Fig. 4—Complete circuit diagram of collector characteristic curve tracer.



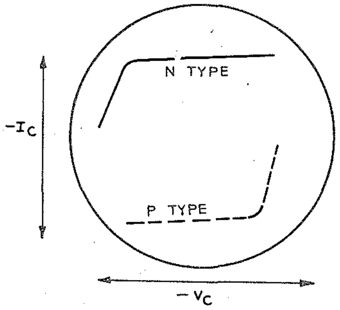


Fig. 5—Sketch of uncalibrated scope face showing collector characteristics of P-type and N-type transistors.

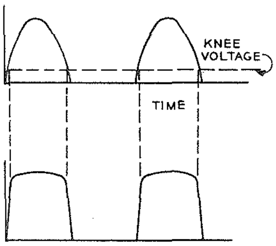


Fig. 6—Sketch showing wave shape of collector sweep voltage and current with time. Note that the collector current resembles a square wave.

In the common-base circuit, the base current is equal to the difference between the collector and emitter currents. Because the emitter current is in the steady state, the base current, like the collector current, is a square wave. The potential developed across the internal base resistance of the transistor by the base current also resembles a square wave. In the point-contact transistor, this square wave of voltage is in phase with the input voltages. If the series emitter impedance is not kept large, this voltage may cause the unit to oscillate or drive it into the "saturation" region, where damage may result if a collector load resistor is not used. The use of an emitter supply having a high internal resistance introduces degeneration and minimizes the tendency toward oscillation. Stray capacitance to ground may present a sufficiently low impedance to the harmonics of the feedback voltage to cause the unit to oscillate over a portion of the cycle, thus causing the collector characteristic to be greatly in error. R_2 is inserted as close as physically possible to the emitter to isolate the wiring capacitance. Despite this precaution, the units having high α_{ce} and/or high internal base resistance exhibit oscillation over a portion of the cycle. Measurements in the laboratory indicate that a capacitance of one microfarad from emitter to base is sufficient to cause border-line units to exhibit this type of oscillation. Care should be taken to reduce stray capacitance as much as possible in order to minimize this effect in the collector characteristic.

The transistor socket is mounted on a small plexiglass sub-panel or adapter. All connections are made to banana plugs which can be inserted into the appropriate jacks on the front panels. These adapters are easily made up in quantity for different types of transistor construction.

TABLE 1

A

$I_b = (1\text{-}\alpha_{ce})\ I_e$

α_{ce}	I_e(ma)	I_c(ma)
0.98	0.5	0.49
0.98	1.0	0.98
0.98	1.5	1.47
0.978	2.0	1.952
0.975	2.5	2.44
0.973	3.0	2.92
0.967	3.5	3.38

B

α_{cb}	I_c(ma)	$I_b(\mu a)$
50	0.5	10
50	1.0	20
50	1.5	30
45	1.8	40
40	2.0	50
35	2.1	60
30.7	2.15	70

C. M. SINNETT has not only shown a vigorous interest in the professional advancement and training of RCA engineers but has also been actively engaged in studying and applying methods of increasing the creativity of RCA engineers. Mr. Sinnett's thoughts on creativity are expressed in his article "(Ideas)^n–Is There A Limit?", Vol. 1, No. 6. Mr. Sinnett is an IRE Fellow, and a member of Tau Beta Pi.

Mr. Sinnett has also been active in editorial work at RCA. He serves as an engineering editor on the staff of the RCA ENGINEER and is chairman of the Cherry Hill Editorial Board. For a more detailed biography of Mr. Sinnett see Vol. 1, No. 5, page 31.

CHERRY HILL ADVANCED ENGINEERING TRAINING PROGRAM–TV RECEIVERS

C.M.SINNETT, Mgr.
Advanced Development Engineering
RCA Victor Television Division
Cherry Hill, N. J.

THE DEVELOPMENT and design of television receivers requires the closely integrated efforts of many engineering specialists. Each basic area such as r-f tuners, i-f amplifiers, sync and agc systems, deflection and high voltage and video amplifiers demands specialization if maximum results are to be obtained. This is particularly true with respect to receiver performance and cost. Then too, as might be expected, many of the younger engineers in the organization have had little opportunity to become acquainted with over-all design requirements of television receivers.

TRAINING PLANS BEGUN OCT., 1955

Consideration of these factors led to the formation of plans for an engineering training program to be conducted at Cherry Hill for members of the Television and Radio/"Victrola" Divisions. The first meeting of the Planning Committee was held on October 25, 1955. At that time subcommittee chairmen were appointed to formulate in more detail the various lectures comprising the course.

OVER 60 LECTURES—TWO CLASSES WEEK

By the end of December a complete list of the lectures, numbering over 60, was available together with an outline of each lecture and the name of the instructor. An Editorial Board consisting of W. Y. Pan, G. L. Grundmann, M. S. Corrington and C. M. Sinnett was set up to review all the lectures and to work with the authors in the preparation of the written material. A schedule was then established for each lecture as to time of completion of the first and final drafts. This was based on a starting date for the course of October 15, 1956. It was also decided that two classes would be held each week from 4:00 to 6:00 p.m.

Coincident with the formation of plans for the Television Division, the Radio/"Victrola" Division established its own program pertaining particularly to radio receiver development and design. It was felt that because of the fundamental nature of the first half of the Television course, Radio/"Victrola" engineers would attend this and at a given point embark upon their own lecture series. This portion of the over-all Cherry Hill program will be discussed in a future issue of the RCA ENGINEER.

COMPREHENSIVE COURSE IN 13 SECTIONS

The amount of time and effort involved in preparing, editing, and reproducing the lecture notes is staggering, but the results to be obtained can be far-reaching. Some indication of the comprehensiveness of the course can be gleaned from the following outline which lists (in 13 different sections) the titles of lectures and the names of the instructors.

Subject	Instructor
I—Introduction to the Signal	Dr. G. H. Brown
II—Transients	R. W. Sonnenfeldt
Introduction to Steady State and Transient Characteristics	
Fourier Integrals	
LaPlace Transforms	
Transient Analysis	
Transient Analysis Concluded	
III—Types of Filters in TV Receivers	T. Murakami
A. Low-Pass Networks	
Low-pass filters, Part I	
Low-pass filters, Part II	
Low-pass filters, Part III	
B. Band-Pass Networks	
Coupled circuits	
Stagger-tuned circuits	
Transients in band-pass filters	
Transients in symmetric and asymmetric side-band systems	
C. Rejector Circuits	
Rejection circuits	
D. Compensating Networks	
Amplitude and phase correction networks	
E. Open Session	
IV—Use of Computers in Engineering Design	R. A. Johnson
Part 1—Methods and uses of computers	
Part 2—Methods and uses of computers	
V—Television Receiving Antennas	R. F. Kolar
Elementary Principles and Requirements	
Specific Antenna Types	
Accessories and Installation	

VI—RF Amplifiers

Subject	Instructor
General Requirements of RF Amplifiers in Commercial TV Receivers	J. C. Achenbach
Noise	W. R. Koch
Types and Tubes of RF Amplifiers	H. M. Wasson
Circuitries of RF Amplifiers	H. M. Wasson

VII—Converters

Subject	Instructor
General Requirements and Considerations of Converters in Commercial TV Receivers	W. R. Koch
Local Oscillators	W. Y. Pan

VIII—IF Amplifiers .... F. T. Ksiazek

Subject	Instructor
General Requirements of TV IF Amplifiers	
Types and Circuitries of IF Amplifiers	
TV Sound IF Amplifier and Detector Circuits	

IX—Detectors and Video Amplifiers

Subject	Instructor
Detectors for TV Receivers	L. P. Thomas
Cross Modulation in Detectors	R. W. Sonnenfeldt G. M. Daly
Thermal and Impulse Noise Performance of Detectors	R. W. Sonnenfeldt G. M. Daly
Practical Sonnenfeldt Detector Circuits	R. W. Sonnenfeldt G. M. Daly
General Considerations of Video Amplifiers	M. C. Kidd
Video Frequency Compensation	M. C. Kidd

X—Color Demodulators and Matrix Circuits

Subject	Instructor
Basic Theory of Color Demodulators	R. W. Sonnenfeldt
Demodulator Circuits	W. W. Cook
Demodulator Pass-Band Characteristics and Matrixing	W. W. Cook

XI—Pulse Circuits ..... R. W. Sonnenfeldt

Subject	Instructor
Pulse Amplifiers	
DC Setters, Clamps and Blocking Oscillators	
Multivibrators	
Pulse Formers	
Gates and Clippers	
AGC System Analysis—Injection-Locked Oscillators	
Automatic Phase and Frequency Control—System Analysis	
Special Problems in Pulse Circuits	

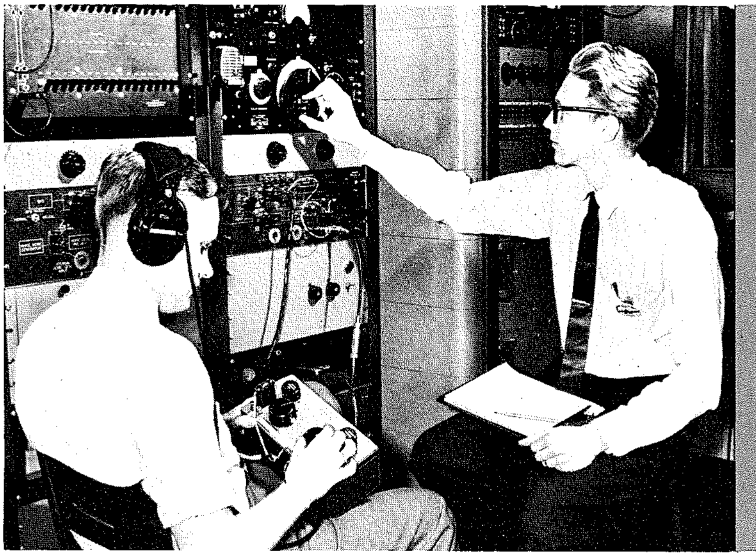
XII—System Limitations in TV

Subject	Instructor
Limitations in Camera Equipment	H. N. Kozanowski
Bandwidth Limitations	T. Murakami
Demodulator Limitations—Transient Crosstalk	T. Murakami
Demodulator Limitations—Threshold and Impulse Noise Effects	T. Murakami
Reproducer Limitations	D. D. Van Ormer
Limitations of the Human Eye	O. H. Schade

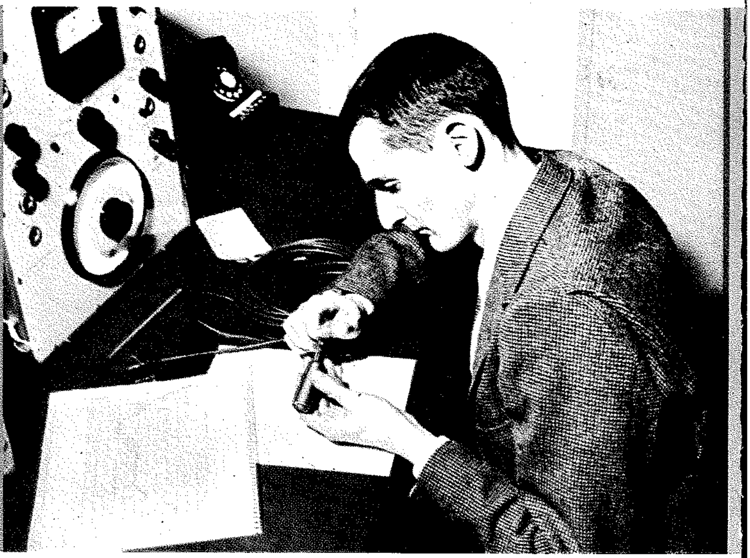
XIII—Color and Monochrome Receiver Design and Test

Subject	Instructor
Convergence	J. C. Schopp
Sync Separators	H. C. Goodrich
Picture Stability Requirements	L. P. Thomas
Vertical Deflection Systems	B. S. Vilkomerson
Horizontal Deflection and High Voltage	C. C. Iden W. E. Scull
Power Supply Systems for TV and U. L. Considerations	H. K. Shoaf
Audio Amplifiers and Acoustics	R. S. Fine R. L. Libbey
Tuner Design Considerations	G. C. Hermeling
IF Design Considerations	F. T. Ksiazek
Radiation Requirements	E. O. Johnson
Over-All Tests	L. P. Thomas

Photo showing the members of the Cherry Hill Engineering Training Editorial Board during an organization session: (l to r) W. Y. Pan, G. L. Grundmann, C. M. Sinnett, and M. S. Corrington.



R. E. Backus (right) and J. W. O'Neill performing a real ear calibration of a headset. The subject alternately hears two tones of different frequency which he adjusts to equal loudness, for a quantitative calibration.



R. E. Werner with the BK-6B microphone, which he developed. This is the smallest self-contained broadcast quality microphone.

THE ART OF ELECTROACOUSTIC TRANSDUCER ENGINEERING

by

R. M. CARRELL

Theater and Industrial Engineering
Commercial Electronic Products
Camden, N. J.

TRANSDUCERS ARE IMPORTANT to the electronics industry since they make "applied electronics" possible in the industrial, communication and entertainment fields.

Electroacoustic transducer design is itself as much an art as a science. The basic laws were formulated by Lord Rayleigh and others long ago. As simply as these may be stated, their specific solution is possible only under very simplified boundary conditions. A similar situation is found in electromagnetism and Maxwell's Equations.

DIFFICULTIES IN MATHEMATICAL ANALYSIS

In acoustics and electromagnetism, mathematical analysis is convenient only when the wavelength of the radiation is either very large or is small compared to the dimensions of the apparatus. If neither condition can be assumed, then analytical prediction of phenomena becomes very difficult.

The range of 50-15,000 cps, which is most important in acoustics, is comparable to the region of 50-15,000 megacycles in electromagnetism. At the low end of these regions, the wavelength is about 20 feet; at the high end, it is about one inch.

The factor which makes circuitry analysis at all practical when working in this region is that the electronics engineer deals essentially with narrowband devices and "effective" inductance, capacity and resistance.

In acoustics, however, most of the transducers are expected to span at least a decade of this range, and for high fidelity, the entire range must be uniformly reproduced. Mathematical analysis is very difficult in most cases, so the actual design of a transducer is apt to proceed by a process of careful cut, try and deduction. As crude as this may seem, it is actually a very strong discipline of engineering skills. The transducer engineer must proceed with considerable, methodical care if he is not to become lost.

THE BLACK BOX PROBLEM

The picture is further complicated by the fact that nearly every transducer presents a classic black box problem. The engineer can measure the input and output of his black box, and he has the privilege of rearranging its contents. It is usually so difficult to measure what goes on inside a transducer that it is rarely attempted.

ELECTRICAL ANALOGUES

The closest approach that can be made to internal measurements is the equivalent circuit and the analogue. An analogue is based on the similarity of the differential equations which describe the behavior of mechanical, electrical and acoustical systems. Inductance corresponds to mass, whether that of a solid body or of the air pumped through a tube. Capacitance corresponds to compliance, whether that of a spring or of the air trapped in a cavity. Resistance corresponds to mechanical friction, or the viscosity of fluids, or of air pumped through narrow slits, tubes or cloth.

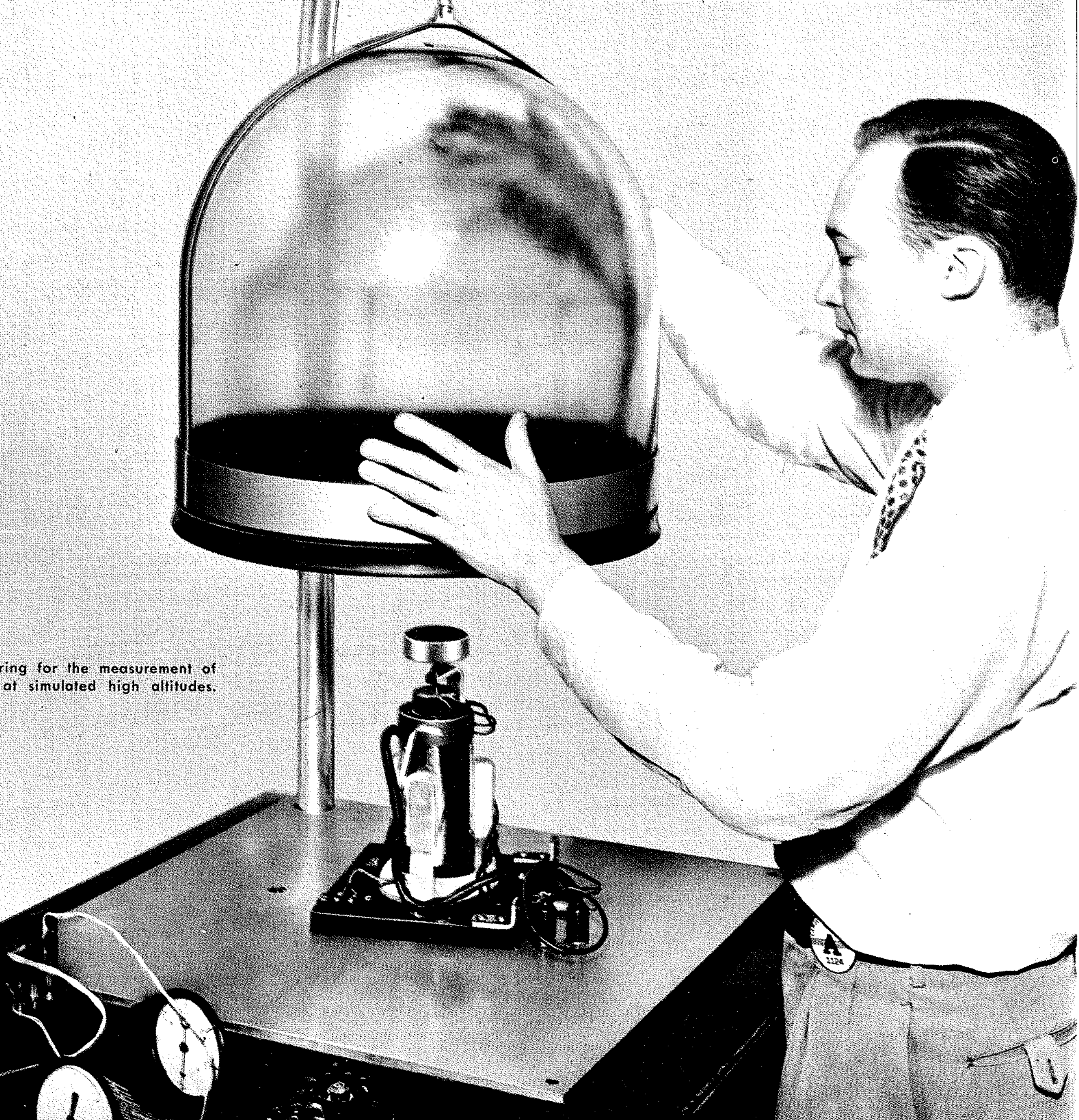
It is possible, then, to construct an electrical network which will exhibit properties similar to those of a microphone. It is possible to monitor the internal processes of the analogue and gain thereby some insight into the behavior of the transducer. An analogue is also useful in predicting the effect of certain changes in the structure of the transducer.

The equivalent circuit is convenient as a guide, but the stockroom does not carry acoustical capacitors, inductors and resistors. The acoustical circuit is a result of the geometry of the transducer itself, and is usually a lion to be tamed. Very rarely does a transducer begin with a desired equivalent circuit which is then incorporated in an actual device.

It is not sufficient that a transducer be built to certain specifications. A task of comparable difficulty lies in establishing the specifications. This

L. M. Wigington (on desk) and M. L. Touger discussing RCA acoustical components for Air Force helmets, including the high pressure oxygen helmets on the desk. The headset in foreground is an RCA development.

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



J. H. Hartley preparing for the measurement of earphone response at simulated high altitudes.

ELECTROACOUSTIC TRANSDUCER ENGINEERING—*continued*

usually involves aesthetic considerations in addition to comfort, human engineering and psychoacoustic criteria. Often the transducer and the user must be considered as a system. This is particularly important in military communications.

MILITARY TRANSDUCERS

RCA has been a major supplier of military transducers from a period prior to the second world war to the present. It made major contributions to the development of the sound powered telephone and was the major supplier of these instruments through the second world war and even to the present. A group in Electronic Components is currently producing sound powered telephones of modern design.

RCA originated the AN/AIC-10 system under Air Force sponsorship.[1] This is still the best military communications system available. The RCA transducer engineering groups in Building 10-4 are still engaged in the refinement of the AIC-10 transducers. (More than 300,000 of these transducers have been in use for three years without a single field operational failure.) These groups also act as consultants to manufacturers of oxygen helmets for the Air Force to assure proper design and installation of the microphone and earphones. Where necessary, special microphones and earphones are designed for the application.

An important part of the engineering of a military communications system is a survey of the noise fields which will be encountered. RCA engineers have collected and analyzed noise specimens in tanks, troop carriers, submarines and helicopters in cooperation with the Navy, Signal Corps and Air Force.

A knowledge of the noise spectra and their overall level permits an estimation of the sensitivity, frequency response, and noise exclusion properties necessary in the microphones and headsets. Noise exclusion in a microphone is obtained by using the differential principle, plus an auxiliary noise shield in some applications.

In the earphone, noise exclusion is obtained by proper design of the earcushion, which must also be as small and light as possible. In some cases, the earcushion may be worn for 24 hours, so comfort becomes an important design consideration. Even the best available earcushions will not give adequate protection to personnel working near jet engines where the sound level may reach 140 db. One project under way in Mr. Touger's group is the development of an active ear defender, which is an electroacoustical system designed to reduce the noise beneath an earcushion by causing the earphone to generate an out-of-phase signal which cancels part of the noise in the ear cavity.

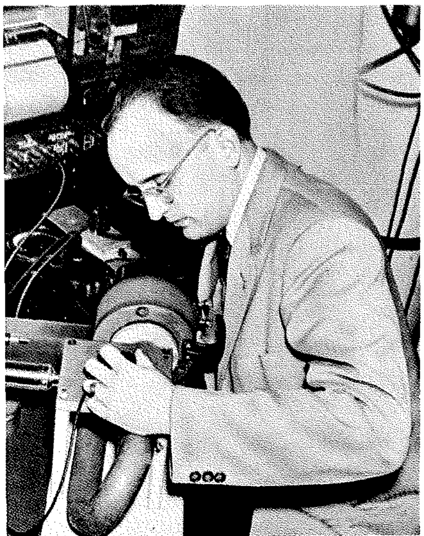
SUBJECTIVE EVALUATION NECESSARY

The evaluation of the response and noise exclusion properties of an earphone-earcushion combination must be done with the methods of experimental psychology, to obtain quantitative data from subjective observations.

The final test of a military communications system is its ability to transmit intelligible speech in intense noise. This capability is evaluated by an articulation test, wherein a talker reads lists of monosyllabic words to a crew of listeners. The system is graded on the basis of the percent words heard correctly.

There is also an interaction between the user and the microphone. A chest microphone for television use[2] sees a different sound spectrum from that which would be seen by a microphone placed in front of the face. This difference must be evaluated, for real talkers, in order to properly design the microphones. In the military area, close talking microphones are used, sometimes with auxiliary noise shields. Here the characteristics of the microphone are altered by the proximity of the sound source. Further, the character of the voice is altered by the noise shield or oxygen mask. These factors are important to the operation of the microphone, and are not evaluated by artificial voice techniques of measurement. Artificial voice, single frequency tests are also inadequate for indicating the dynamic performance of the system. Where distortion is present in the microphone or amplifiers, the overall performance can be assessed only by real voice methods of measurement.[3]

R. M. Carrell shown working with an acoustical impedance meter.



The technique of real voice measurements involves the use of an audio frequency spectrum analyzer and an integrator. Such an integrating audio-spectiometer is one of the many specialized acoustical tools constructed by the transducer engineering groups in RCA.

COMMERCIAL TRANSDUCERS

The commercial transducer line is also important to RCA. RCA microphones today are present in virtually every television studio, although usually just out of sight of the camera. The patriarch of the RCA microphones, the 44BX, is so much a part of broadcasting that nearly every cartoonist who sketches a microphone gives it the characteristic diamond shape of the 44BX. Among the newer commercial microphone designs are the BK-5A, a high quality television boom microphone,[4] and the BK-6B, the smallest self-contained broadcast microphone obtainable.[5] RCA developed one of the two basic sound-on-film recording systems, and the theater loudspeakers, developed in Camden, are among the best.

MECHANICAL DESIGN

Since the acoustical parameters are a direct function of the dimensions of the transducer, the maintenance of uniform performance requires careful mechanical design and careful assembly. A high quality transducer is in every sense a precision instrument which nonetheless must withstand severe usage.

TEST FACILITIES

The proper testing of electroacoustical transducers requires facilities which are costly, complex and spacious. In Building 10 there are two listening rooms and two large anechoic (echoless) rooms, each occupying two bays (720 square feet). These are all isolated from the building. There are also two smaller rooms, one designed for very low level acoustic measurements. There is also a completely equipped theater in Building 10-4 for the testing of theater projectors and sound equipment.

The anechoic rooms are used for standardized testing of microphones and loudspeakers. Articulation tests are performed in a moderately reverberant room equipped with diffusers and a battery of theater loudspeakers driven by 180 watts of audio power. Sound levels approaching 120 db can be obtained for simulating the noise of armored vehicles and aircraft.

Incidental to the main task of developing better transducers, a considerable family of specialized test instruments have been developed by members of the transducer engineering groups to meet special requirements. These include standard sound sources, standard microphones and devices for the measurements of acoustical impedance, hum pickup[6] and wind noise.[7]

TRANSDUCER ENGINEERING ACTIVITIES

There are several groups in RCA carrying on transducer engineering activities. Much of the basic electroacoustical research is done at the David Sarnoff Research Center under the direction of Dr. H. F. Olson. Advanced development and design is done by several groups in Camden and Cherry Hill, N. J.

At Cherry Hill, television acoustical development is carried on by R. L. Libbey under the supervision of M. S. Corrington (see paper this issue on Anechoic Chamber at Cherry Hill). In the Radio and Victrola Division, acoustical development is carried out by S. V. Perry and Roy Fine (see paper this issue by Mr. Fine on High Fidelity). Record changers and tape transport engineering is done by a group headed by Alex Burt.

In Camden, a Component Parts Engineering Group under D. H. Cunningham, designs loudspeakers and sound powered telephones. In Commercial Electronic Products, advanced development of theater reproducers has been carried on under the supervision of John E. Volkmann, who also serves as a staff engineer and consultant on architectural acoustics to RCA Sound and Theater customers.

Microphone, pickup and tape recorder engineering activities are under the supervision of L. M. Wigington, reporting to L. J. Anderson. Mr. Wigington's group is also responsible for design of the AIC-10 microphones. In Defense Electronic Products, the engineering of headsets, military communication system studies and sound powered equipment, is under the supervision of M. L. Touger, reporting to M. L. Graham.

Advanced development on video and special tape recording systems is done by a group under H. E. Roys. On the West Coast, motion picture recording equipment is designed under the supervision of M. Rettinger.

CONCLUSION

The range of skills necessary to transducer design is a wide one. Members of the transducer engineering groups have often been called upon to lend their skills to the solution of problems in other areas, particularly where these relate to noise and vibration, which are within the province of the acoustician.

Within RCA alone, transducer design involves mechanical filters, video tape recordings, phonographs, electrofax and computer reading and writing devices. These are as essential to the vitality of RCA and the electronics industry as the art of electronics itself, and the challenges presented will test the mettle of the best of engineers.

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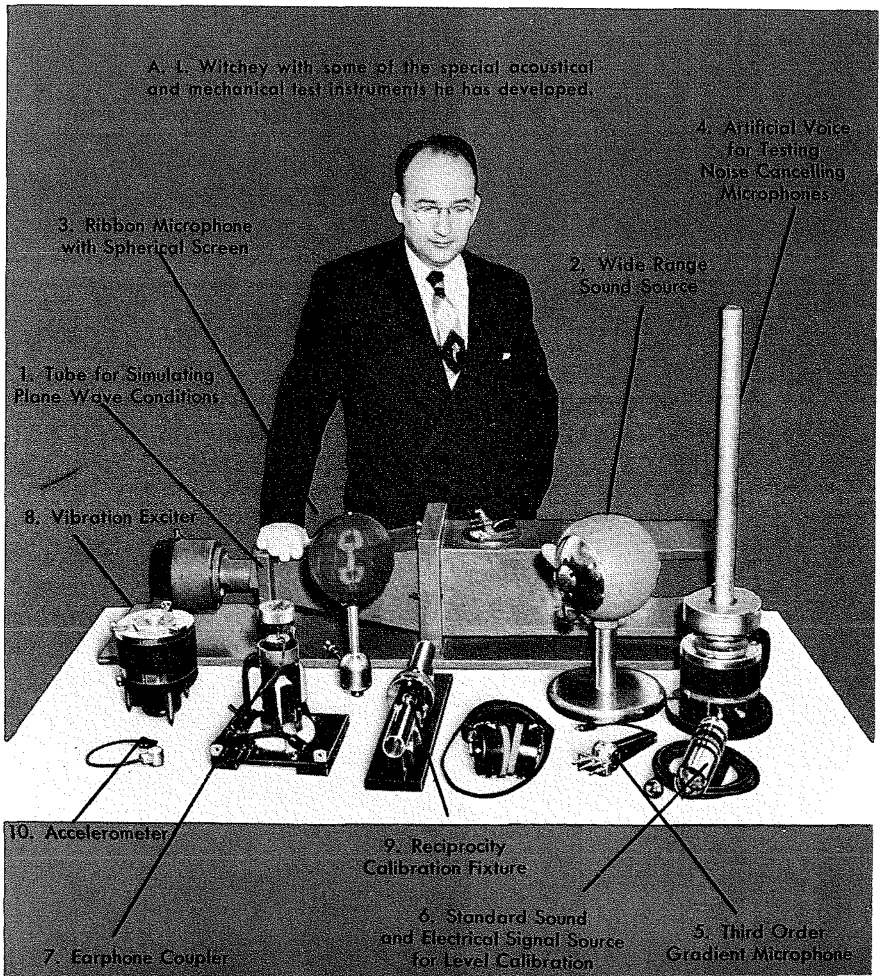
A. L. Witchey with some of the special acoustical and mechanical test instruments he has developed.

THE ENGINEER AS AUTHOR

by
W. O. HADLOCK, *Editor*

By the nature of their training, engineers possess the background to write technical papers of professional value . . . right from the very first one! Their critics may think otherwise whenever there is a scarcity of published articles or an abundance of papers prepared too hastily. This occurs only when the engineer neglects to include enough writing time in his plans. To allot sufficient time and take positive action are "must" requirements.

A primary aim of this article is to offer suggestions that will help the engineer assume his role as author, with a minimum of time and effort. Other aims are to point out the benefits enjoyed by writing, and review reasons why the engineer is qualified to write.

It is true, of course, that the occasion to write, the inspiration, and proper confidence are sometimes lacking—but not the ability. Let's examine the unmistakable proof.

QUALIFICATIONS OF ENGINEER AS WRITER

The engineer is trained to think logically. He has the knack of organizing well! Both of these qualities are just as essential in writing professional papers, as they are in practical engineering. Because the engineer writes with authority, he can analyze to the satisfaction of others the reasons behind a product design. He instills confidence in the reader that his plan is well-conceived.

Consider the extent to which the engineer contributes source material for the preparation of published information by specialists in other groups . . . Sales, Merchandising, Servicing, Advertising and Purchasing. The writing efforts of the engineer may include technical reports, patents, customer presentations, brochures, catalogs and specifications, in addition to technical papers. All these thoughts are further backed up by the expressed aim of Electronic Equipment Manufacturers to employ engineering graduates in technical writing roles. The answer to the question—"is the engineer qualified"—is *definitely yes.* Next, how does the engineer benefit by writing?

HOW YOU BENEFIT*

There are so many advantages for both the engineer and his company that it is impossible to do much more than briefly review the following outstanding benefits for the writer: (1) Provides a means of recording your accomplishments (2) Increases your professional prestige (3) Gains acceptance of your idea (4) Gives you broader perspective (5) Helps you to help others, and

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*See "Why Engineers Should Write Technical Papers" by M. S. Corrington, RCA ENGINEER, Vol. 1, No. 1, June-July 1955.

perhaps most important of all (6) Provides a logical evaluation of your work.

The rewards of a systematic, written review cannot be over-estimated. You benefit immediately, even as you write. Putting the idea on paper will necessitate a recheck of your analysis of the problem and choice of solutions. If the idea is practical, it will withstand the test of being put on paper and may be further improved by doing so. Conversely, writing down an impractical idea will reveal its shortcomings.

Another pleasant surprise may be the discovery that the technical article is an unusually convenient and flexible method of presentation. Unlike the oral presentation, it can be shaped, re-shaped and changed again and again until perfected.

Once the advantages have been recognized—what is the next move for the prospective "engineer-writer"?

DETERMINE A NEED—CHECK FITNESS—DESIRE ACCEPTANCE

The next logical step is to determine that a definite need exists for the article proposed. Then, carefully check the "fitness" or propriety of the topic. To do this, the following questions must be answered satisfactorily: (1) Will the paper contain valuable information? (2) Will it describe a new or novel idea? (3) Will it carry a definite message to the reader? (4) Does the topic have supervisory and policy approval? and (5) Have you completed patent disclosures far enough in advance to permit patent coverage?

By giving these questions sufficient care and attention in the beginning, you will gain better acceptance of your paper—and reduce the time required to obtain final approvals. All points named above are necessary "preliminaries".

Other requirements are the occasion to write, and the desire to get your idea accepted by others. The desire, present in most of us, is needed to motivate the writer. The occasion may be an expression of interest by associates or by a technical journal. Perhaps your initial invitation to write for a technical journal will result from contacts made through Professional Society activities. Proposed articles may be submitted at any time to RCA's engineering editors for consideration and placement in trade journals. Ask your editorial representative (see list back cover) to help you evaluate topics proposed for the RCA ENGINEER.

PRIMARY CONCERN OF WRITER IS READER

The reader is the one to satisfy. Quality, style, thoughts, subheads, phrases, captions, illustrations and every element of a paper must be evaluated with the reader in mind. Whatever the subject, it has to be written to a particular class or classes of readers. When you are writing for the RCA ENGINEER, your readers are your associates. This will require more thought than that given to a journal tailored for one specific field. Your readers at RCA include engineers in many fields . . . electrical, mechanical, physical and chemical, optical—and many more. All must be considered.

Here are several elements that directly affect the reader; therefore, they are worthy of your consideration . . .

TITLE: This is an important, attention-getting element of your paper. Keep it short, but make sure it tells a story. You will usually change the title and improve it several times before completion.

OPENING PARAGRAPHS: The introductory part of your paper should gain the favorable attention of the reader. Convince him to continue reading. Write it quickly, then rewrite and strengthen later.

TALK TO READER: Gain reader interest by writing your paper exactly as you would talk to associates. This will make it equally suitable for oral presentation.

VARY SENTENCE LENGTH: This provides variety and change of pace.

SUBHEADINGS: Well-chosen paragraph subheadings assist the reader. They act as "road-markers" for the reader who "scans".

CAPTIONS AND ILLUSTRATIONS: Include enough illustrations to completely support your paper. It is wise to provide your editor a choice by including too many illustrations, rather than too few. The figure captions are all-important, particularly to the reader who is pressed for time

SAMPLE OUTLINE

(Dealing with Engineering Design and Development Papers. Use only portion which applies in your particular case.)

A. INTRODUCTORY SECTION

1. Evaluate Design briefly and cite uses for readers.
2. Purpose and performance goals.
3. How new work ties in with old.
4. How results are new.
5. Brief mention of significant work on which design depends.
6. Significance of results to other RCA engineers.
7. Possible circuit applications for associates, for users.
8. Variations of possible interest to other engineers, to users.

B. DESCRIPTIVE, TECHNICAL SECTION (Previous Knowledge, Designs, & Contributions)

1. Describe and communicate valuable information in successive stages.
2. Features of previous designs or contributions utilized.
3. Design tasks requiring completion.
4. Mention impractical approaches tried and reasons why other engineers should avoid.
5. Early challenges and successes.
6. Principles of design and operation.

C. DESIGNING THE CIRCUIT OR PRODUCT (Discussion Section)

1. Decisions made to achieve objectives or goals.
2. Engineering investigations and tests conducted to confirm design.
3. How problems were overcome.
4. Develop points covered in conclusion.

D. THE FINAL DESIGN

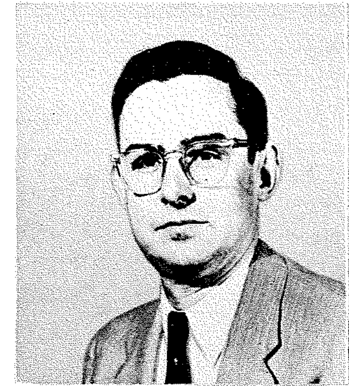
1. Final tests and results.
2. How performance goals were met.
3. Brief description.

E. SUMMARY OF CONCLUSIONS

1. Cite advantages of final design.
2. Significance for present and future.
3. Message for associates.

THE ENGINEER AS AUTHOR

Continued



R. C. BITTING, JR.

M. S. CORRINGTON

DR. L. B. HEADRICK

THESE RCA ENGINEERS GIVE THEIR

and relies on the captions for the story.

STRIVE FOR QUALITY: It is necessary to strive for a level of quality beyond "acceptable". You will gain prestige with your readers. Careful attention to usage. arrangement and clarity will result in faster clearance of papers, since only a minimum of editing will be needed. Get the criticism of associates and help from company editors. See "Tips on Writing Technical Papers" available from Commercial Engineering, Tube Division, Harrison, N. J.

RELIABILITY: Technical articles do not need to be written in a fancy manner. The essential facts should be covered in enough detail to substantiate your conclusions. If there is an element of uncertainty, then the degree of uncertainty should be stated.

TECHNICAL ACCURACY: Every engineer will strive for technical accuracy, however, the "checking" should be done before the paper is submitted for formal approvals. Time will be saved by doing so.

CONCLUSION: Whether or not you label it as "conclusion", you must leave a definite message for your reader.

There are other elements that help the reader, such as: definitions, glossary of terms, references, acknowledgements and appendices. These vary with the audience and the wishes or style of the journal involved. The engineer doing the writing is best qualified to know the areas requiring definition or further explanation. However, there is a tendency on the part of the engineer-author to overestimate the readers' knowledge of a specialized subject.

The importance of these "reader-aids" must not be forgotten during the mechanics of writing.

THE MECHANICS OF WRITING

The need for clarity, proper use of the language, and other important fundamentals are fully described in most every text and are not repeated here. Instead, the less glamorous side of writing does deserve our attention. This includes the frequently overlooked considerations of mechanics and effort. Inertia and writing don't mix well. Effort, persistence and patience are essential requirements for writing. This is particularly true of technical papers which are difficult to prepare and even harder to simplify. Nevertheless, such effort is more than repaid by the writer's satisfaction of seeing the finished article in a professional journal.

Before preparing your paper, it is wise to study the style and format of the journal in which you are interested. In most cases the order will be title, introduction, design problems, body text, detailed description, conclusions, and then the references, acknowledgements and appendices. A sample outline which might be used for preparing papers for the RCA ENGINEER is included here. Consider this outline to be extremely flexible. Shorten it, lengthen it, reshape it in any way you require in telling your story.

Most texts claim that a formal outline is a "must". There's no doubt about the value of an outline in guiding the writer, but it must be subject to change. The most carefully prepared outlines are susceptible to improvement as the writing progresses. Many engineers will find it possible to write their articles logically and clearly, just as it occurs to them, without the benefit of an outline. To start the job of writing, may require pushing yourself into action. Whether or not an outline is prepared, your rough manuscript will require frequent reorganizing, interchanging of paragraphs, and considerable "word-juggling". You may have to "cut and paste" your way through several rough drafts before reaching the final manuscript. You should not be embarrassed at the need for a constant reorganizing and reshuffling of your presentation. This is exactly what an editor might do when writing his own paper or assisting you with yours. Don't be discouraged in the event your paper is not accepted by the particular journal you had in mind in the beginning. A well-written, informative technical paper can often be modified to suit the editorial wishes of another magazine.

RCA EDITORS CAN HELP

Another suggestion in striving for perfection is to solicit the comments of other engineers and writers. At RCA, there are technical editors who are well qualified to offer constructive suggestions. Ask them to assist you in your writing efforts. They are familiar with the makeup and format of numerous technical journals and have daily contacts with the editors of these magazines.

When you are writing for the RCA ENGINEER, contact the editorial representative in your activity for assistance and suggestions. He is acquainted with the proper methods of scheduling and obtaining approvals of papers.

ENGINEERS CAN AND SHOULD WRITE

Certainly, based on the qualifications and abilities of the engineer, the benefits he will gain and the help available to him, there can be but one conclusion. The engineer can and should accept his role as writer —without hesitation!

E. A. LAPORT

S. D. RANSBURG

J. H. ROE

J. W. WENTWORTH

OPINIONS ON THE IMPORTANT ASPECTS OF WRITING PAPERS

R. C. BITTING, JR.
General Engineering Development
Defense Electronic Products
Camden, N. J.

Bob Bitting offers these thoughts on the necessity of including time in writing plans: "Frequently overlooked is the necessity of including adequate time for the writing job. Careful planning and a methodical writing schedule are great aids to those of us for whom the expository process is, in the words of Edison, '1% inspiration and 99% perspiration'. That last 99% need not—and should not—be necessitated by haste, however. It takes time, lots of time, to write well; realization of this fact is half the battle!"

M. S. CORRINGTON, *Mgr.*
Audio, Acoustics and Antennas
Advanced Development Section
RCA Victor Television Division
Cherry Hill, N. J.

Murlan Corrington feels this way about the importance of the reader: "An author who is struggling to complete a paper is often tempted to use short-cuts and to omit illustrations to 'get it over with' so he can move on to something more interesting. When it comes to making it easy for the author, or easy for the reader, the author's troubles should get no consideration whatever. The writer only does the job once. If he does not do his job well, thousands of readers may have to spend endless hours trying to figure out what was meant. Do the best job you know how; the savings are obvious."

DR. L. B. HEADRICK,
Staff Engineer
Color Kinescope Engineering
Tube Division
Lancaster, Pa.

Dr. Headrick says this about the value of an outline: "Consider the writing of a technical paper as an engineering problem. Analysis of a problem is essential to understanding and an organized plan of attack.

Analysis of writing a technical paper is outline preparation. The value and organization of a paper may depend upon a good outline. Elimination of unimportant material may be made more readily through outline revision, thus, writing time can be saved. Outline changes can be made easily without waste of writing time. Thus, the value of an outline lies in: (1) Analysis of material, (2) organization, (3) improved paper, (4) emphasis on important items, (5) reduced writing time, and (6) simplifies needed changes."

E. A. LAPORT, *Director*
Communications Engineering
Radio Corporation of America
New York City

Ed Laport feels that the principal problem in starting to write is to overcome inhibitions: "Starting is easy when you 'talk' to your readers. If time is short, just write a snatch at a time to record the main ideas—straight-forward, informal. In any event, start writing, no matter how it looks initially. Write the introduction first, develop the thoughts and arrangement of the paper as you go along, and rewrite the introduction last. Until you gain confidence in yourself as a writer, procrastination is enemy #1 and over-modesty is #2."

S. D. RANSBURG,
Record Engineering
RCA Victor Record Division
Indianapolis, Indiana

Steve Ransburg states: "As for obtaining quality in technical writing, the following points are suggested—(1) *Sincerity:* Believe in your subject. Know it. (2) *Directness:* Get down to your subject immediately. Come to the point at once. Use only one major thought in either a paragraph or a sentence. (3) *Thoroughness:* Be comprehensive enough that there can be no question of uncertainty as to what is intended. Avoid the use of unnecessary details or unsupported statements. (4) *Concreteness:* Make your reader visualize the subject. If possible, illustrate abstract statements with specific and concrete examples. (5) *Mechanics:* Use good grammar, proper punctuation, and correct spelling. Use the sentence structure that best expresses your exact thought."

J. H. ROE, *Mgr.*
TV Camera Engineering
Commercial Electronic Products
Camden, N. J.

John Roe has this to say about the qualifications of engineers: "Most engineers are qualified as technical writers though they may not realize it. From college training they have learned to think clearly and to express themselves logically and concisely. Enthusiastic interest in, and thorough knowledge of, the subject supply the incentive and the tools to write interesting and informative papers."

J. W. WENTWORTH, *Mgr.*
TV Terminal Engineering
Commercial Electronic Products
Camden, N. J.

John Wentworth affirms: "Remember the reader! *The reader comes first* is a cardinal rule of writing that becomes increasingly important as the size of the expected audience increases. A technical writer can profitably spend an hour polishing up a section of a manuscript if he can thereby shorten by two minutes the time required for a reader to reach an understanding of some technical point. Proper consideration of the reader's needs should prevent a writer from cluttering up his manuscripts with superfluous information or from abbreviating his writing to such an extent that the reader must engage in mental gymnastics to fill in the gaps in the author's reasoning. A good technical writer is one who can transfer a thought from his mind to the reader's with minimum time and effort on the latter's part."

MODERN ANALYSIS OF COMMUNICATION SYSTEM PERFORMANCE

by **B. A. TREVOR**
RCA Laboratories
Princeton, N. J.

THESE DAYS the electronic engineer is continually faced with the problem of reliability. This is a vague term meaning, in the strict sense, suitability or trustworthiness. It is difficult to associate radio system performance figures with the term "reliability," so it is suggested that this term not be used when precise statements of performance are to be made. The reasoning behind this suggestion will become apparent later.

Due to the large number of random variations affecting the performance of a communication system it becomes necessary to resort to statistical methods to describe performance in quantitative terms. This is because we do not know enough about the instantaneous variations of individual stages involving many system variables to predict overall system results at a particular time. Statistical treatment is simply a dodge to get around this difficulty. It works only if we talk about a large number of performance tests of the same radio link or about a large number of similar radio links, or both. Therefore, it is the aim of this paper to provide a better understanding of reliability as applied to radio system performance, and present a statistical method of analysis for interpreting overall performance.

RANDOM VARIATIONS

A random variation is something we know very little about in detail. All one knows is that 50% of the time the variable will exceed a known median value and that the rms deviation from the median has another known value. In many cases a normal or Gaussian distribution describes the variables with sufficient accuracy for practical purposes. It so happens that the variables affecting a radio communication system are usually symmetrical in db about the median value rather than being symmetrical in a linear sense of voltage, power, field strength, etc. Such a distribution, which is normal when expressed in db units, is referred to as a log normal distribution. It is completely described by two parameters, namely, the median value and the rms or standard deviation from the median, both expressed in db.

PROBABILITY

Fig. 1 is shown to refresh the memory of those who may have forgotten a few of the elementary facts of probability theory.

It shows a normalized Gaussian distribution such that x also represents the number of standard deviations from the median or zero value of x. The bottom curve is the probability density function. The ordinate represents the probability of occurrence of the corresponding value of x. The upper curve is the cumulative distribution and is simply the area under the bottom curve from $-\infty$ to x. Its ordinate, at any x_a, represents the probability of x being less than x_a.

Fig. 2 shows the cumulative distribution plotted on arithmetic probability paper which is designed to give a straight line as shown.

A convenient property of the normal distribution is that two or more are easily combined, always giving a new normal distribution having a median value equal to the sum of the individual median values and a standard deviation equal to the root sum squares of the individual standard deviations. Log normal distributions may be combined in the same way when the median values and standard deviations are expressed in db. *This property then permits all of the system variables having log normal distributions to be combined into a single distribution which is more easily handled.*

SYSTEM VARIABLES

There are a number of items contributing to performance variations of radio circuits. The most important ones are:

Atmospheric noise
Propagation fading
Antenna patterns
Receiver noise figure
Speech input
System maintenance

ATMOSPHERIC NOISE

In the 2 to 20 mc band, a large variable will be atmospheric noise. This is believed to originate in electrical storms most of which are over land masses. Since such storms are most frequent in the tropics, these areas have the greatest noise level. The noise is then propagated by ionospheric transmission to other areas of the world. A very large number of measurements have been made in an attempt to establish noise levels at various geographical locations.* The job is complicated by the fact that different median values are found for every hour of the day at a given spot and also there are seasonal differences. For this reason, published data show seasonal median values for each hour of the 24 hour day for a given location. It appears that a standard deviation of 10 db describes the seasonal variation about each median value for a given hour of the day with fair accuracy. Fig. 3 shows the variation of median

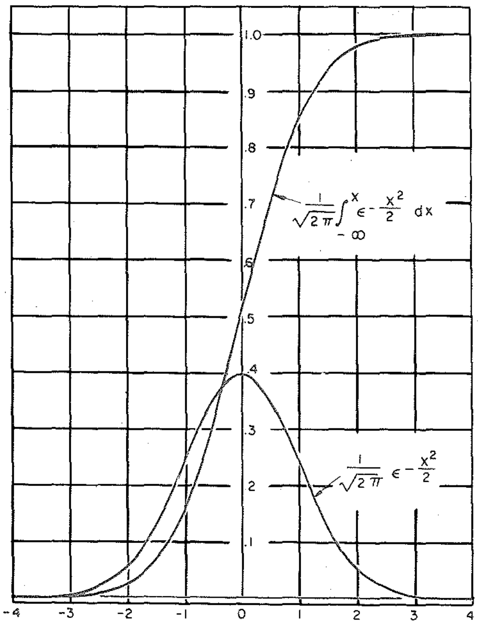


Fig. 1—Gaussian probability density and cumulative distribution functions.

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* NBS Circular 557, "World Wide Radio Noise Levels Expected in the Frequency Band 10KC to 100MC," W. Q. Crichlow et. al., August 25, 1955.

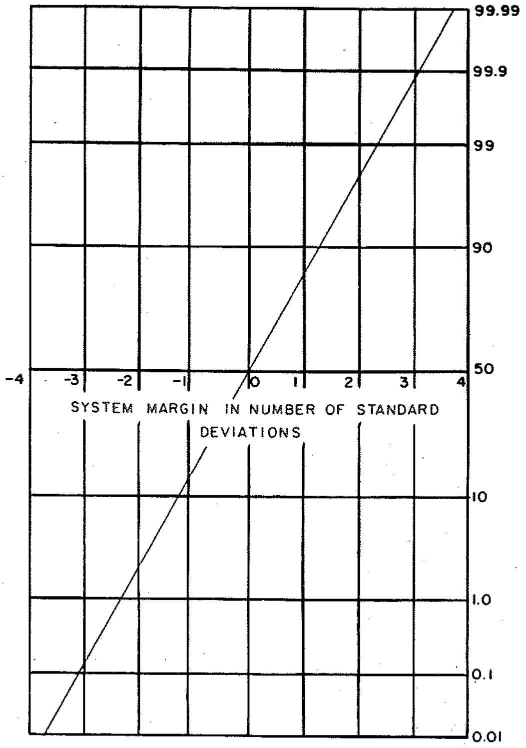


Fig. 2—Cumulative distribution curve plotted on probability paper.

values of noise levels with frequency for New Jersey at noon and at night.

In the VHF and UHF bands atmospheric noise is not normally strong enough to over-ride the receiver thermal noise. So at these high frequencies atmospheric noise will not constitute a system variable.

PROPAGATION FADING

Another major variable in most radio systems arises from variations in propagation. These variations are particularly severe in the 2 to 30 mc band due to skywave propagation. In the VHF and UHF bands, tropospheric variations cause signal variations which usually vary with distance. In the case of ground or ship to aircraft circuits, even greater variations are caused by the combination of direct and reflected waves at various distances and heights.

ANTENNA PATTERNS

In military systems, network operation is commonly used in which a number of terminals all use a common frequency on a party line, time sharing basis. In this arrangement non-directive antennas are used so that every terminal may receive every transmission. Non-directive antennas rarely have a uniform horizontal pattern. Shipboard and aircraft antennas are particularly poor in this respect giving quite large variations in performance with direction. Measurements have shown that these variations may be approximately described by a log normal distribution.

RECEIVER NOISE FIGURE

In the VHF and UHF bands, receiver thermal noise usually limits the weakest useable signal. Since all the receivers of the system will not have the same noise figure, this fact introduces another system variable.

SPEECH INPUT

If voice transmission is being considered there will be large variations between a loud talker and a weak one. The range of variations may be reduced but not eliminated by automatic gain control means.

SYSTEM MAINTENANCE

The last variation is concerned with system maintenance, adjustment and deterioration. The overall communication system will contain many pieces of equipment, hopefully, most of which are working. Of these, some will have deteriorated performance from tired tubes, incorrect tuning or other misadjustments. The net result is perhaps occasional outage time on some circuits or lower than normal performance on others. These things must be considered as system variations. This particular subject is the one commonly associated with the concept of equipment reliability and is under intensive study in RCA and other organizations. It forms only one of the many variables in a communication system.

TRANSMISSION LOSSES

The four main items contributing to transmission losses in a radio system are: propagation loss, antenna patterns, transmission lines and system maintenance. These are in the nature of fixed losses if median values are used in each case. The median propagation loss is the largest item and will be a function of distance, frequency, antenna height, and often other factors which must be taken into account. The loss due to antenna patterns comes about because the median value of an irregular directivity pattern is less than that of a symmetrical non-directive antenna. Transmission line losses are usually small, but become more important at the higher frequencies. Losses due to system maintenance must be estimated from available data for each type of system.

If P_T is the transmitter power in dbw, i.e., db above 1 watt, and P_L is the total of all the median transmission losses in db, then the median received power P_R is equal to $P_T - P_L$ in dbw. In other words 50% of the time the received power will exceed P_R and 50% of the time it will be less than P_R.

REQUIRED RECEIVED POWER

For each particular type of service such as voice or telegraph there will be a minimum value of received signal-to-noise ratio which will give satisfactory performance. This ratio may be measured in the laboratory under steady thermal noise conditions to give what may be called the *end of range ratio* of received signal power to received noise power in a specified bandwidth.

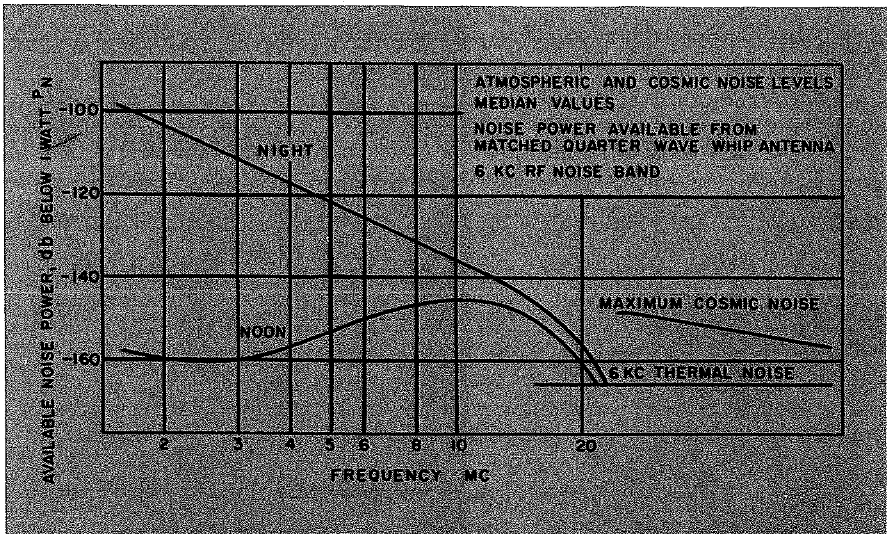


Fig. 3—Variation of median values of noise levels with frequency for New Jersey.

MODERN ANALYSIS SYSTEM PERFORMANCE

—continued

In the case of voice transmission in the presence of thermal noise, determination of the end of range figure is complicated by many factors which will not be discussed here. If full modulation of a single tone is applied to the transmitter, the audio tone-to-noise ratio may be measured at the receiver output. End of range received power is commonly accepted as the r-f received power giving a 16 db tone-to-noise ratio in the receiver low pass filter output. This value of received power P_Q will give acceptable voice intelligibility if moderate speech clipping is used at the transmitter.

With frequency shift telegraph the end of range figure may be chosen to correspond with a certain error rate. In military use of radio teletype it is usually desired to have an average of less than one character in error for every 1500 characters transmitted. A well designed teletype system will give this error rate at a carrier-to-noise ratio of about 9 db as measured in a 240 cycle i-f band with thermal noise. This 9db figure allows calculation of the corresponding value of P_Q.

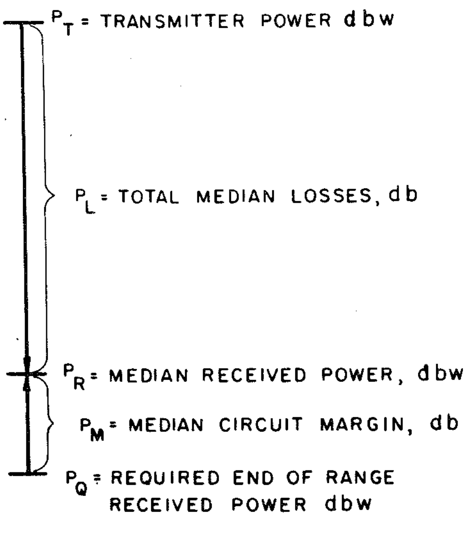


Fig. 4—An illustration of current margin.

CIRCUIT MARGIN

In Fig. 4 is shown what is meant by circuit margin. This shows:

P_T = Transmitter Power, dbw
P_L = Total of all Median Losses, db
P_R = Median Received Power, dbw
P_Q = Required Received Power for End of Range Acceptable Performance, dbw

Then:

$$P_R = P_T - P_L$$

and:

$$P_R - P_Q = M = \text{Median Circuit Margin in db.}$$

In other words M is the db margin above the median condition or the margin exceeded 50% of the time.

Referring back to the remarks on circuit variables, it will be necessary to assign a figure of variability to each one, namely, the standard deviation in each case. Some typical values are shown below which might be different for different systems.

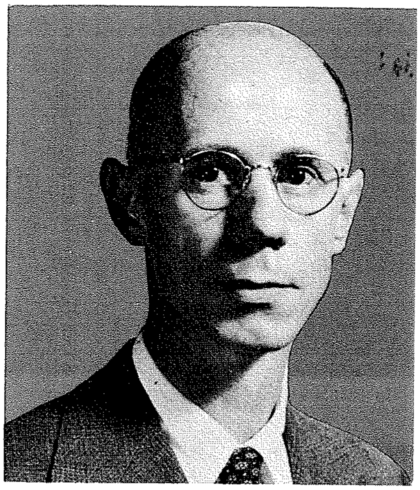
Atmospheric Noise, 2-20 mc, σ = 10 db
UHF Propagation, Low Antennas, σ = .185 (distance in miles), db
Antenna Patterns, σ = 2 to 6 db
UHF Receiver Noise Figure, σ = 1 db
Speech Input With Automatic Gain Control, σ = 1 db
System Maintenance, σ = 1 db

The appropriate sigma values for a particular system may be combined to give a total sigma which shows the extent of variation of P_R or M above.

EXAMPLE OF METHOD

For simplicity, assume a 20 mile UHF radio circuit for double-sideband voice operation. The applicable variables will be those previously mentioned, with the exception of atmospheric noise, which is not a factor at UHF. Since all of these variations are assumed to have a log normal distribution they may be combined into an equivalent single distribution by taking the root sum squares of the individual sigmas. By assigning a σ of 4 db per antenna and the other values of σ shown, we get a total σ of 7 db for all of the variations in this example.

Having previously calculated the circuit margin M at 20 miles using the proper values for transmitter power, circuit losses and required received power, we can now find the number of sigmas of circuit margin. This is $M/7$ in this case. Suppose, for example, the circuit margin M was 16.2 db. Then $M/7 = 2.32$ sigmas of margin. Using the cumulative Gaussian distribution, Fig. 2, we can read the percent of time that the output signal-to-noise ratio is greater than the end of range limit chosen. This shows that acceptable speech will occur 99% of the time. Or conversely, unacceptable performance may be expected one percent of the time at this distance. If the transmitter power, and consequently the system margin, is reduced by 7 db the system margin becomes 1.3 sigmas giving acceptable speech only 90% of the time. In a similar manner the transmitter power must be increased by 5.5 db, giving a sigma margin of 3.1, to achieve acceptable performance 99.9% of the time.



B. A. TREVOR has had extensive experience in HF and UHF communication systems during his service with RCA. He received his EE degree from Cornell University in 1928. Following graduation, he joined the Advanced Development Group of RCA Communications, Inc., and was transferred to the Communications Research Section of RCA Laboratories Division in 1942. As Assistant Section Head of the Riverhead Laboratory group from 1938 to 1950, he participated in and directed the design and development of HF equipment. Since that time he has been project engineer at Princeton on a classified project for BuShips involving HF and UHF communications problems. Mr. Trevor received an I.R.E. Fellow Award in 1953 for "contributions in the field of pulse-multiplex communication systems and long-range receiving equipment." He is also a member of Tau Beta Pi, Eta Kappa Nu, and Sigma Xi.

As another example, imagine a number of ground wave teletype circuits between ships operating at 10mc at 8 to 9 P.M. every day of a three month season. Assume also that for the short distance and frequency chosen, there will be inappreciable skywave interference. The ground wave over water will have almost no fading so we may assume a constant received power at a fixed distance. In this case the largest transmission variable will be atmospheric noise. Lesser variations will arise from antenna patterns and system maintenance. The receiver noise figure will not be a factor since all the noise is atmospheric.

The same procedure as used in the previous voice example may be used. Knowing the transmitter power, distance, circuit losses and required received power allows calculation of the circuit margin M in db. The combined standard deviation of all variables might be, in this case, as follows:

Atmospheric noise, $\sigma = 10$ db
Two antenna patterns, $\sigma = 6$ db
System maintenance, $\sigma = 1$ db
Total $\sigma = 11.7$ db

Therefore the sigma margin$=M/11.7$. The percent of time the error rate is less than the chosen value may be read directly from the cumulative distribution, Fig. 2.

For comparison purposes note the margins required for various performances in this example.

Performance	Sigma Margin	db Margin	Relative Transmitter Power	
90%	1.3σ	15.2 db	0 dbw	1 w.
99%	2.32σ	27.2 db	12 dbw	16 w.
99.9%	3.1σ	36.2 db	21 dbw	126 w.

This shows that to increase the useful percent time from 90 to 99.9% requires an increase in transmitter power of 126/1. This large increase is due almost entirely to the effects of atmospheric noise. In tropical regions, noise levels are extremely high which requires rather large transmitter power in the 2 to 20 mc band.

In a teletype system we usually would like to know the probability of a character being in error, or in other words how many characters will be in error out of a very large number transmitted. The method used previously does not give this result. It would give this result if the teletype made no errors with all signal-to-noise ratios above the end of range value and made all errors below this value. Since the teletype does not operate this way a different form of analysis is required.

Using the same 10 mc teletype circuit as an example, we must first experimentally measure the performance of the printer under steady thermal noise conditions to obtain a curve of the type shown on Fig. 5. This shows the probability of getting a character error plotted against the rms carrier-to-noise ratio as measured in the i-f pass band of the receiver with steady thermal noise. A statistician calls such a curve a regression line. For convenience call this function $p(x)$; x being rms carrier-to-noise ratio in db.

We must next choose a fixed distance and calculate the corresponding median carrier-to-noise ratio, or simply the ratio of P_R/P_N. Since all of the noise P_N is atmospheric, P_N may be obtained from data such as that shown on Fig. 3. We now have two functions $p(x)$ just mentioned, and $f(x)$ which is the normal probability density distribution (lower curve Fig. 1) having a median value P_R/P_N (in db) and a standard deviation $\sigma = 11.7$ db. The average probability of a character being in error is then:

$$\int_{-\infty}^{+\infty} f(x)\, p(x)\, dx$$

Since we do not have an expression for $p(x)$ it becomes necessary to do the integration numerically which turns out to be quite easy. This is because appreciable contribution of errors occur only for carrier-to-noise ratios in the range of —10 to +11 db.

This process must be repeated for each distance to obtain a curve of probability of error vs. distance if this is desired.

CONCLUSION

To return to the question, "what is meant by reliability?" From the foregoing discussion it should be clear that a radio circuit stated to have 99% reliability is meaningless. A more precise statement is required. For example, in a voice circuit a good statement could be: This circuit will transmit acceptable speech intelligibility 99% of the time. Or, this circuit will give a speech-to-noise ratio greater than a specified end of range value, 99% of the time. In the case of teletype circuits, you might say, the long term probability of character error is .01%. Or again, this circuit will give an error rate of less than .1%, 99% of the time. The point is you cannot define reliability to mean all of these things. A whole sentence is necessary to say what you mean.

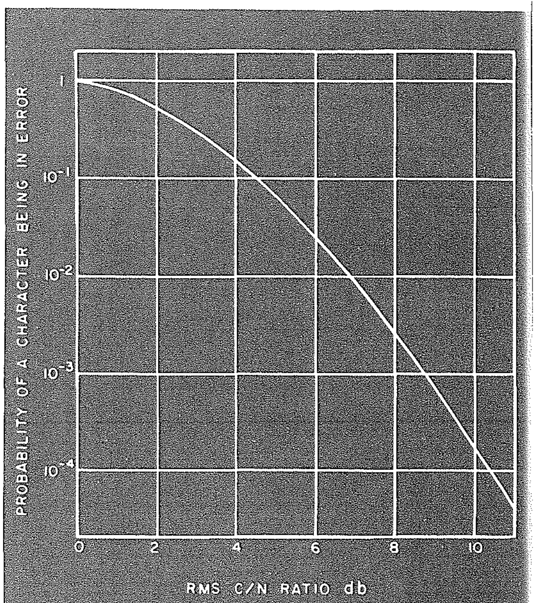


Fig. 5—Regression line showing probability of character error vs. rms carrier-to-noise ratio in a teletype circuit.

Finally, in order to talk about reliability it will be necessary to use a statistical approach to obtain meaningful statements. This approach requires factual data on all of the system variables. These data are often not available because experimental determination is tedious and their value may not be appreciated. An important result of the statistical analysis method is that it clearly points out what experimental data must be obtained and the relative importance of each variable. This guidance is needed to insure availability of the proper data for specification of system performance for the systems engineer.

CONSIDERATIONS IN THE DESIGN OF AUTOMATIC MACHINERY FOR ELECTRON-TUBE PRODUCTION

By

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THE EQUIPMENT designer's job consists of the analysis and integration of the various allied problems encountered in the design of automatic machinery. He must consider not only the immediate requirements for a particular machine, but also the effects of automation on the quality, uniformity, and cost of the end product. Many types of machines have been designed to automatize operations utilized in electron-tube production which were previously performed manually. Specific requirements of the machines are determined by the nature of the parts involved, the degree of cleanliness required, the electrical specifications and tolerances for the end product, and the volume desired.

THE PRODUCT

Component parts used in a typical miniature pentode receiving-type tube are shown in Fig. 2. These parts include insulating spacers of natural mica, nickel sleeves, wire elements of tungsten and other materials, metal stampings, and glass parts. Materials such as barium and alundum are also used for coatings on some of the parts.

Because most tube elements or parts possess little mechanical strength, finger pressure is usually sufficient to distort them and render them unusable. The first machine-design problem, therefore, is that of handling the parts during fabrication, subsequent processing, and eventual assembly in the tube.

Another important requirement for tube parts is cleanliness. Each part must first be completely degreased, then heated in a hydrogen atmosphere to remove all oxides. In addition, it must not be exposed to contaminants such as salt from the operators' hands. In the machines, therefore, every measure must be taken to achieve and maintain a high level of part cleanliness.

The finished tube, of course, must meet a rigorous electrical specification. As many as eight electrical tests may be required to insure that each tube meets its requirement. In machine design, then, the end electrical requirement must also be considered. Part variations, processing, and assembly must be precisely controlled to yield the desired end result.

PRODUCTION REQUIREMENTS

The introduction of a new tube type requires the making of many samples for the purpose of evaluating every aspect. These sample tubes may be made entirely by hand or by the use of simple low-cost tools useful only for small-lot production. If the preliminary tests are satisfactory, the next stage is the design of machines for factory production. At this point, the question of volume arises. The machines must be economically suited to the estimated volume requirements for the new types. Consideration is also given to future potential and to the conversion of the machines to other uses as future types are introduced.

Even when estimates of relatively large-volume production dictate the design of high-speed, expensive machines, some thought must be given to the period of time during which the tube type will remain at high production levels. Preferably the machine cost should be justifiable over the anticipated production schedule.

NEED FOR MECHANIZATION

Although the tube industry has mechanized numerous operations to good advantage, there remain many areas which represent fertile fields for the machine designer. Many operations are still performed entirely by hand, and thousands of operators are employed to do this work. The industry is constantly on the alert for new methods and techniques which would increase production and reduce cost of the end product. Care must be exercised, however, in the selection of a project for mechanization. Preferably the choice should be in the area of slow and costly manual operations in order to effect the maximum cost reduction. As mentioned previously, the cost of such mechanization must be justifiable within a period of time determined by the stability of the product.

Prior to the design of new machinery, a study should be made of the manual method of manufacture and another study of the proposed mechanized method. A comparison of the two methods will indicate whether the mechanization cost is a warranted expenditure. Mechanization for the sake of mechanization is not justifiable.

In addition to cost justification, there are other considerations of importance, as follows:

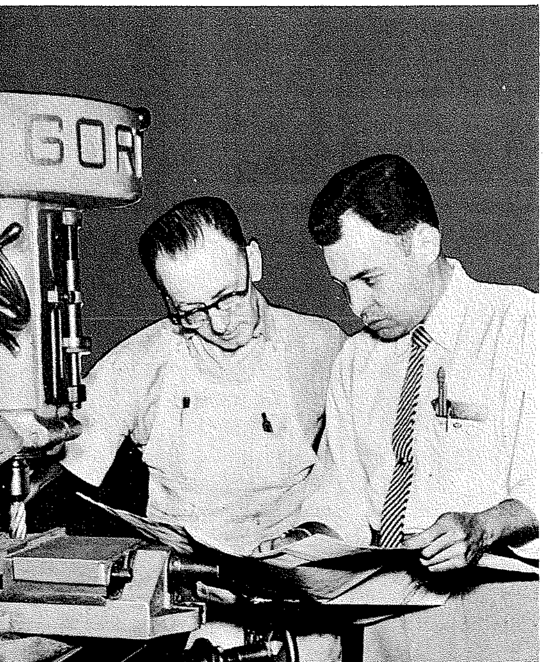


Fig. 1—Equipment Development engineer D. Colasanto discussing a difficult machining problem with tool-and-die maker G. Grindley.

Fig. 3—Typical receiving-tube grids. Siderod wires vary from 0.015 inch diameter to 0.030 inch diameter, lateral wire from 0.001 inch diameter to 0.005 inch diameter. Finest pitch shown is 210 turns per inch.

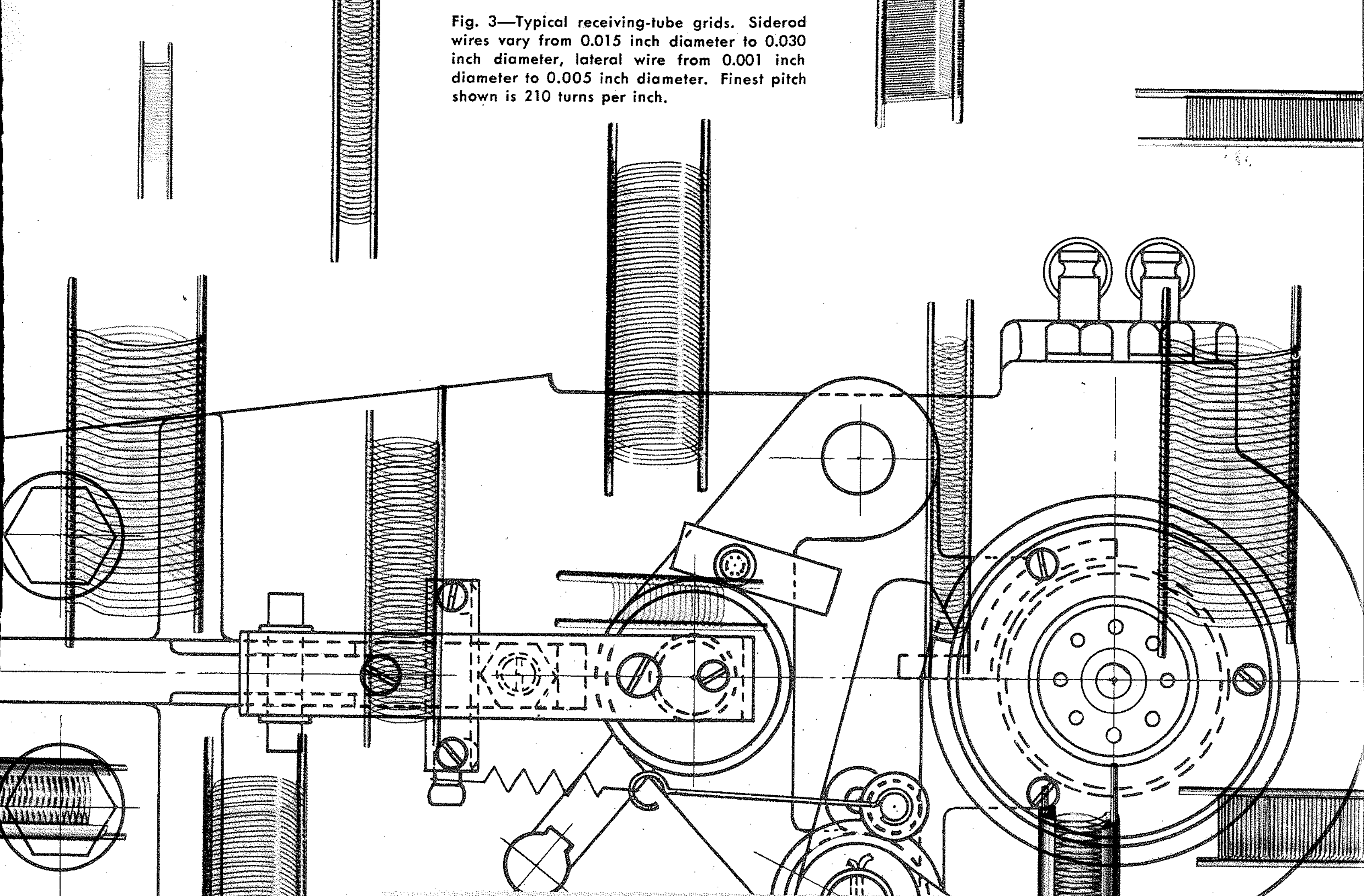
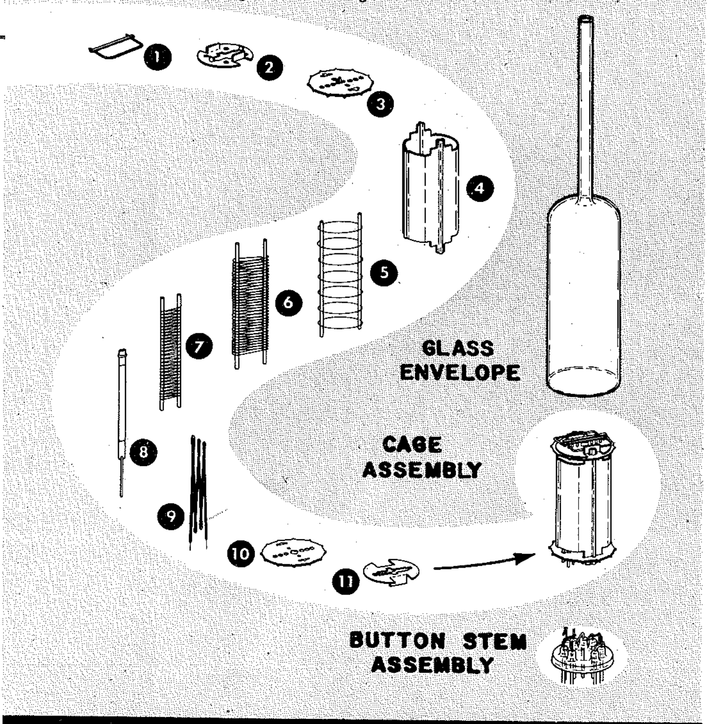


Fig. 2—The parts and construction of a representative miniature glass receiving tube.



CAGE PARTS

1. Getter and Support
2. Top Spacer Shield
3. Insulating Spacer
4. Plate
5. Grid No. 3 (Suppressor)
6. Grid No. 2 (Screen)
7. Grid No. 1 (Control Grid)
8. Cathode
9. Heater
10. Insulating Spacer
11. Bottom Spacer Shield

Fig. 4—Development Engineer, D. B. Pearson is shown inspecting wire-feed mechanism on RCA grid Lathe.

1. Quality advantage in a competitive market is not to be overlooked. Improved quality may be sufficient reason for mechanization. Justification on this basis alone, however, may be very difficult to evaluate unles the gain is obviously of large magnitude.

2. Uniformity of product, which is related to quality, is another possible gain.

3. There is also the aspect of possible military needs. In the event of a national emergency, manpower for factory operation becomes a premium commodity while, at the same time, the product itself must be supplied in large quantities. This situation illustrates another possible advantage of mechanization. In such cases, cost is essentially a secondary factor.

THE APPROACH

In every industry, some degree of mechanization is to be found. Very few, if any, have attained the goal of "push-button" operation or, more specifically, "complete automation." For numerous reasons, it is usually preferable to approach the problem in an evolutionary manner, i.e. to mechanize an operation with little or no change in the basic product design. In this way, the end product of mechanization is physically, mechanically, and electrically substantially the same as that made by pre-mechanization methods.

Another approach, designated as "revolutionary," begins with a redesign of the product so that it lends itself more readily to mechanization. An example of this approach is the recently publicized "Operation Tinker Toy." The use of this approach in the tube industry might yield an end product physically and mechanically radically new, but the product would still have to meet the electrical specifications of its predecessor.

Even when the evolutionary approach is used, the problem is not a simple one. The equipment designer does not find himself involved in a one-man project, but rather forms one part of a larger team. He works with the product designer so that he becomes thoroughly familiar with all phases of the product and is in a position to suggest product changes which might simplify the equipment design. He works with factory personnel who will use the equipment so that he understands their problems and can tailor the equipment to their needs and desires. He deals with time-study and methods groups to reach agreement on cost analysis and equipment-cost justification. He works with other designers within his own group to complete the equipment design, and follows the construction closely. He works with other laboratories and engineering groups to obtain acceptance tests of the machine product for evaluation and comparison. And, finally, he works again with factory personnel to secure their acceptance and understanding of the equipment, and to insure its proper usage, operation, and maintenance.

MATTHEW M. BELL received the B.S. degree in Electrical Engineering from Newark College of Engineering in 1941. He was an instructor in the evening courses at Newark College of Engineering from 1942 to 1944, and at the Jersey City Technical Institute from 1950 to 1951. He was engaged as a tool designer by the Singer Engineering Company from 1941 to 1944, and as a design engineer by the Zenith Engineering Company from 1944 to 1948. In 1948, he joined the Tube Division of the Radio Corporation of America in Harrison, N. J., as an electrical engineer in the Equipment Development activity. He became Leader of Electrical Equipment Design in 1952, Manager of Advanced Equipment Development in 1954, and since 1955 has been Manager of Mechnical Design for the Equipment Development activity.

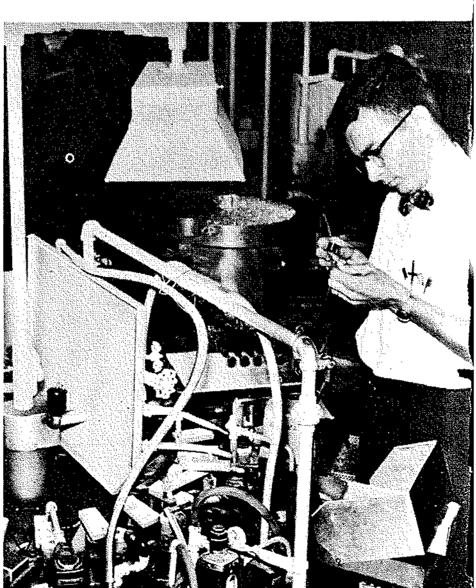


Fig. 5—Equipment Development engineer Henry Blust inspecting stem produced on 24-head automatic miniature-stem-making machine.

As previously pointed out, the equipment designer, in working with the product designer, may suggest changes in the product design that simplify the equipment. For example, the machine designer may find that the original design of a part does not lend itself to mechanization for any one of many reasons. Changes are proposed in the product, and samples are made and submitted to the required tests for evaluation. If the results prove satisfactory, these changes are included in the final design.

OTHER CONSIDERATIONS

Because production schedules do not always permit the luxury of unlimited time, the original design must often be produced in the factory in order to meet these schedules. With small-volume requirements, there may not be justification for product redesign or major mechanization. If, however, the product meets with good acceptance and the production volume is increased, efforts are made to accelerate production rates and reduce costs by product redesign and mechanization, as previously described.

The evaluation of a particular problem cannot be considered as an isolated entity. Because many operations are integrated to form a whole, any change in one area may affect other areas. Before any modification is made, careful consideration must be given to possible effects on prior or subsequent operations. For example, when a machine is introduced in place of a manual operation to yield a higher output rate, the cost advantage gained might easily be offset if an added cost is introduced in the previous or following operations, or if an extra operation is required. An obvious case is that of a machine which displaces an operator who also performed a visual inspection; this inspection function is lost. It might be necessary, therefore, to set up an additional inspection, which would thereby offset the original gain.

In a manufacturing activity such as the tube industry, there are many hand operations and many mechanized operations. In some respects, this production system has an advantage over "complete automation." For example, it permits temporary interruptions such as breakdowns and necessary maintenance to occur without causing a complete halt in output. With "complete automation," interruptions in one manufacturing stage affect the entire system unless interstage storages are provided.

GRID-MAKING EQUIPMENT

A typical machine development in the tube industry is the evolution of grid-manufacturing equipment. A grid consists of two supporting siderod wires, spaced a certain distance apart, around which is wound a lateral wire. The lateral wire is fastened at each half-turn to the siderods. This lateral winding may vary on different grids from a few widely spaced turns to many turns spaced very closely. The exact shape of the grid may also vary, as well as the wire diameter and the siderod spacing. In addition, the winding may be of variable pitch. Fig. 3 shows a representative assortment of electron-tube grids.

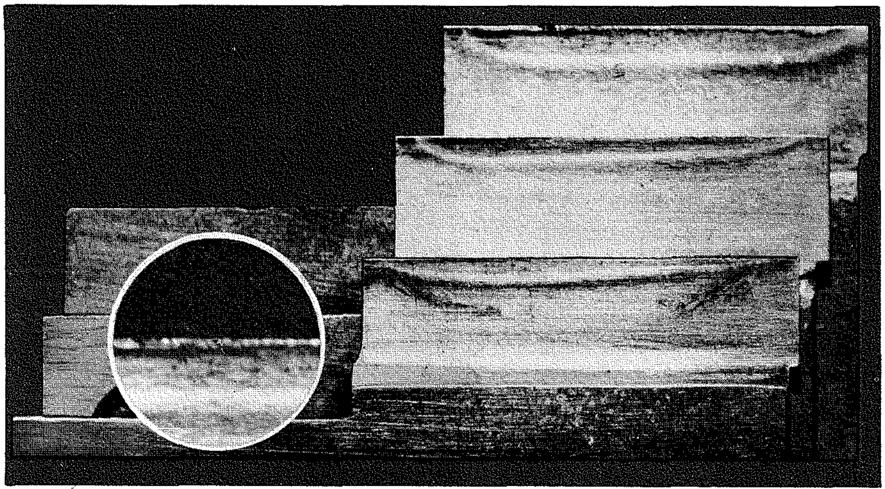
In the early years of tube manufacture, grids were similar in structure to modern types and differed primarily in the number of turns of lateral wire and their spacing. Grids having about 25 turns per inch were used at that time, as compared to some of the present grids having 200 to 300 turns per inch.

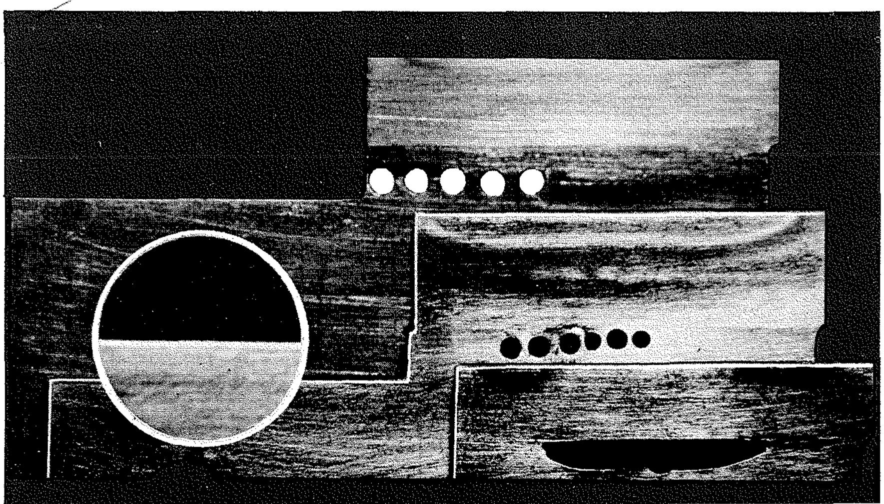
The original method of grid manufacture was to wind the lateral wire by hand and weld each wire at the point of contact with the siderod. The first marked improvement in grid manufacture resulted from the development of a grid-winding lathe. These lathes were comparatively crude by present-day standards, and produced grids similar to the hand-wound types. Because welding techniques and controls were poor, the results obtained were equally poor. Bad welds, missed welds, and wire "burn-off" were some of the typical faults.

After several years, a new method of grid making was incorporated into the grid lathe. In this method, the

Fig. 6—Electrodes used in the automatic welded-grid machine showing heat concentration at the ends as evidenced by the oxidation pattern.

Fig. 7—Redesigned electrode used in the automatic welded-grid machine. Oxidation pattern shows more uniform heat distribution.





siderod is notched, the lateral wire is laid in the notch, and the displaced siderod metal is peened back to lock the wire. This method provides good electrical contact and mechanical strength. Early lathes which incorporated this method produced grids in strip form, i.e. a multiple number of grids end to end on continuous siderods. The strips were cut into individual grids during a subsequent operation. The lathes operated at spindle speeds of about 550 revolutions per minute and produced about 400 grids per hour.

This notching method, however, produced internal stress in the siderods which caused them to bend or bow, or weave. In order to overcome this undesired effect, an additional operation had to be introduced. This operation consisted of stretching the grid strip a very small amount. No significant change of individual grid dimensions occurred during the stretching operation.

The grid lathe was later improved in many ways. A new design enabled the machine to operate at spindle speeds of 1050 revolutions per minute. The introduction of better control of notching, peening, wire feeds, wire-tension devices, and the like made it possible to wind grids having as many as 300 turns per inch. It should be noted that although an improved product resulted, machine efficiency rose, and maintenance was reduced, the net output of the machine at this point was only about 325 grids per hour because, despite the increase in spindle speed, the greater number of total turns required a greater total winding time.

Present-day grid-winding lathes include many other features, such as the winding of right- or left-hand grids, the winding of grids having a variable pitch, and other factors which are not of significance in this discussion. Tube plants still utilize a large number of these lathes to produce the millions of fine-pitch grids required for various tube types.

A new approach to grid manufacture was made several years ago in a machine which does not utilize the principle of winding the lateral wire. In this machine, each of the parallel lateral wires is drawn from a separate spool and welded to the siderods. The lateral wires are drawn from their respective spools, and then passed through a comb which spaces them and forms them on a mandrel to the desired shape. The mandrel also provides the means of advancing the finished grid into the ejection position. Siderod wires are automatically fed from spools and straightened, and the lateral wires are then welded.

Because there are two sides to a grid, two sets of lateral wires must be provided. The welding operation, therefore, actually consists of making several hundred welds simultaneously. With the use of present-day welding methods and controls, this method has proved successful. Although one missed weld or loose turn results in a rejected grid, current grid production on this machine is about 2500 grids per hour with a very low percentage of rejects.

During the development of this machine, a study of the welding-electrode oxidation pattern disclosed a concentration of weld current at the electrode ends, as shown in Fig. 6. By proper redesign of the electrode and the introduction of holes, more uniform current flow was achieved over the entire electrode face, as shown in Fig. 7.

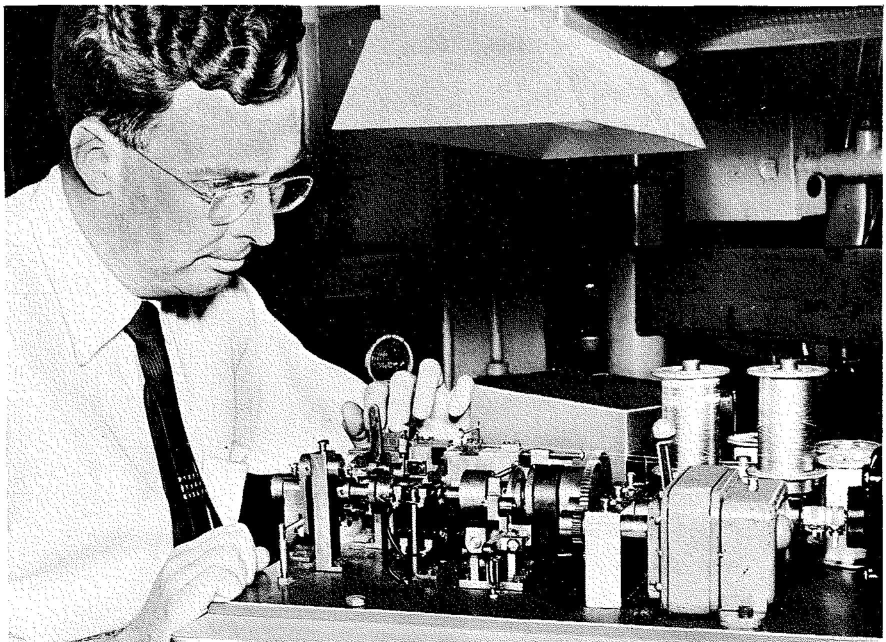
The use of this machine provides many advantages in addition to the high production rate. Material economy results because no forming, stretching, or subsequent finishing of grids is required. The machine design represents an accumulation of experiences in many fields, among which are wire handling, welding, forming, and feeding. Still, there remains room for further progress. There now exists a limitation in the number of lateral wires per inch that can be used. The present maximum is about 100 TPI. Further development is being carried on, however, and it is expected that this machine will soon produce grids which can presently be made only on precision grid lathes.

STEM-MAKING EQUIPMENT

Another typical machine development is illustrated in the area of stem making. Typical stems used in electron tubes are shown in Fig. 9. The original equipment for making electron-tube stems was an adaptation of that used in the lamp industry. This equipment was a rotary machine which formed the flat-press stem shown at the upper right in Fig. 9. The lead wires and glass were hand-fed to the machine by an operator.

When metal tubes were developed, stem machines were built along new lines. These machines were required to mold the glass into a special metal header so that the lead wires were brought through the glass, and an exhaust tubulation extended from the header. All of the parts were hand-fed into the molds. Fig. 9 shows this stem in the upper left position. The glass-to-metal header seal required careful control of the header material and molding techniques in order to achieve the desired results.

Fig. 8—Equipment Development engineer George Shaffer testing an automatic cathode-tab feeding-and-welding machine in the Equipment Development Shop.



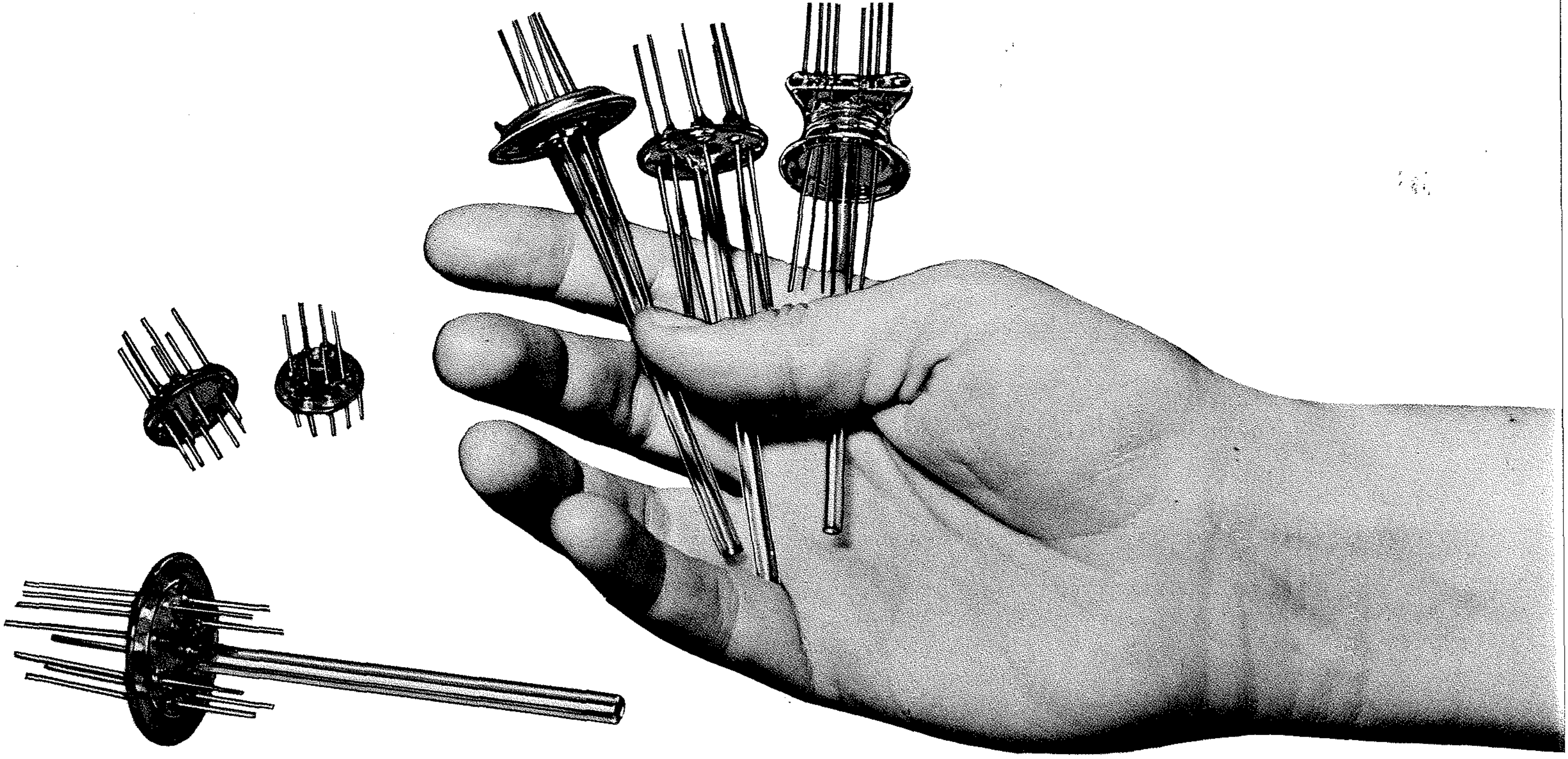


Fig. 9—Receiving tube stems: Left to Right Top Row; glass-to-metal header stem, one-inch 8-pin button stem, flat-press stem—Bottom Row; 1¼-inch 8-pin button stem, 9-pin miniature button stem, and 7-pin miniature button stem.

The introduction of the miniature line of tubes made necessary the development of other stem-making machines for the 7-pin and 9-pin button stems shown in Fig. 9. These machines are also of the rotary indexing type. The original machines consisted of a 24-head turret into which the operator hand-fed the required leads and two glass beads. The turret then indexed successively through the 24 positions while gas flames heated the glass to bring it to a molten condition and, at the proper time, upper molds were brought down to form the button to the required shape. Early machines of this type indexed at the rate of 450 per hour.

A series of machine improvements have been made in order to realize a greater output. The first improvement was the addition of an automatic wire-lead loader which inserted the leads into the mold. This change resulted in an increase in the machine output to 600 per hour. The use of a single glass bead and the development of a mechanical bead feeder permitted an increase in index speed and increased the output to 1000 per hour.

This machine has now reached the point where it is fully automatic, and an operator is required only to see that materials (wire leads and glass beads) are supplied to the machine.

Simultaneously with the addition of automatic feeding devices, it was necessary to incorporate detection devices which insured that (1) all of the wires were in the molds; (2) if one or more wires were missing, no bead would be fed; (3) if one or more wires were missing, those leads already in place would be ejected; (4) if a glass bead was not fed, the lead wires would be ejected.

The incorporation of these detection devices made the machines fully automatic. One attendant can now service a number of these machines.

A new design incorporating all of the features described, but having 30 heads, was the most recent development. This machine operates automatically at an index speed of 1500 per hour. In addition to the 7-pin and 9-pin miniature button stems described, larger button stems such as those shown in Fig. 9 are made on similar machines.

The molding of wire leads into glass involves the selection of materials having the same coefficient of thermal expansion. The portion of the lead in contact with the glass is a copper-clad steel wire; this section is butt-welded to nickel end leads.

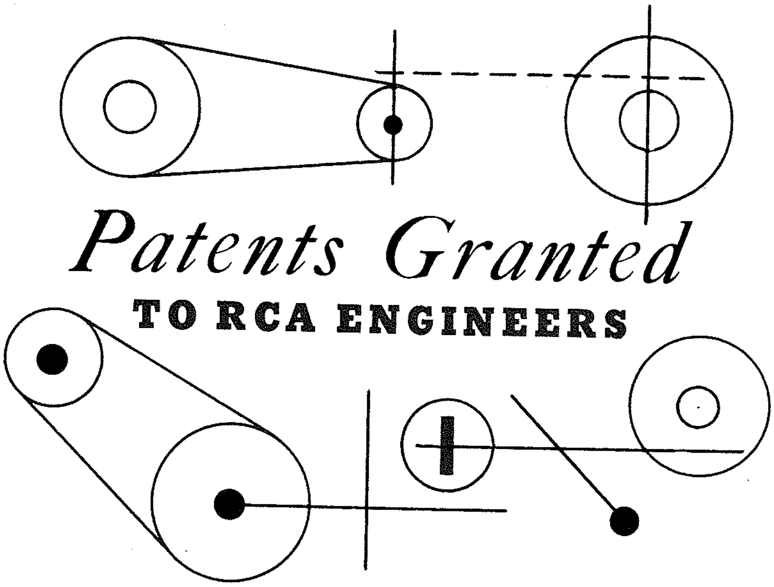
Molding of the glass to the desired shape is not the only problem in stem manufacture. The fire setup on the machines must be maintained consistently in order to yield a product having the desired internal strains. A check is kept on the product quality by visual observation of the strain pattern with a polariscope. Experienced fire setters are employed to set up and maintain the machine fires.

Because of the nature of the operation (i.e. because the process requires considerable heat and a high degree of accuracy in mold lineup), careful attention must be given to proper turret and head design to minimize expansion and distortion of the machine parts at the elevated temperatures.

END USAGE

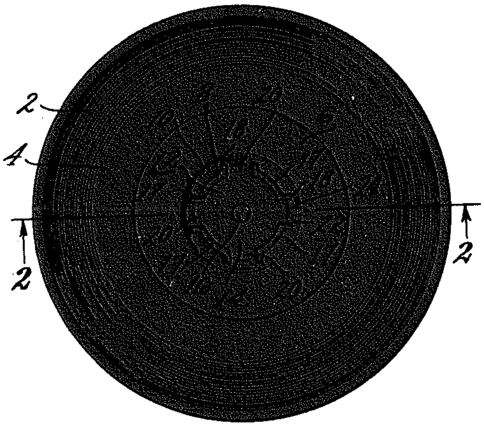
These typical examples of machine developments have been possible only through the coordinated efforts of all the various activities previously outlined. Not to be underrated in any sense is the cooperation required of the end user, which in this case is the factory personnel. No matter how fine the design of the machine, or how precisely it is built, it must be accepted by the user with every intention of making it work in order to achieve eventual success. It is only because of his complete willingness to accept, use, maintain, and prove out a machine that it can ever be successful. Failure of the user to fulfill his responsibility is almost certain to result in failure of any machine-development program.

Patents Granted
TO RCA ENGINEERS



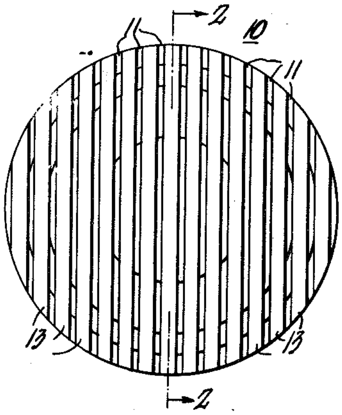
BASED ON SUMMARIES RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

DISC PHONOGRAPH RECORDS (Patent No. 2,734,748)—granted February 14, 1956 to J. L. PARVIN, ART DIRECTOR, RCA ENGINEER, Camden, N. J. Record has a large diameter spindle opening 8 with a hub portion 12 disposed therein. The hub portion has a central part 14 with small diameter spindle opening 16 and has sections 20 connecting this part to the remainder of record along areas 24 of weakened structure outside the diameter of the large spindle hole. The hub can be pushed out by consumer without leaving any burrs which would interfere with using the record on a large diameter spindle.



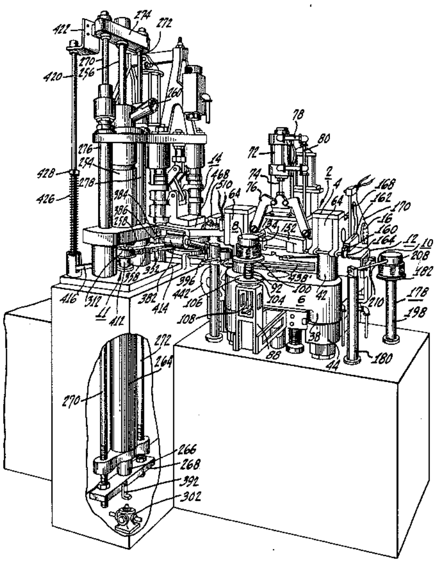
Pat. No. 2,734,748

LENS ANTENNA (Patent No. 2,729,816)—granted January 3, 1956 to C. F. CRAWFORD, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. The invention includes a radio-frequency lens and a shield mounted to the lens. The shield is relatively transparent to radio waves but reflects a small portion of the energy impinging on it back to the feed. Supports located in the null or shadow areas of the beam pattern mount the shield to the lens to prevent the shield from moving with respect to the lens. Since the supports are in the shadow areas they have little or no effect on the beam pattern. Placement of the shield ½ wavelength from the lens causes reflections from the lens and shield to reach the feed out-of-phase, thereby improving the isolation between feed and lens.



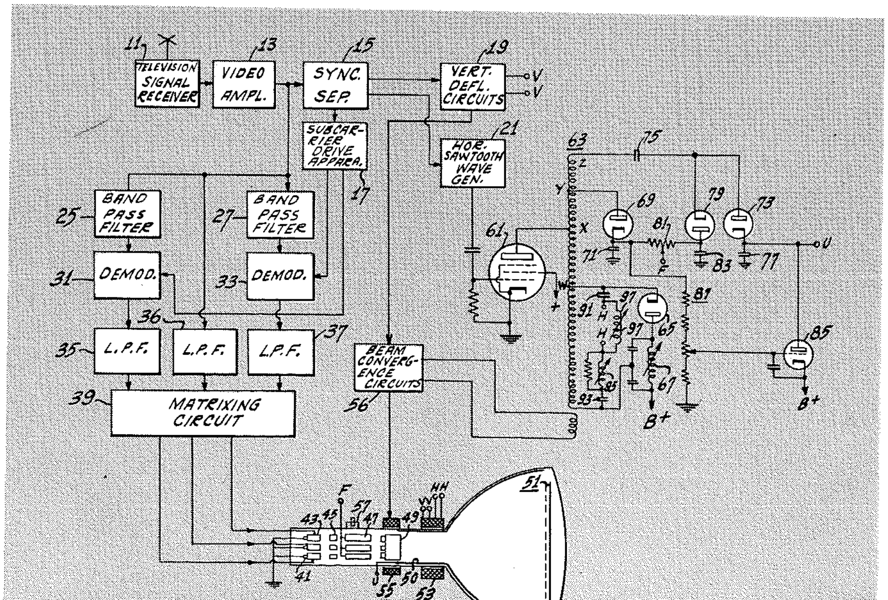
Pat. No. 2,729,816

AUTOMATIC MOLDING APPARATUS (Patent No. 2,743,478)—granted May 1, 1956 to L. C. HARLOW, RCA VICTOR RECORD DIVISION, Indianapolis, Ind. and Q. E. SMITH, TUBE DIVISION, Marion, Indiana. The apparatus includes a compression molding press 2 having an upper platen 4 and a lower platen 6, means 10 for automatically applying labels to the lower platen, means 8 for automatically applying labels to the upper platen, means 11 for feeding charges of molding composition to the press, means 12 for removing molded articles from the press, means 14 for performing finishing operations on the molded article, and means for disposing of the flashing.



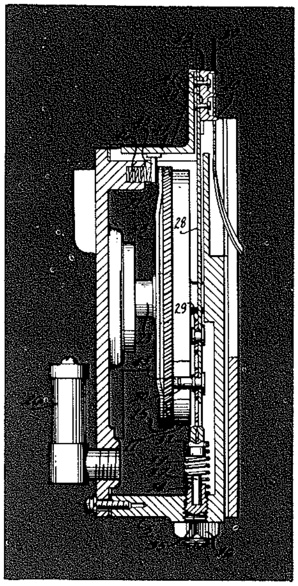
Pat. No. 2,743,478

HIGH VOLTAGE SUPPLY (Patent No. 2,729,764)—granted January 3, 1956 to L. DIETCH, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. Color kine HV supply employs a novel 1½" type of voltage multiplier in association with horizontal output transformer rather than conventional voltage doubling: DC output of focus rectifier is added to flyback pulses at input of ultor rectifier. As an additional power-saving feature, ultor regulator sampling voltage is derived from bleeder associated with focus rectifier.



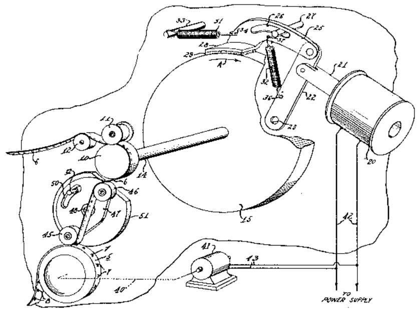
Pat. No. 2,729,764

TELEVISION MOTION PICTURE PROJECTOR MECHANISM (Patent No. 2,743,647) — granted May 1, 1956 to J. J. Hoehn, Commercial Electronic Products, Camden, N. J. To obtain long-life and accuracy of a motion picture pulldown mechanism, a constant speed gear 15 has a serpentine up-and-down cam groove 43 on one side and an in-and-out cam plate 21 on the other side. Each cam is double to provide two pulldown cycles spaced 216 degrees and 144 degrees apart of claw 39 during one revolution of gear 15. Claw body 28 is light to reduce wear.



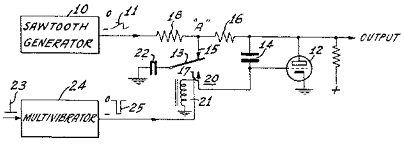
Pat. No. 2,743,647

FILM DRIVE MECHANISM (Patent No. 2,743,922)—granted May 1, 1956 to J. J. Hoehn, Commercial Electronic Products, Camden, N. J. To rapidly accelerate a film stabilizing drum 10 and flywheel 15, a solenoid 20 is energized at the same time as motor 41 driving sprocket 5, the solenoid moving friction pad 29 in the direction of movement of film 6. After de-energization, springs 31 and 32 return pad 29 to flywheel 15 to brake it.



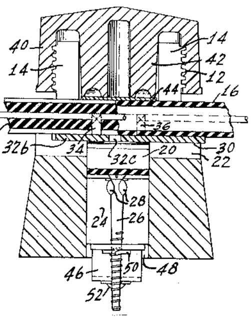
Pat. No. 2,743,922

ELECTRICAL DATA STORAGE DEVICE (Patent No. 2,741,756)—granted April 10, 1956 to A. C. Stocker, Defense Electronic Products, Camden, N. J. Electrical data representing target information is supplied as an electrical charge on a temporary storage capacitor. Then a switch or relay quickly transfers the charge to a second storage capacitor in a Miller memory store. The second capacitor is normally isolated from the charging circuit due to the open switch or relay, which is closed only for a short time to transfer the charge. The switch or relay may be closed periodically to supply corrections to the stored electrical data.



Pat. No. 2,741,756

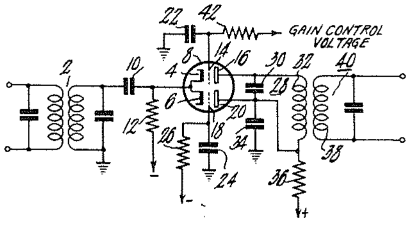
CONNECTOR FOR TWO WIRE TRANSMISSION LINES (Patent No. 2,742,549) — granted April 17, 1956 to C. L. Peters, Tube Division, Camden, N. J. This connector is an improvement over the one described in Johnson Patent No. 2,440,748. Some important features of this connector are: 1. The use of a generally U-shaped resistive inert element, the ends of the U engaging the two line piercing contacts. This shape reduces the capacitance introduced by the resistor. 2. The resistive insert element of (1) is resilient (formed of rubber) and maintains good electric contact with the line piercing contacts when slightly compressed. 3. The connector design is such that water cannot accumulate in the body of the connector. 4. The line piercing contacts are displaced from one another in the direction of the transmission line with which they make contact, thereby reducing the capacitance introduced by the contacts. 5. The connector includes a force-applying insert member having a contour complementary to that of the transmission line in order to apply force uniformly. 6. The design in general is such that losses in the UHF region are minimized.



Pat. No. 2,742,549

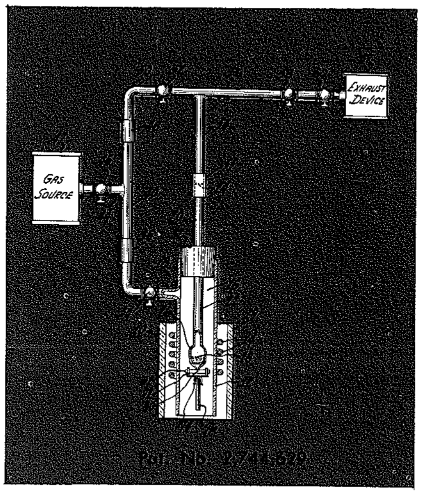
SYNTHETIC RESIN ENAMEL STRIPPING COMPOSITIONS (Patent No. 2,737,465)—granted March 6, 1956 to Leopold Pessel, Tube Division, Camden, N. J. A liquid composition capable of rapid softening of most synthetic resin materials—comprising: pentanedione 2, 4 - 50-98 volume %; formic acid or one of its principal derivatives 2-50 volume %.

GROUNDED GRID UHF AMPLIFIER WITH GAIN CONTROL AND CONSTANT INPUT IMPEDANCE (Patent No. 2,739,189) — granted March 20, 1956 to W. R. Koch, RCA Victor Television Division, Cherry Hill, N. J. The input impedance of a grounded-grid amplifier subject to gain control is maintained substantially constant for all conditions of gain by virtue of an auxiliary tube connected in parallel with the amplifier such that an inverse in input impedance of one is accompanied by a proportional decrease in the input impedance of the other.



Pat. No. 2,739,189

METHOD AND APPARATUS FOR PROCESSING CHEMICALS (Patent No. 2,744,629)—granted May 8, 1956 to B. H. Vine, Tube Division, Lancaster, Pa. A quantity of chemical 28 is placed in a container 20. The container is positioned within a hollow member 12 which is provided with a heating coil 14. A source of gas is connected to the hollow member 12 through a line 40 and to the container 20 through lines 50 and 54. Suitable valves are provided for blocking these lines and determining which flow path the gas is to follow. An exhaust device 57 is also connected to the container 20 through lines 56 and 54 which have suitable valves 58 and 60. Gas flow is adjusted to provide a gas medium within the member 12 and to promote the flow of gas through the chemical. Gas flow is also regulated to force a quantity of the chemical into a capsule 62.

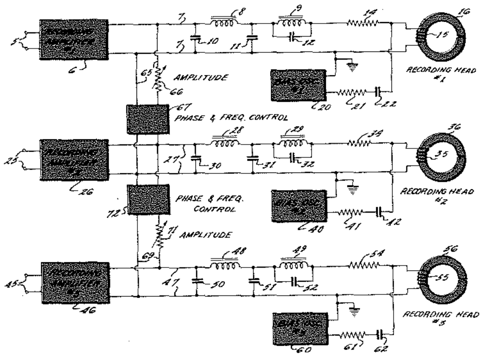


Pat. No. 2,744,629

ANTI CROSS-TALK MULTI-TRACT MAGNETIC SOUND SYSTEM (Patent No. 2,727,096)—granted December 13, 1955 to Kurt Singer, Commercial Electronic Products, Hollywood, Calif. To prevent leakage flux coupling between adjacent magnetic recording heads and fringing flux in magnetic film, each adjacent channel is interconnected to the other by a volume control resistor and a phase and frequency characteristic control for applying to adjacent heads a signal of correct amplitude and 180 degrees out of phase at adjacent heads with the signal being recorded. The 180-degree phase relationship may be obtained by reversing connections to the heads.

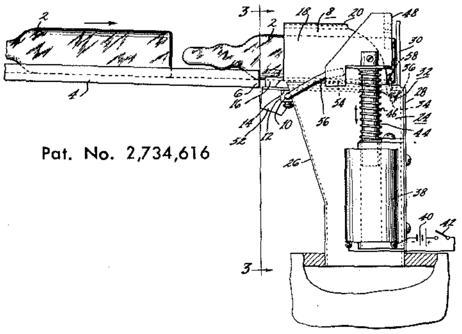
PATENTS GRANTED

Continued



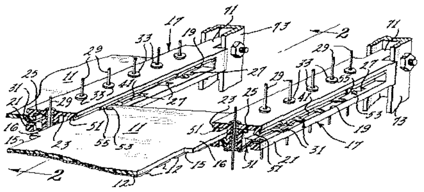
Pat. No. 2,727,096

ARTICLE TRANSFER DEVICE (Patent No. 2,734,616)—granted February 14, 1956 to R. E. Schell, Commercial Electronic Products, Camden, N. J. and L. R. Moskowitz (formerly with RCA). The invention is an infeed device for feeding ampules 2 to an inspection device (not shown). The infeed device comprises a support member 8, to receive successive articles, pivotally mounted on bearings 12, over a chute 24, and having a friction latch 32 normally biasing the member in a horizontal position. Means to cause the support member to pivot downward in response to an external signal comprises a solenoid-operated plunger 44 having a horizontal extending arm 48 connected to its upper end. The plunger is caused to move downward and the arm bears on the top of the ampule causing the support member to swing open. If no ampule is present the support member will not open.



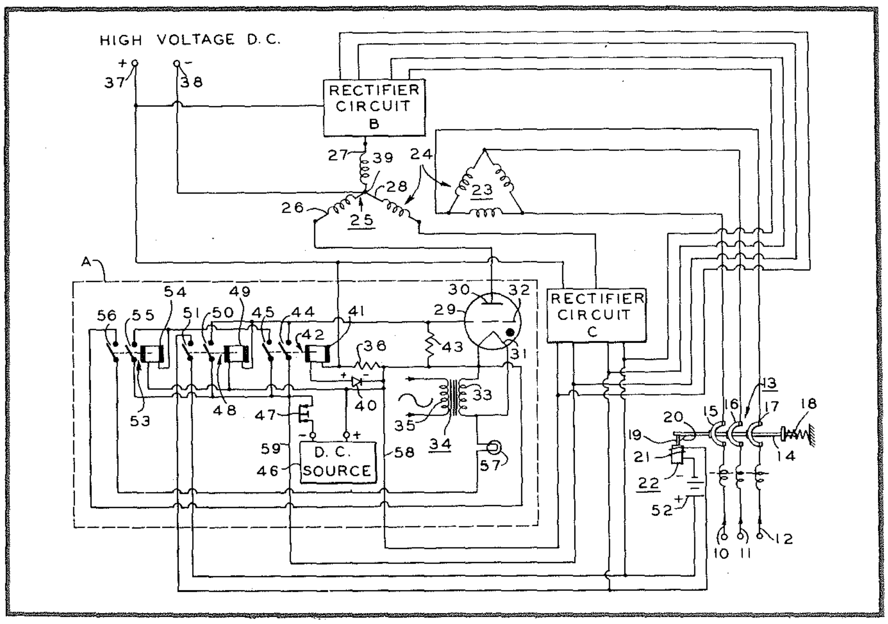
Pat. No. 2,734,616

SLIDING CONNECTOR FOR PRINTED CIRCUIT BOARDS (Patent No. 2,731,609)—granted January 17, 1956 to J. A. Sobel III, Defense Electronic Products, Camden, N. J. The connector comprises an elongated block 17 having grooves 19 along either side to accommodate the edge of a circuit board 11. Vertical conductors 29 extend through the block and provide connection between adjacent connectors. Contact members 31 are connected to the conductors 29 and extend to lie against one side of a groove 19 in position to engage the terminals 12 of the board 11. A ledge 41 extends part way along the same side of the groove to keep the board 11 away from the contacts 31 while it is being inserted. The ledge acts in cooperation with tab 16 to lock the board in place.



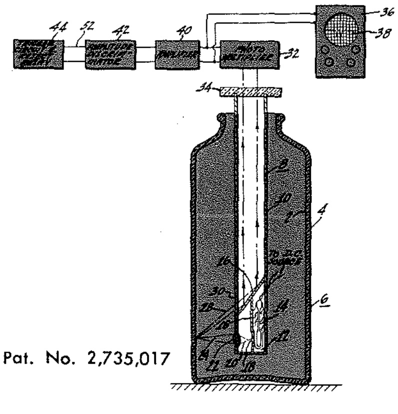
Pat. No. 2,731,609

PROTECTIVE CIRCUIT (Patent No. 2,740,083)—granted March 27, 1956 to Lester S. Lappin, Commercial Electronic Products, Camden, N. J. The invention relates to a protective circuit for gas tube rectifiers having a control element. The protective circuit comprises at least two relays and means for energizing these relays whereby to apply a cut-off voltage to the control element of the gas rectifier when arc-back occurs due to inverse currents through the gas rectifier.



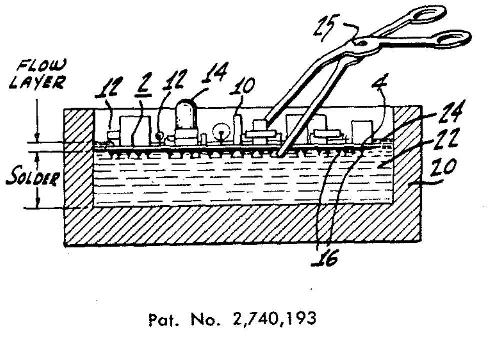
Pat. No. 2,740,083

METHOD AND APPARATUS FOR INSPECTING HOLLOW ARTICLES (Patent No. 2,735,017)—granted February 14, 1956 to Arthur D. Beard, Defense Electronic Products and Everett Eberhard (formerly with RCA). A spot of light is focussed on the surface being inspected and the diffuse reflection is picked up and directed to a photocell. Where the surface being inspected is transparent glass, the light source may be ultraviolet. Relative rotation and vertical movement are effected between the light spot and surface so that the inspection beam scans the surface. Dirt is detected as a sudden increase in output of photocell due to increase in the amount of light diffusely reflected.

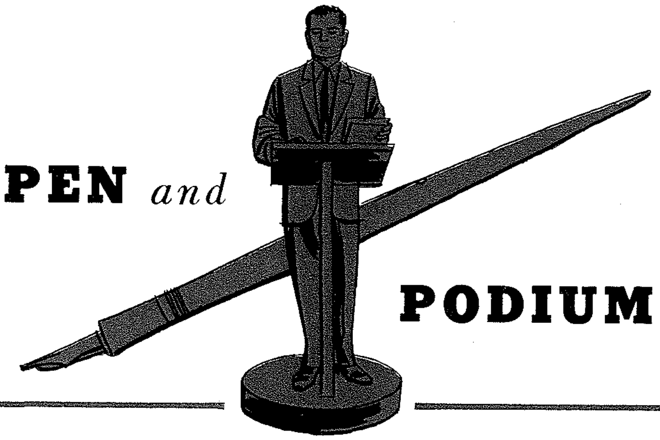


Pat. No. 2,735,017

METHOD OF SOLDERING PRINTED CIRCUITS (Patent No. 2,740,193)—granted April 3, 1956 to Leopold Pessel, Tube Division, Camden, N. J. The assembly 2 to be soldered is first immersed in a conventional bath or molten solder. Next, the assembly is immersed in a bath comprising molten solder 22 having a top layer 24 of a relatively inert organic liquid which may be an organic phosphorus derivative alone or in combination with an organic acid or derivatives thereof having a carboxyl group, or in combination with an oil, wax or resin, or in combination with a mixture of an organic acid or derivative and an oil, wax or resin. The assembly is exposed to and preferably manipulated in the second bath until substantially all the undesired solder is removed therefrom.



Pat. No. 2,740,193



PEN *and* PODIUM

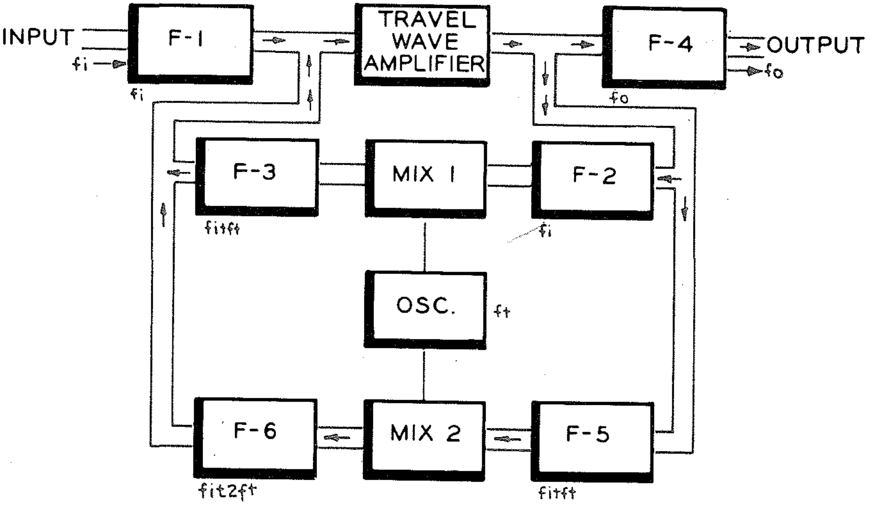
Based On Reports Received Over a Period of About Two Months

LIGHTING FOR OPAQUES ON TV . . . By H. N. Kozanowski, Commercial Electronic Products, Camden, N. J. Presented on May 1, 1956 at the 79th SMPTE Convention Meeting, Hotel Statler. The use of 3-V Film Cameras to provide high quality Color TV reproduction of color opaques has brought new requirements for lighting sources. These must cover uniformly a limited field at light levels of the order of 10,000 foot-candles. Such levels are currently in use for Monochrome TV reproduction of opaques. Various methods of obtaining adequate illumination for Color are compared.

COLLAPSING-LOSS IN AIRBORNE RADAR DISPLAYS . . . By L. E. Mertens, J. P. Mayberry, Defense Electronics Products, Moorestown, N. J. and P. N. Nesbeda, Defense Electronics Products, Waltham, Mass. Presented at the Conference of the I.R.E., Professional Group on Aeronautical and Navigational Electronics at Dayton, Ohio, on May 16, 1956. Appreciable reduction in radar detection range may result from collapsing-losses in the radar display. Collapsing-loss is caused by repeated superposition of thermal noise, atmospheric clutter, or ground clutter on the target return. In many cases the collapsing may be intentionally introduced so as to permit presentation of three-dimensional data in the two dimensions of a conventional display. In other cases the collapsing may be due to poor resolution in the data processing circuits or displays. Methods of analyzing radar detection performance and predicting collapsing-loss were described.

FILTER MEDIA . . . By M. L. Whitehurst, RCA Victor Record Division, Indianapolis, Ind. Presented at the National Convention of the American Electroplaters' Society, Washington, D. C., June 18-22, 1956. The paper was authored by a committee from the Indianapolis Branch of the American Electroplaters' Society. The object of this paper is to collect and classify available information for presentation as an aid in the selection of filter media for specific use.

MEASUREMENTS OF THE NEAR FIELD OF AN APPROXIMATELY PLANE RADIATOR . . . By R. M. Carrell, Commercial Electronic Products, Camden, N. J. Presented on June 22 at the International Congress on Acoustics, Boston, Mass. An acoustic radiator consisting of an array, two-feet square, with 67 small loudspeakers was built. Tests showed that the sound field within six inches of the radiator had the essential properties of a plane wave. A close-talking, noise-cancelling gradient microphone placed in this field exhibited a frequency response essentially the same as that obtained in an anechoic chamber six feet from the sound source. This was also the case when the response was measured using the radiator in an ordinary room on a bench top. This indicates that this radiator can be used to test the noise cancelling properties of a microphone without requiring an anechoic chamber as at present.



Frequency Shift Re-entrant Loop.

ENGINEERING FILES . . . By H. R. Ketcham, Defense Electronic Products, Camden, N. J. This paper has been published as a part of the Manual presented to conferees at the American Management Association session on "System Planning and Control," held in New York City on April 23-24, 1956. This paper reviews a method for evaluating the present situation in an Engineering Design activity's files. It describes the evaluation of this review, and a way of installing a new system.

RELATION OF MATERIALS TO DESIGN . . . By C. Eddison, Components Division, Camden, N. J. Presented as Preamble to Third Session of Design Engineering Conference sponsored by Machine Design Division of American Society of Mechanical Engineers at Convention Hall, Phila., Pa. on May 16, 1956. This paper discusses the relationship between the chemistry and physics of materials and design engineering, a relationship which becomes closer as design becomes more complex or sensitive or as the completed product is required to perform more efficiently under a wider variety of conditions. The relationship between new or more efficient design and new or improved materials is evaluated. The necessary properties of materials are described as functional, processing, operative, and protective. The paper points out that the partnership between design and the chemistry and physics of materials is best exercised at the design concept stage to provide minimum cost and maximum quality of the completed product.

THE ROLE OF THE DESIGN ENGINEER IN THE FIELD SUPPORT OF COMPLEX AIRBORNE ELECTRONIC EQUIPMENT . . . By H. W. Brown, Defense Electronic Products, Camden, N. J. Presented at the National Conference on Aeronautical Electronics, Dayton, Ohio, on May 14, 1956. The increasing complexity of military equipment, demanded by modern tactical concepts, has accentuated the Services' problem of providing adequately trained personnel to maintain the equipment. By becoming maintenance conscious, the design engineer can make a significant contribution. Foremost are the considerations of packaging, self testing circuitry, test points, and accessibility of adjustments, all contributing to ease of maintenance.

RCA EXPERIMENTAL MICROWAVE SYSTEM EMPLOYING TRAVELING WAVE AMPLIFIERS . . . By D. Hochman and B. F. Wheeler, Commercial Electronic Products, Camden, N. J. Presented at the Meeting of the Tucson Section IRE, Tucson, Arizona. This paper described the application of traveling-wave tubes in a microwave system in which a frequency shift re-entrant loop was used to exchange some of the spare bandwidth for useful gain. Typical microwave relay terminal and repeater stations were described, and slides illustrating the principles and experimental layout shown.

PEN *and* PODIUM
continued

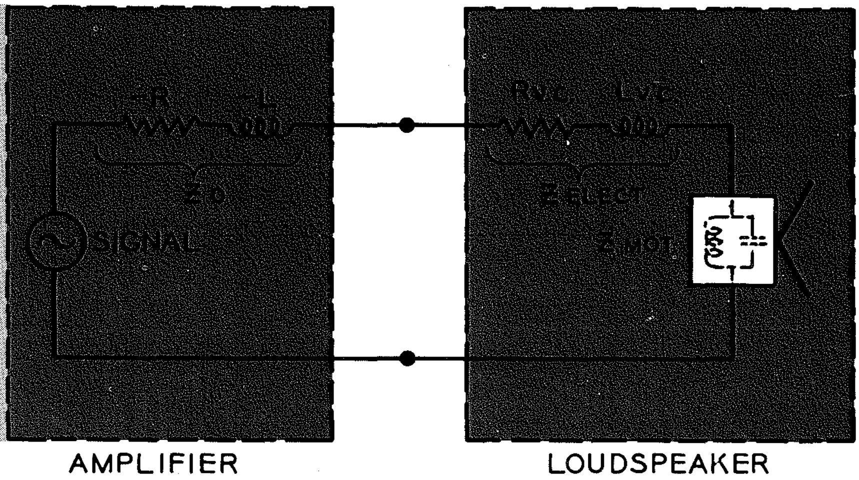
RCA COMPUTER TUBES . . . By H. J. PRAGER, TUBE DIVISION, Harrison, N. J. Presented at Lincoln Laboratories, MIT, Cambridge, Mass., on May 17, 1956 and at Remington-Rand and Minneapolis-Honeywell, Minneapolis, Minn., on June 19, 1956. This paper reviews the need for special tubes for computer applications, and discusses the features of the RCA line of computer tubes. Special design features such as grid design and choice of cathode materials are considered. Process controls and test specifications are also discussed, and performance results based on life-test data are presented.

A DEVELOPMENTAL HIGH-POWER TUNABLE X-BAND PULSE MAGNETRON FOR AIRBORNE APPLICATIONS . . . By W. F. BELTZ, TUBE DIVISION, Harrison, N. J. Published in ELECTRONICS, March, 1956. This paper describes a developmental tunable X-band magnetron in which a new tuning technique is employed to provide stable, wide-band tuning.

The operating frequency is varied by adjustment of the dimensions of separate tuning cavities which are contained in the tube and coupled into the magnetron resonant system. With this method, it is possible to obtain good mode separation and stable operation over a wide tuning range. Stabilizing effects of the cavities and the incorporation of an effective getter improve performance.

A METHOD FOR SALVAGING COMPONENTS OF BRAZED ASSEMBLIES . . . By M. B. LEMESHKA, TUBE DIVISION, Lancaster, Pa. Published in ELECTRICAL MANUFACTURING, March, 1956. A practical method is described for the separation of complex and fragile assemblies of parts joined by brazing alloys such as silver, copper, zinc, gold, or their alloys. The separation is accomplished at relatively low temperatures, without mechanical or thermal stresses, and at a very low cost. The use of this method results in savings in the cost of manufacture and in the time and cost of development work because it eliminates the loss of time and material normally incurred by rejects or "scrap" of the completed product or of brazed assemblies.

THE EFFECT OF A NEGATIVE IMPEDANCE SOURCE ON LOUDSPEAKER PERFORMANCE . . . By R. E. WERNER, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented at the Delaware Chapter, Acoustical Society of America, Camden, N. J. on June 7, 1956 and at the International Congress on Acoustics, Cambridge, Mass., on June 22, 1956. A direct radiator moving coil loudspeaker driven by an amplifier whose output impedance approaches the negative of the blocked voice-coil impedance can be made to exhibit extended low-frequency response with reduced distortion. The effect of the system is in some ways analogous to a many-fold increase in loudspeaker efficiency. In a typical case, neutralization of 70% of the blocked voice-coil impedance completely damps the cone resonance, as well as substantially reducing the nonlinear distortion below resonance. When the amplifier is compensated for the falling radiation resistance at low frequencies, uniform output can be obtained to any arbitrary low frequency, limited only by the ultimate power handling capability of the amplifier and speaker. In this system, no additional amplifier power is required at frequencies down to the speaker resonance; additional power is required below that point.



Equivalent circuits showing negative source.

HIGH-EMITTER-EFFICIENCY ALLOY MATERIALS FOR P-N-P TRANSISTORS . . . By L. D. ARMSTRONG, C. L. CARLSON, and M. BENTIVEGNA, TUBE DIVISION, Harrison, N. J. Published in RCA REVIEW, March, 1956. In the past, the performance of p-n-p alloy transistors at high currents has been limited by the decrease of emitter efficiency with current level. The addition of small percentages of gallium or aluminum to indium, for use as the emitter alloy, produces greatly improved high-current characteristics. As compared with pure indium, the use of gallium alloys improves emitter efficiency by about 3.5 times, and the use of aluminum-bearings alloys by about 10 times. Techniques for preparation of the alloys and results of tests on transistors using the various emitters are described.

A SYSTEMATIC METHOD FOR DETERMINING THE FLEXURAL EFFECTS OF STATICALLY LOADED NON-UNIFORM BEAMS ON MULTIPLE ELASTIC SUPPORTS . . . By R. A. DITARANTO, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented on June 14, 1956 at the National Applied Mechanics Conference, Urbana, Illinois. The paper presents a method for finding the slope, deflection, shear and moment at any point along a beam which is statically loaded and has non-uniform stiffness along its length. The beam may have any number of supports and these supports may be rigid or have flexibility.

INVESTIGATION OF POWER GAIN AND TRANSISTOR PARAMETERS AS FUNCTIONS OF BOTH TEMPERATURE AND FREQUENCY . . . By A. B. GLENN, and I. JOFFE, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented at the National Conference on Aeronautical Electronics, May 14, 1956. In order to intelligently design equipment over wide temperature ranges, it is important to know how the performance of individual components used on the equipment is affected. This is especially true in equipment utilizing transistors since transistors are known to be temperature sensitive. The purpose of this paper is to present the results of an investigation made to determine the effects of temperature and frequency on the power gain and equivalent circuit parameters of both alloy-junction germanium and grown-junction silicon high-frequency transistors. The temperature and frequency range covered was —55°C to +125°C and 0.5 to 4.0 megacycles respectively.

ELECTRONIC LENS TESTER . . . By E. KORNSTEIN, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented June 4, 1956 as part of a Symposium on Optical Image Evaluation at E. Leitz Co., Wetzlar, Germany. Background information on the need for optical lens evaluations compatible with electronic equipment evaluation to give overall estimates of system quality was presented. A non-mathematical introduction of aperture response theory was presented, and many questions which arose during this discussion were answered. A series of slides describing the RCA Electronic Lens Tester was shown. A round table discussion on the general subject of optical image evaluation concluded the symposium.

CURRENT TRENDS IN CATHODE RAY TUBE DESIGN AND DEVELOPMENT . . . By B. H. ROSEN, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented at the 1956 Electronics Components Symposium, Washington, D. C. on May 2, 1956. Recent developments in cathode ray tube design for both military and commercial applications have been towards developing a product of smaller volume, lower power drain and improved performance. This has been achieved by such innovations as low-voltage electrostatic focus, small neck diameter, large deflection angle, spiral accelerator to mention just a few. The long range goal of cathode ray tube development encompasses the design of a flat indicating device suitable for use with transistors. This paper discusses both the military and commercial trends in the development of cathode ray tubes. In addition, items such as low grid base and triode gun have also been instrumental in improving cathode ray tubes. The relative merit of these types of improvements and others were discussed.

ALKALI-COMPENSATED SILICATE PHOSPHOR . . . By G. E. Crosby, Tube Division, Lancaster, Pa. Presented at Electrochemical Society, San Francisco, Calif., May 1, 1956. The results of incorporating alkali ions into cerium-activated calcium-magnesium silicate (Akermanite) phosphor are reported and discussed. Alkali-ion compensation of the silicate phosphor yielded a product having greater luminescent efficiency and slightly shorter decay. The incorporation of alkali ions during preparation greatly improved the yield of good phosphor.

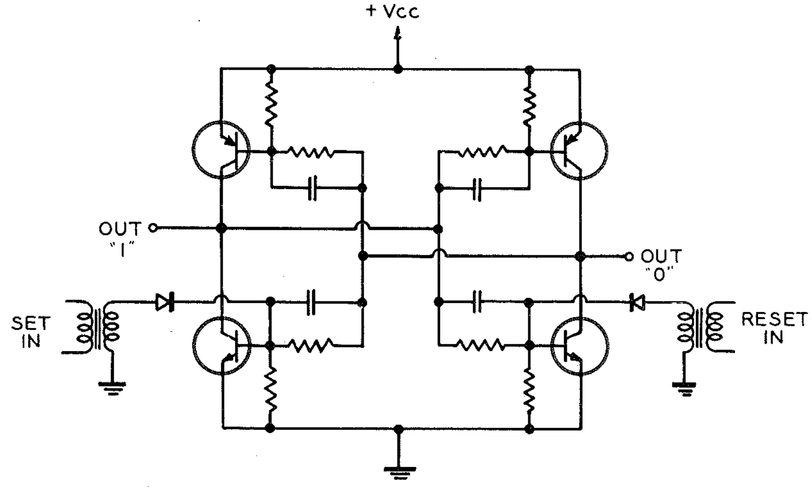
A BISTABLE SYMMETRICAL SWITCHING CIRCUIT . . . By T. P. Bothwell and L. Kolodin, Defense Electronic Products, Camden, N. J. Presented at the Meeting of IRE Transistor Circuits Subcommittee, Cornell University, on June 4 and 5, 1956. The principal shortcomings of high-speed bistable transistor circuits have been their limited power output relative to standby power, unsymmetrical rise and fall times, and design complexity. The availability of high-speed complementary transistors has made possible a circuit employing two complementary pairs of transistors which are capable of delivering a load power greater than standby power. Since minimum requirements are placed on the transistor, practically any available high-frequency transistor can be used. An analysis of the transient and static circuit characteristics are given and a design for computer application is carried out.

PREPARATION OF SELENIDES OF HYDROGEN AND ZINC . . . By G. E. Crosby, Tube Division, Lancaster, Pa. Presented at Electrochemical Society, San Francisco, Calif., May 1, 1956. The need for hydrogen and zinc selenide necessitated the study of various techniques of preparing these compounds. A report of a literature survey and a laboratory evaluation of many processes are given. Some processes are reported for preparing luminescent-grade zinc selenide directly from selenide without use of the toxic hydrogen selenide.

A SYSTEMATIC PLAN FOR PREDICTING ELECTRONIC RELIABILITY . . . By J. A. Conner, Defense Electronic Products, Camden, N. J. Presented at the 1956 Electronics Components Symposium, Washington, D. C., May 3, 1956. The engineering details required to evaluate the Reliability potential of new electronic systems range from component-part and material properties to system-application factors. This paper describes an engineering program of Components-Application Review established to cope with these problems in a methodical manner. The crucial nature of component-parts is emphasized along with the need for deriving a system Reliability in terms of valid failure characteristics of individual circuit elements.

RELIABILITY THEORY AND VITAL ENGINEERING INTERPRETATIONS . . . By H. L. Wuerffel, Defense Electronic Products, Camden, N. J. Presented at the 1956 Electronics Components Symposium, Washington, D. C., May 3, 1956. The proper choice and application of mathematical tools of Reliability analysis for complex systems necessitates a keen appreciation for the physical factors involved. Valid and effective calculations of predicted Reliability have been accomplished by means of the methods outlined in this paper. A new insight into the statistical evaluation of electronic system designs is provided by illustrating the utility of such summarizing numerics as mean life, survival probability, thermal design efficiency and debugging time.

PREPARATION OF COPPER-ACTIVATED ZINC-SELENIDE PHOSPHOR BY THE "DRY PROCESS" . . . By G. E. Crosby, Tube Division, Lancaster, Pa. Presented at Electrochemical Society, San Francisco, Calif., May 1, 1956. A "dry process" is described for preparation of zinc-selenide phosphor having luminescent properties equivalent to those of the same phosphor prepared from precipitated selenide. Optimum conditions for preparation and optimum chemical concentrations are discussed.



Circuit Diagram of Bistable Symmetrical Switching Circuit.

A NEW MAGNETRON FOR COMMERCIAL AIRBORNE WEATHER RADAR . . . By W. F. Beltz and R. W. Kissinger, Tube Division, Harrison, New Jersey. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 14-16, 1956. This paper describes the RCA-6521 magnetron, a C-band packaged tube designed especially for use in pulsed weather radar mapping from commercial airliners. Design considerations involving long tube life in flight service and high reliability of operation are discussed. Important aspects of tube-performance varitions with life and with varying operating conditions are also considered.

TEST PROVISIONS AND PACKAGING OF AIRBORNE ELECTRONIC EQUIPMENT . . . By R. Trachtenberg, Defense Electronic Products, Camden, N. J. Presented at the Second Symposium on Electronics Maintenance, Rome Air Development Center, Rome, N. Y., May 10, 1956. Several current equipments were used as examples to highlight techniques of construction and packaging for space premium aircraft. Internal construction using plug-in units has become universal for such applications. These units were categorized and illustrated and the means for replacement and test of the units were shown to have major effect on the ease of maintenance of the overall equipment. Provisions for test in place in the aircraft and on the bench were discussed. Criteria for packaging were proposed taking into account the demands of high performance aircraft. An approach to packaging for easy maintenance was presented.

HUMAN ENGINEERING ASPECTS OF ELECTRONIC EQUIPMENT RELIABILITY . . . By H. L. Wuerffel, Defense Electronic Products, Camden, N. J. Presented at the Second Symposium on Electronics Maintenance, Rome Air Development Center, Rome, N. Y. on May 9, 1956. Techniques have been developed to cope with the problems of performance degradation and chance failures in complex electronic equipments and to predict accurately the reliability which will subsequently be obtained in the field while the equipment is still in the design stage. However, these techniques are based on the assumption that all of the system application factors are known. Frequently this is not the case. To assist cognizant personnel in obtaining the required information, a series of charts and check lists have been developed.

ADAPTIVE AND DISTRIBUTION-FREE FILTERS . . . By L. E. Mertens, Defense Electronic Products, Moorestown, N. J. Presented at the IRE National Convention on Aeronautical and Navigational Electronics, May 15, 1956. Considerable effort has been devoted in recent years to the development of high-performance servo and data processing systems. Methods of discriminating against various random or noise-like disturbances is a central problem in the design of these systems. Quantitative statistical information concerning the signal and noise processes is particularly difficult to obtain in many airborne applications. Two methods of approach in this situation are suggested. The first approach may be termed an adaptive filter since observations over some specified past interval are processed to obtain useful statistical data for modifying the filter parameters. The second design method has been termed non-parameteric or distribution-free since it does not require (a priori) probability distributions for the signal and noise processes. Several applications are discussed.

COMMUNICATIONS CIRCUITS USING GERMANIUM TRANSISTORS . . . By R. E. Wilson, Defense Electronic Products, Camden, N. J. Presented on May 15, 1956 at the 1956 National Conference on Aeronautical Electronics. The paper describes several circuits used in communications systems and discusses some of the associated design problems. The Time-Division Multiplex System for which these circuits were developed is described. The use of germanium transistors has made possible the construction of communication developmental equipment having approximately 1/6 the size and weight, and drawing less than 1/10 the power of previous vacuum tube units.

A DAMPER ON AMERICAN SCIENTIFIC PROGRESS . . . By R. W. Pearson, Defense Electronic Products, Moorestown, N. J. Presented to the Engineering Drawing Division of the American Society for Engineering Education at Iowa State College, Ames, Iowa, June 22, 1956. The colleges are finding it more difficult each year to squeeze in additional courses required to keep young technical students abreast of modern scientific advancements. Some colleges are attempting to get more available time for instruction in the newer fields by reducing the time spent on engineering drawing. This paper points up the serious consequences of reduced engineering drawing training, since engineering drawings are the only media for conveyance of practical engineering information.

DEVELOPMENT OF A 5-INCH DIRECT-VIEW STORAGE TUBE . . . By E. M. Smith, Tube Division, Lancaster, Pa. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 14-16, 1956. This paper describes the development of a direct-view storage tube which provides an exceptionally bright visual presentation of radar-type information for relatively long periods. Principles of operation and the important features of this type of storage tube are considered. The design of the direct-view storage tube is explained to show how extended viewing duration, high brightness, half tones, fast writing and erasure, and good resolution are achieved.

RCA APPROACH TO AUTOMATIC PROGRAMMING FOR COMMERCIAL PROBLEMS . . . By J. H. Waite, Jr., Commercial Electronic Products, Camden, N. J. Presented at the Office of Naval Research Symposium, The Pentagon, Washington, D. C., June 29, 1956. Automatic Programming at RCA concerns three areas: problem definition, machine logic requirements and techniques which can associate these two areas together in such a way as to permit the computer to produce its own program from a simple and concise definition of commercial problems. This paper describes work done at RCA in these areas with emphasis on some of the critical problems encountered: such as; data layout, program layout, instruction sequencing, classification of decision elements, address assignment, program optimization and derivation of basic instruction sequences.

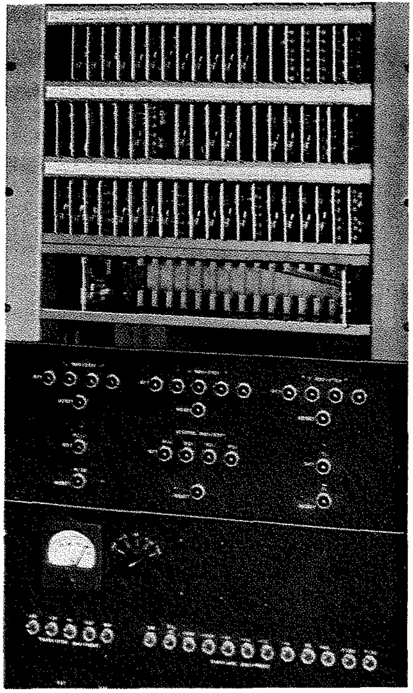


Photo showing a Transistor Arithmetic Unit.

LOGIC CIRCUITS FOR A TRANSISTOR DIGITAL COMPUTER . . . By G. W. Booth and T. P. Bothwell, Defense Electronic Products, Camden, N. J. Presented by T. P. Bothwell at the Airborne Electronics Conference at Dayton, Ohio, May 16, 1956. A group of transistor logic circuits which allows efficient implementation of airborne computing functions was described. A static flip-flop, a gated-pulse amplifier and a power-pulse amplifier are the three basic circuits used. For a few exceptional cases where d-c amplification is required at the output of a flip-flop, an emitter follower is provided. Information in a system of this sort is propagated between storage units in the form of pulses. Gating levels are derived directly from the flip-flops, hence no inverter is required. Uniform 2.8 volt, ½ microsecond pulses and 6-volt levels are used throughout. An experimental transistor arithmetic unit has been constructed and operated in a test computer.

TRAVELING-WAVE TUBES: APPLICATIONS AND APPLICATION CONSIDERATIONS . . . By F. R. Arams, Tube Division, Harrison, N. J. Presented at National Conference on Aeronautical Electronics, Dayton, Ohio, May 14-16, 1956. This paper discusses the application of various types of traveling-wave tubes, and describes the operation of a typical traveling-wave tube in detail. The different types of tubes described include amplifiers, oscillators, electronically-tunable oscillators and amplifiers, frequency multipliers, limiters, low-noise input tubes for radar, single-sideband modulators, mixers, and frequency shifters. The use of traveling-wave tubes for amplitude, phase, and pulse modulation is also discussed.

EMPIRICAL ALTITUDE FACTORS TO 100,000 FEET . . . By M. R. Alexy, Defense Electronic Products, Camden, N. J. Published in the June, 1956 issue of Electrical Manufacturing. This paper describes an empirical method of determining the "Altitude Factor", one of the major "tools" of the design engineer. The investigation results in data expressed in the form of an "Altitude Factor" curve. The curve plots measured values up to 100,000 feet altitude and is further extrapolated up to 130,000 feet. The curve is the graphical representation of the herein derived formula.

$$A = .00106\, X^2 + .016\, X + 1$$

Typical examples are included illustrating how the curve can be used to establish design parameters of high voltage, high altitude components such as switches and relays.

MANUFACTURING SUBMINIATURES TO MEET THE MIL-E-1B VISUAL INSPECTION . . . By R. E. Brooks, Tube Division, Harrison, N. J. Presented on May 1, 1956 at the Electronic Components Symposium, Washington, D. C. This paper describes the two-pronged program undertaken at RCA to meet the MIL-E-1B Visual (Finished-Tube) Inspection. The training of inspectors to examine the items included in the specification is discussed. Changes made in the mounting procedure, the sealing-and-exhaust schedule, and other manufacturing processes to eliminate various types of defects are also described, and the quality of tubes made under the new method is evaluated. As a result of this program to improve subminiatures, RCA is now producing large quantities of these tubes with no rejection of lots at the MIL-E-1B Visual Inspection.

COLORIMETRIC PROBLEMS IN THE USE OF FILM FOR COLOR TELEVISION . . . By H. N. Kozanowski and S. L. Bendell, Commercial Electronic Products, Camden, N. J. Published in the SMPTE Journal, April, 1956. Increasing use of film programming for color telecasting has emphasized the need for a more critical view of the capabilities of both the film and the television system for a greater understanding of the colorimetric behavior of the combination. A discussion of the main problems was presented, in which operational requirements of present-day broadcasting were considered. Various attempts at the solution of these problems were examined and recommendations were suggested.

MEASUREMENT OF ALUMINUM FILM THICKNESS . . . By C. P. Hadley, Tube Division, Lancaster, Pa. Published in REVIEW OF SCIENTIFIC INSTRUMENTS, March, 1956. This paper describes a nondestructive method of measuring the thickness of metallic films such as those used in aluminized kinescopes. The underlying principle of this method is that a coil carrying an alternating current will lose power to an adjacent conductor. The Q of the coil is, therefore, a function of the conductor geometry. Aluminum thicknesses in the range of 500 to 2000 angstroms can easily be measured by this technique.

DRAFTING PROBLEMS IN INDUSTRY AND SOME SOLUTIONS . . . By R. W. Pearson, Defense Electronic Products, Moorestown, N. J. Published in the May, 1956, issue of *Journal of Engineering Drawing*. The paper covers some of the problems which have developed because of reduced time allotted to the teaching of Engineering Drawing in Colleges and Universities, and because of the present-day lack of "pride-of-workmanship" in factory work performed. Special emphasis is given for embryonic engineers to gain a grave respect for the importance of tolerances in both mechanisms and electrical circuits.

LOW-LEVEL TRANSISTOR AMPLIFIERS . . . By F. L. Putzrath, Defense Electronic Products, Camden, N. J. Presented at the National Conference on Aeronautical Electronics, Dayton, Ohio, May 15, 1956. Because of its economy in size, weight and power consumption, the transistor has excelled the vacuum tube as the active element in low-powered electronic equipment. To obtain the desired performance, it becomes necessary to understand transistor characteristics and how to overcome certain difficulties. This paper shows how the transistor operating point may be stabilized for temperature and gain variations in low-level applications. Equivalent transistor amplifier circuits are described for audio, video, and tuned amplifiers. Performance limitations, transistor noise, and control circuits are considered.

DESIGN AND APPLICATION OF METHODS FOR EQUIPMENT MAINTENANCE . . . By J. R. Barger and J. P. Eugley, Defense Electronic Products, Camden, N. J. Presented at the Air Development Center, Rome, N.Y., May 10, 1956. The design of the AN/APN-70 direct reading Loran receiver has incorporated several interesting features to increase equipment effectiveness in the field. Maintenance time is reduced by providing excellent accessibility, and a unique system of test points which incorporates a test for marginal components. An internal calibration test is provided for the operator. The use of reliable circuits and components in addition to these features has resulted in an excellent service record.

DESIGNING FOR RELIABILITY THROUGH THE PROPER APPLICATION OF TUBES . . . By C. M. Ryerson, Defense Electronic Products, Camden, N. J. Presented at the RETMA Symposium on Reliable Applications of Electron Tubes, University of Pennsylvania, Philadelphia, Pa., on May 22, 1956. The author deals with the reliable applications of vacuum tubes in the following three sections: (1) Discussion of types and causes of tube failures, (2) Analysis of problem, (3) Designing for degradation. Reliability depends on the thorough knowledge of the exact end use conditions, complete information on the immediate local environment for each tube and the exact quality conditions of tubes, their time dependencies and their circuit degradation effects. It is contended that reliable design is an operation involving complete knowledge of capabilities and limitations at every step. Engineering design compromises must be based on repetitive analyses of all causes and effects, modified by all previous events and extrapolated to the final time of use.

DEVELOPMENT OF THE RCA ELECTROFAX MICROFILM ENLARGER . . . By Henry G. Reuter, Jr., Commercial Electronic Products, Camden, N. J. Presented before the Society of Photographic Engineers at their Sixth Annual Meeting, West Point, N. Y., on May 10th. The author described the RCA Electrofax Enlarger, a high-speed, continuous reproducer designed for the U. S. Navy's Filmsort system. The system accepts card-mounted or roll microfilm and produces direct engineering prints using the new RCA dry electrophotographic process known as Electrofax. A brief review of the Filmsort system and an explanation of the RCA Electrofax process was followed by a detailed description of the design approach, unique features, and operational characteristics of the RCA Electrofax Microfilm Enlarger.

HIGH-POWER, LOW-FREQUENCY APPLICATION OF TRANSISTORS . . . By A. I. Aronson, Defense Electronic Products, Camden, N. J. Presented on April 17, 1956, this paper was part of the IRE Lecture Series on Transistor Applications. The lecture discussed the advantages and limitations of transistors peculiar to high-power applications. Class A and class B push-pull amplifiers were described, along with techniques for minimizing distortion in class B amplifiers. Various circuits using the concept of complementary symmetry were presented. The problems of thermal runaway and temperature stabilization in power amplifiers were analyzed.

THE RCA BIZMAC ELECTRONIC ACCOUNTING SYSTEM . . . By W. K. Halstead. Presented by Arthur S. Kranzley, Commercial Electronic Products, Camden, N. J., at the opening of a panel discussion on Systems Engineering at the Systems and Procedures Conference on May 17th at Chicago, Ill. The paper which was first published in the RCA ENGINEER presented the features of the RCA BIZMAC System, the most highly integrated business machine system that has been announced. It was pointed out that business problems involved a large amount of input and output information, as contrasted with scientific problems, with relatively simple computations being performed internally. The completely new devices were developed to handle the high-speed inputs and outputs, such as the fast magnetic tape handling mechanisms and the high-speed printers. In addition, considerable emphasis was placed on sorting, arranging and extracting of data with respect to the recorded files. Consideration of these problems led to the development of the integrated RCA BIZMAC System.

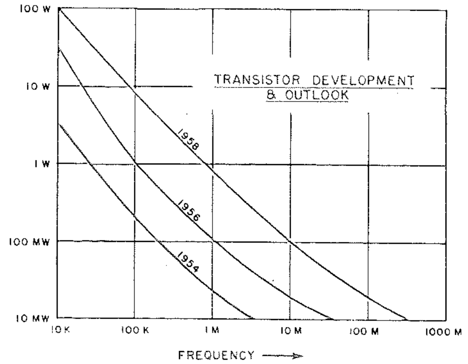
SWITCHING APPLICATION OF TRANSISTORS . . . By D. E. Deuitch, Defense Electronic Products, Camden, N. J. Presented at the University Museum, University of Pennsylvania, May 9, 1956 as part of an IRE tutorial lecture series on transistor applications. This paper covered the important features of transistors for switching operation, including d-c characteristics, transient and switching speed performance, and the storage phenomena. Various transistor switching circuits were described to illustrate some of the useful applications of transistors and their advantages and limitations in this service.

TACTICAL SUITABILITY OF ELECTRONIC EQUIPMENT . . . By G. F. Breitwieser and R. H. Lesser, Defense Electronic Products, Moorestown, N. J. Presented on May 9, 1956 at the Symposium on Ease of Maintenance of Electronic Equipment, Rome Air Development Center, Rome, N. Y. Since there is an increasing trend toward larger and more complex military weapon systems, this paper is slanted toward the electronic portions of such systems. From an equipment designer's standpoint, maintainability cannot be considered independently from performance, reliability, spares support, field support, or training. Maintainability must be considered along with some of these factors as an intimate part of the original systems concept. It is assumed that the military users of such systems would like to get a kind of "Tactical Suitability Insurance" policy along with each system. Coverages under such a policy would be Performance, Reliability, Spares and Publications Support, Field Engineering Support, and "Maintainability".

SOME CHARACTERISTICS OF ELECTROFORMED IRON DEPOSITS . . . By A. M. Max, RCA Victor Record Division, Indianapolis and Dr. R. G. Van Hauten, formerly of RCA. Presented at the American Electroplaters Society Annual Convention, Washington, D. C. by Mr. Max on June 19, 1956. Deposits from a typical iron chloride electroforming solution were investigated under a wide variety of deposition and solution variables. Cathode efficiency, deposit stress, tensile strength, and ductility as well as pitting were correlated with temperature, current density, acidity, ferric ion concentration and agitation. The importance of temperature was demonstrated and related to deposit stress. Deposits in general were of typical columnar crystal structure varying in ultimate strength between 45,000 psi to 65,000 psi. At the higher temperatures, deposits tended to be softer and more ductile with lower ultimate strength.

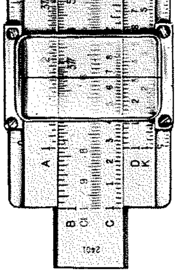
CATAPHORETIC DEPOSITION OF THORIA ON TANTALUM . . . By C. P. Hadley, Tube Division, Lancaser, Pa. Published in the REVIEW OF SCIENTIFIC INSTRUMENTS, March 1956. This paper describes the preparation of a thermionic emitter by the cataphoretic coating of thoria on a tantalum base. The advantages of thorium chloride instead of thorium nitrate as an electrolyte are discussed. Details of the coating technique are given, and data are presented showing the emision capabilities of the coatings.

A REPORT ON THE STATE OF THE ART OF SEMICONDUCTOR DEVICES . . . By D. B. Kret, Defense Electronic Products, Camden, N. J. Presented at the 1956 Electronic Components Conference, Washington, D. C. on May 2, 1956. This paper covers the areas of semiconductor device reliability, recent developments and expected improvements with primary emphasis on advantages and limitations concerning equipment development and manufacture. Major area of emphasis is on transistors, although other semiconductor devices are considered. The paper covers essentially three points: (1) Performance data and additional information on reliability, (2) Applications of specific components and (3) a resume of plans for future semiconductor applications.



Curves showing trends of Transistor Development.

Engineering NEWS *and* HIGHLIGHTS



EXECUTIVES NAMED TO NEW POSTS

T. A. SMITH ELECTED EXECUTIVE VICE-PRESIDENT, RCA DEFENSE ELECTRONIC PRODUCTS

A. L. Malcarney Named Vice-President and General Manager, RCA Commercial Electronic Products

Election of Theodore A. Smith as Executive Vice-President, Defense Electronic Products, Radio Corporation of America, and Arthur L. Malcarney as Vice-President and General Manager, Commercial Electronic Products, RCA, was announced by Brig. General David Sarnoff, Chairman of the Board of RCA, following a meeting of the Board of Directors.

Mr. Smith has been Vice-President and General Manager, Defense Electronic Products, since October, 1955. For two years previously, he was Vice-President in Charge of the Engineering Products Department of the former RCA Victor Division. *See RCA ENGINEER Vol. 1, No. 4, for Mr. Smith's biography.*

Mr. Malcarney, who joined RCA in 1933, has served as General Manager, Commercial Electronic Products, since October, 1955. Previously, he had been for two years Manager of Production of the former Engineering Products department. From 1947 to 1953, he was General Plant Manager of the Department, and earlier he had engaged in component manufacturing and quality control activities of RCA. He served in the United States Air Force from 1930 to 1933.

T. A. Smith

A. L. Malcarney

ROYS HEADS RECORD ENGINEERING

H. E. Roys, formerly Manager of Optical and Recording Systems Development, General Engineering Development, DEP, has been appointed Manager, Engineering, RCA Victor Record Division.

Mr. Roys is an authority in the fields of audio, acoustics and recording and his work in these fields has brought him several awards, among these is an award by the National Association of Broadcasters for "Meritorious Service" for his work in the development of NAB recording and reproducing standards. In making this award, Mr. Roys was cited for the thoroughness of his efforts and for the high degree of perfection which the standards represent today.

Mr. Roys has been active in his participation in editorial activities of the RCA ENGINEER from its inception. He has helped generate several articles in the DEP area which have been later published in the magazine. Mr. Roys has recently been named a member of the Editorial Advisory Board of the RCA ENGINEER.

Mr. Roys received his BS Degree in EE from the University of Colorado. He joined RCA in 1930 and became associated with the phonograph section, and in 1937 became a member of the Advanced Development Group of the Photophone Section. From 1941 to 1946 he was located with this group in Indianapolis, working mainly on disk recording and reproducing problems. He returned to Camden in 1946 to General Engineering Development.

Mr. Roys is a member of Tau Beta Pi and Eta Kappa Nu. He is a Fellow of the Audio Engineering Society, the Acoustical Society of America, and the IRE.

—*S. D. Ransburg*

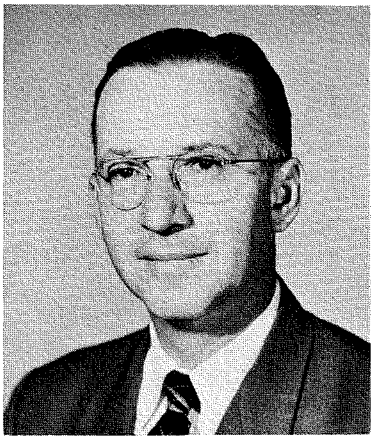
H. E. Roys

MAYER AND HOLTZ ARE APPOINTED TO MANAGEMENT POSTS IN RCA ASSOCIATED COMPANIES OVERSEAS . . . Management appointments at associated companies of the Radio Corporation of America in Great Britain and Switzerland were announced recently by A. F. Watters, Vice-President of RCA and Operations Manager, RCA International Division.

Effective July 1, C. G. Mayer became Chairman of the Board and Managing Director, RCA Great Britain, Ltd., Middlesex, England. R. F. Holtz has been appointed General Manager, Laboratories, RCA, Ltd., Zurich.

Mr. Mayer was formerly RCA International Division technical representative in Europe as well as Manager, Licensee Relations, for that area. Mr. Holtz was formerly responsible for new product development and engineering products administration as Manager, Engineering Products Development, RCA International Division, New York.

DALE NAMED CHIEF ENGINEER



B. V. DALE APPOINTED CHIEF ENGINEER COMPONENTS DIVISION . . . B. V. Dale was appointed Chief Engineer of the newly formed RCA Components Division on June 1, 1956.

Mr. Dale graduated from Drexel Institute of Technology with a BS Degree in EE in 1932. He came to RCA Victor the same year as a Test Maintenance man. In the following years he rose rapidly in the Field of Quality Control, becoming Superintendent of Quality Control in 1944. From 1945 to 1952 he held various managerial posts in Manufacturing Methods, Engineering Services, Transformer Development Engineering, Test Measurements Equipment Development, and Manager of Parts Engineering.

In 1953 Mr. Dale was made Manager, Engineering Section, Electronic Components Operating Division, Tube Department when this activity was transferred from RCA Victor Division, a post he has held until his present appointment.

SPITZER AND WOOD IN NEW POSITIONS

E. E. SPITZER TO MANAGE ENGINEERING AT MARION AND LANCASTER . . . Edward E. Spitzer, formerly Manager, Power Tube Engineering at Lancaster, has been named Manager, Engineering, at Marion and Lancaster, in a recent promotion announcement by the Tube Division.

Mr. Spitzer was graduated from the Massachusetts Institute of Technology in 1926 with a B. S. degree in electrical engineering. He obtained his Master's degree from M.I.T., in 1927.

He joined RCA in 1933 as Leader, Power Tube Development at Harrison. In 1943, he was assigned to the Lancaster plant as Manager, Power and Gas Tube Development, Engineering Section, and remained in that position until his appointment as Manager, Power Tube Engineering. Mr. Spitzer has contributed numerous articles to technical magazines and to the proceedings of professional societies. A Member of the Institute of Radio Engineers, he has acted as chairman of the local Lancaster sub-section of the I.R.E. At present he is secretary of the Joint Electron Tube Engineering Council (JETEC).

—*W. G. Fahnestock*

E. E. Spitzer

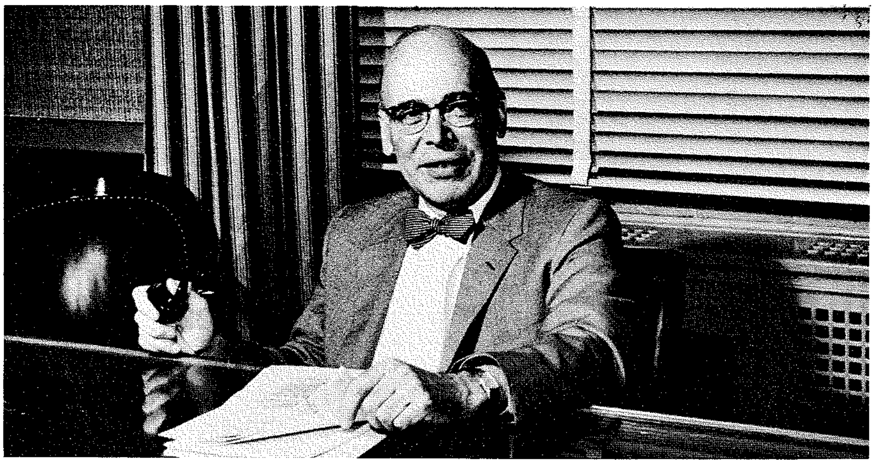
L. A. Wood

L. A. WOOD NAMED TO RCA STAFF POSITION . . . Starting July 1, 1956 Lawrence A. Wood was appointed Administrator, New Process Development Laboratory by Arnold K. Weber, Director of Manufacturing, RCA Staff. Mr. Wood received his B.S. in chemical engineering from Purdue University in 1936. From 1936 to 1943, he was employed by Reilly Tar and Chemical Corporation, Indianapolis, Indiana as a development engineer and Production Superintendent. He joined RCA Victor Record Division in 1943 as a development engineer on phonograph record compounds. In 1945, he was made Supervisor of the Plastics Group and since 1946 has served as Manager of Product Engineering. In 1956, he received the Award of Merit for outstanding work in guiding many new developments in phonograph record manufacturing.

In his new job, Mr. Wood will act as coordinator between various manufacturing divisions on new development of materials and manufacturing methods, particularly those associated with automation.

—*S. D. Ransburg*

JOHN B. COLEMAN ELECTED AIEE FELLOW



John B. Coleman, Administrative Engineer, Product Engineering, Radio Corporation of America, Camden, N. J., has been elected to the grade of Fellow in the AIEE " . . . for contributions to the development of radio transmitters and standards in the radio engineering field."

The award came as no great surprise to Mr. Coleman's many associates in the Corporation. His work in the fields noted in the award citation are reflected in the excellence of RCA's position in radio transmitters, and in the importance placed on Standards in RCA.

Mr. Coleman is currently active in scatter propagation problems, and in coordinating activities relative to transmitters and transmitting tubes, in addition to his direction of Corporate Standards activities.

Mr. Coleman received a BS degree in EE in 1923 from the Carnegie Institute of Technology. He then joined the Westinghouse Electric and Manufacturing Company in 1923. In 1924, as chief engineer, Station WBZ, Springfield and Boston, Mass., he developed one of the first crystal-controlled broadcast transmitters. He then served as radio engineer on transmitter development and design for Westinghouse, and as section engineer in charge of high-power transmitter development and design.

In 1930, he joined the RCA Victor Division of the Radio Corporation of America. He became Chief Engineer, Special Apparatus Division in 1939, and Assistant Director of Engineering for RCA Victor Division in 1945. Mr. Coleman has been in his present position as Administrative Engineer, Product Engineering, RCA, since 1955.

Since 1930, Mr. Coleman has been active in the Radio-Electronics-Television Manufacturers Association. At present he is chairman of the Technical Products Panel and responsible for the work of ten main committees. He is a Fellow of the IRE, and a member of the American Society of Naval Engineers and the Franklin Institute.

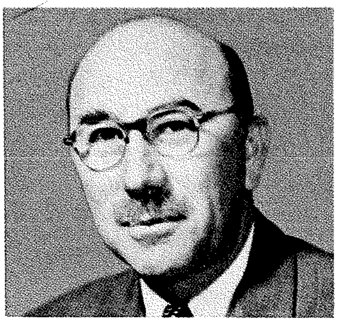
Mr. Coleman was a member of the U. S. Delegation at meetings of Comite Consultative International Radio (CCIR) in Stockholm, Sweden, 1948; Geneva, Switzerland, 1951; and London, England, 1953, and was Chairman U. S. Delegation to meeting of CCIR Study Group I on Transmitters at Brussels, Belgium, 1955.

He has served on the following AIEE Committees: Communications (1937-49); Air Transportation (1945-48); Television Broadcasting Systems (chairman, 1949-50); Television and Aural Broadcasting Systems (1950-56, chairman 1950-52); Technical Program (1949-50); Standards (1949-50); Award of Institute Prizes (1952-53); Special Communications Applications (1953-56); and Technical Operations (1954-56).

Mr. Coleman has been active on the following IRE Committees: Broadcast Communications (1933-34); Constitution and Laws (1952-55); Membership (1949-51). He was Chairman of the Philadelphia Section, 1942-43, and a member of the IRE Board of Directors 1948-49. He is a member of the Tau Beta Pi and Eta Kappa Nu.

As we go to press, Mr. Coleman is in Warsaw, Poland as a Member of the United States Delegation to the Eighth Plenary Assembly of the CCIR.

WEGE NAMED MGR., MISSILE AND SURFACE RADAR DEPT.



Appointment of Harry R. Wege as Manager, RCA Missile and Surface Radar Department, was announced by Theodore A. Smith, Executive Vice President, Defense Electronic Products.

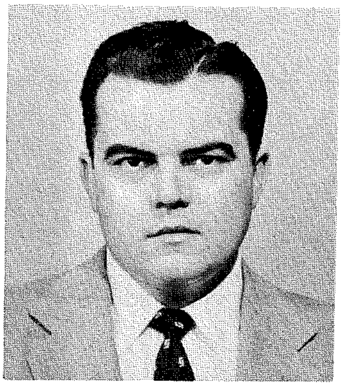
Mr. Wege has been Operations Manager of the department since its establishment last November to coordinate engineering, design, production, and marketing activities for RCA Electronic Surface Radar equipment, missile launching systems, and surface display and information handling systems for military use. The Department has its headquarters at Moorestown. See *Engineering News and Highlights* Vol. 1, No. 5 for Mr. Wege's biography.

DR. JANES HONORED AT LANCASTER

Shown at testimonial for Dr. Janes are (left to right) H. R. Seelen, Manager, Color Kinescope Operations; Mrs. Janes; Dr. Janes; F. S. Veith, Manager, Camera, Oscillograph and Storage Tube Development; and D. D. Van Ormer, Manager, Color Kinescope Development.

Approximately one hundred people attended a testimonial dinner on May 14, 1956, at the Log Cabin honoring Dr. R. B. Janes, fomerly Manager, Color Kinescope Design, Lancaster. The occasion marked Dr. Janes' transfer to the Semiconductor Engineering group at Harrison as Manager of the Design activity. Many valued gifts, as well as humorous offerings, were tendered as mementos of the occasion. (See Volume 1, Number 1, page 61, for biography.) *—D. G. Garvin*

NEW EDITORIAL REPRESENTATIVE APPOINTED



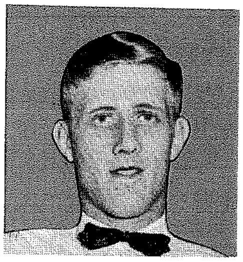
W. G. Fahnestock

W. G. Fahnestock, Cathode Ray and Power Tube Engineering, Tube Division, Lancaster, has replaced C. C. Simeral as Editorial Representative for the RCA ENGINEER for that activity. Mr. Simeral has transferred to Microwave Tube Engineering, Harrison.

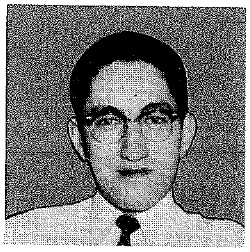
W. G. Fahnestock graduated in 1947 from Franklin & Marshall College with a B. S. degree in Physics. Prior to his graduation and while on Military duty with the U. S. Air Force, he completed special courses in Meteorology at Haverford College, Communication Systems at Yale, Electronics Principles and Radar Systems at Harvard and MIT respectively. He served as an Electronics Officer in the U. S. Air Force until early in 1946.

Mr. Fahnestock joined the Tube Division in Lancaster in February 1947 as an engineer in the Life Test and Data Activity. In January 1954 he was appointed Manager of this Activity and served in this capacity until May 1946. His present position is that of Manager, Cathode Ray & Power Tube Engineering Administration.

ASSISTANT EDITORIAL REPRESENTATIVES APPOINTED: Because of the recent transfer of Paul J. Burns and Morris N. Slater, two assistant editorial representatives have been appointed by Jan de Graad for the Marion location.



W. L. Ball



T. E. Sisneros

Wesley L. Ball covering Manufacturing Engineering, received a bachelor's degree in Electrical Engineering from Clarkson College of Technology in 1950. After graduation, he became associated with the Sylvania Cathode Ray Tube Plant at Seneca Falls, New York. A year later he entered the Army Corps of Engineers. After two years Mr. Ball joined RCA as a manufacturing engineer on metal cathode ray tubes.

Tom E. Sisneros covering Development Engineering, graduated from the University of New Mexico in 1952 with a BS degree in Chemical Engineering. He joined RCA as a specialized trainee, and was assigned to the Marion Plant. Mr. Sisneros is a member of Advanced Development and is presently working on phosphors. He is a member of the A.I.C.H.E. and Sigma Tau.

COMMITTEE APPOINTMENTS

W. H. Robinson, Tube Division, has been elected vice chairman of the Professional Group on Broadcast and Television Receivers of the Los Angeles Section of the IRE. *—F. R. Arams*

Donald C. Fontaine, DEP Airborne Fire Control Engineering, Camden, has been elected to Dist. of Columbia, Alpha Chapter of Tau Beta Pi, newly installed chapter at Howard Univ., Washington, D. C. *—T. P. Canavan*

Edward Stanko, Manager, Engineering Operations, RCA Service Company, Cherry Hill, has been appointed Membership Committee-man for the Society of Motion Picture and Television Engineers.

S. Kaplan, Research Mathematician, BIZMAC Engineering, CEP, was elected Chairman, Delaware Valley Section, Society for Industrial and Applied Mathematics on May 22, 1956.

This section comprises Delaware, Eastern Pennsylvania, Central and Southern New Jersey. *—W. K. Halstead*

B. F. Wheeler, Communications Engineering, CEP, Camden, has been appointed a member of the Papers and Meeting Committee of the Philadelphia Section, AIEE.

James Beuoy, Parts Manufacturing, Marion Plant, has been appointed Chairman of Public Relations for the Muncie chapter of A.S.T.E. In the past he served as Chairman of the Education and Professional Engineering Committee. *—J. de Graad*

DEP Engineering Standards and Services

H. S. Dordick, of DEP Component Design, has recently been appointed Chairman of RETMA Engineering Division, A-5 Committee on Testing and Product Control. This committee is working in the field of process standards for automation. He is also serving as Chairman of the Membership and Attendance committee in the Science and Electronics Technical Division of the AIEE, Philadelphia Section. Mr. E. J. Sager, also of DEP Component Design, is likewise a member of the latter committee.

G. H. Williams, of DEP Component Design, has been designated chairman of the Membership Committee of the Communications Technical Division of the Philadelphia Section of the AIEE.

Mr. R. W. D'Andrea, packing designer in DEP Standards Engineering has completed a two week intensive course in military packaging at the Rossford Ordnance Depot at Toledo, Ohio.

Mr. V. R. Monshaw of DEP Standards Engineering has recently been appointed to the RETMA Engineering Department SQ-7 Committee on Special Quality Capacitors.

Mr. J. R. Breen of DEP Standards Engineering is a member of a task force the RETMA Engineering Department SQ-14.1 committee on I.E.C. Matters. The Task Force on Mechanical Robustness of Terminations is developing specifications for improved mechanical design of terminals and terminations. *—H. E. Coston*

ENGINEERING DEGREES AWARDED

Semiconductor Division

The following engineers in the Semiconductor Division received College degrees this June.

Gerald A. Sullivan (Standards) MS in Physics from Boston College (Day School).

Anthony P. Peldunas (Test Engineering) MSEE in Electrical Engineering from Newark College of Engineering (Evening Sessions).

Marvin D. Berkowitz (Test Engineering) MSEE in Electrical Engineering from Newark College of Engineering (Evening Sessions).

Robert Minton (Applications Laboratory) MSEE in Electrical Engineering from Stevens Institute of Technology (Evening Sessions).

Charles R. Eshelman (Applications Laboratory) MSEE in Electrical Engineering from Stevens Institute of Technology (Evening Sessions).

Robert E. Blake (Applications Laboratory) MSEE in Electrical Engineering from Newark College of Engineering (Evening Sessions).

William R. Davies (Applications Laboratory) MSEE in Electrical Engineering from Newark College of Engineering (Evening Sessions).

John Rivera (Production Engineering) MS in Industrial Management from Stevens Institute of Technology (Evening Sessions).

Israel H. Kalish (Design) MSEE in Electrical Engineering from Columbia University (Evening Sessions).

Henry D. Harmon (Design) MSEE in Electrical Engineering from Stevens Institute of Technology (Evening Sessions).

—R. E. Rist

Commercial Electronic Products

Daniel Hochman, Communication Engineering, CEP, was awarded the degree of MS in EE at the University of Pennsylvania on June 13, 1956. *—B. F. Wheeler*

DEP Standards Engineers

A. V. Balchaitis of DEP Standards Engineering this month received his BSEE degree from Drexel Institute of Technology.

I. K. Munson, Manager of DEP Standards Engineering has recently been awarded his MSEE degree by Drexel Institute of Technology.

James Tabur, DEP Standards Engineering has recently completed a short course in "Dynamic Measurements" at M.I.T.

—H. E. Coston

Tube Division

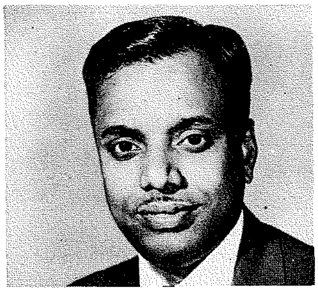
Miss Rosaline Pekarowitz, Microwave Tube Engineering, Harrison, received a Master of Science degree in mathematics from the Stevens Institute of Technology on June 9, 1956. *—F. R. Arams*

DEP TECHNICIAN WINS DEGREE
LaSalle Honors Wife

John J. Ervin, Jr., formerly a technician at the Moorestown plant, DEP, was promoted to engineer June 1, 1956 as a result of his being awarded a B.S. degree in Physics-Electronics by LaSalle College.

Mr. Ervin, father of seven girls under twelve, received his degree with high honors after five years of evening classes. LaSalle College could not let this singular accomplishment go by without awarding Mrs. Ervin a special degree of PhT—"Putting Hubby Through," at special exercises at the College. Perseverance? They're talking now of a Master's Degree!

—J. A. Bauer



Dr. R. N. Ghose

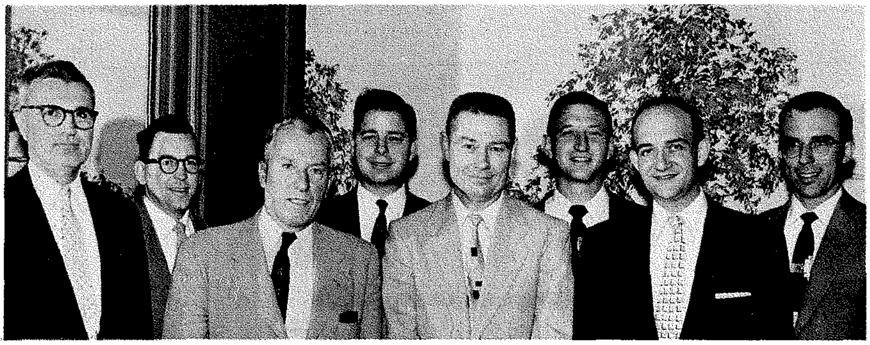
Dr. R. N. Ghose, Broadcast Transmitter Engineering, CEP, was recently awarded the Professional Degree of Electrical Engineer from the University of Illinois, while at the same time completing the requirements for a PhD degree in mathematics at the same university. Because of a rule of the university, regarding the awarding of two degrees in one year, Dr. Ghose will have to wait until next year to learn the outcome on his PhD.

Although only thirty years of age, Dr. Ghose deserves special recognition for his academic achievements. A native of Howrah, India, he received the degree of Bachelor of Electrical Engineering in 1946 from the College of Engineering and Technology, Bengal, with first class honors, standing first in order of merit. In 1947 he entered the Indian Institute of Science, Bangalore and received the post-graduate Diploma of the Institute in 1948. From 1946 to 1949, he served the college of Engineering and Technology, Bengal as an Instructor of Electrical Engineering. He entered the Corps of Signals, India and held the position of the Technical Maintenance Officer and Chief Technical Instructor for the H.Q. Western Command Signal Regiment until 1951 when he entered the University of Washington, Seattle. He received the degree of M.S. in E.E. from the University of Washington in 1952, and the degrees of M.A. in Mathematics, and PhD in Electrical Engineering from the University of Illinois in June 1954. He held the position of Research Fellowship and Research Assistanship sponsored by the National Bureau of Standards, and the Engineering Experiment Stations of the University of Washington and the University of Illinois. Since May 1954, he has been employed as a member of the Technical Staff of the Radio Corporation of America.

He is a senior member of Institute of Radio Engineers and an Associate Member of the Institute of Electrical Engineers, London. He is also a member of Sigma Xi, Eta Kappa Nu and Pi Mu Epsilon.

—C. D. Kentner

DINNER IS HELD HONORING FIVE RCA ENGINEERS WHO RECEIVED MASTERS' DEGREES FROM FRANKLIN AND MARSHALL COLLEGE



Pictured at the dinner honoring five tube engineers—left to right; D. F. Schmit, Vice President, Product Engineering, RCA; L. E. Siepietowski; H. R. Seelen, Manager, Color Kinescope Operations; J. L. Hudson; R. Saunders; C. P. Smith, Manager, Color Kinescope Engineering; L. P. Fox; and D. J. Ransom, Manager, Color Applications Engineering Laboratory.

A dinner was given at the Yorktown Hotel, York, Pennsylvania, on June 28, 1956, to honor five RCA engineers who recently received degrees of Master of Science in Physics. The guests of honor were: Leonard P. Fox, Chemical and Physical Laboratory; John L. Hudson, Color Kinescope Design Engineering; Donald J. Ransom, Color Kinescope Applications Engineering; Lawrence E. Siepietowski, Equipment Development Engineering, all of whom are located at the Lancaster Plant; and Romaine Saunders, Jr., who is now employed at the Marion Plant in B. & W. Kinescope Application Engineering. (see photograph) Each of the degree recipients was accompanied by his wife.

C. P. Smith, Manager of Color Kinescope Engineering, was master of ceremonies at the informal gathering. Following dinner, he introduced H. R. Seelen, Manager of Color Kinescope Operations, who presented each man with a gold and onyx desk pen and stand as a memento of the occasion.

D. F. Schmit, Vice President, Product Engineering, closed the evening and spoke briefly concerning the growth of RCA engineering, its accomplishments during recent years, and the challenges of the future. It is a "first" in the annals of scholastic achievement at RCA Lancaster to have five of our people receive master's degrees at the same time. Other Lancaster employees who achieved the same goal in previous years are H. A. Wittenberg, 1949; A. A. Rotow, 1951; J. A. Markoski, 1952; G. E. Crosby, 1953; H. F. Kazanowski, 1954; J. L. Weaver, 1955.

These men have all availed themselves of the opportunity for graduate work at Franklin and Marshall College under the Training Section's Tuition Loan and Refund program. They are to be congratulated upon their perseverance in pursuing a program which necessitated several years of concentrated study and effort before the coveted Master of Science degree could be attained.

—D. G. Garvin

MEETINGS, COURSES AND SEMINARS

Microwave Tubes

E. W. Kinaman and R. W. Kissinger, Microwave Tube Engineering, Harrison, are conducting a lecture series for microwave tube technicians. The lectures are given by engineers within the Microwave Tube Engineering activity who have become specialists in the various important aspects of Microwave Tube Fabrication.
—*F. R. Arams*

Boundary Value Problems in Microwave

The educational program of the Microwave Tube Engineering activity in Harrison is presenting a course given by D. J. Blattner on Boundary Value Problems in Microwave. The purpose of these lectures is to familiarize engineers with solutions of the Laplace and Wave Equations and their applications to microwave tube and circuit problems. —*F. R. Arams*

Reliable Tube Applications

David C. Ballard, design engineer, Marion, attended a symposium on "Reliable Applications of Electron Tubes" which was sponsored by the Engineering Department of RETMA, held at the University of Pennsylvania on May 21 and 22.
—*J. de Graad*

Operations Research

William Hartzell, Manager, Life Test and Applications, Marion, attended a short course in Operations Research at Case Institute of Technology on June 4-15.
—*J. de Graad*

Automation

Jack Stewart, Manager, Equipment Engineering, and Philip Wolverton, Manager, Methods Engineering attended a seminar on Automation. The course was conducted at Pennsylvania State University from June 10 to 15. —*J. de Graad*

ENGINEERS COMPLETE FIRST YEAR OF SYSTEMS ENGINEERING COURSE

Missile & Surface Radar, DEP.

C. M. Brundley
A. D. Davies
K. Fischbeck
J. Jarem
J. D. Sable

BIZMAC Engineering, CEP.

H. S. Dordick
L. A. Fernandas-Rivas
F. R. Tanco
R. Sinn

General Engineering Development, DEP.

E. Moore
J. E. Robinson

Airborne Fire Control Eng., DEP.

N. R. Hill

The Systems Engineering course, given by University of Pennsylvania's Moore School of Electrical Engineering, is in its second round with the twelve engineers mentioned above attending from RCA. Twelve other RCA engineers successfully completed the course in June 1955. The present group will complete the course in June of 1957 and will be eligible for Master of Science Degrees in Systems Engineering. The course is geared for the complex requirements of the expanding military and civilian developments in electronics and related sciences. It was developed three years ago by educators at the University working with management and engineering officials of RCA in Camden and Princeton. The students study new approaches to complicated problems involved in the application of advanced principles of research, both from a technical and an operations standpoint.

Engineers currently attending were selected from a large group of applicants within Defense and Commercial Electronic Products. Applicants are selected by a special committee consisting of N. I. Korman, Dr. D. G. C. Luck, J. N. Marshall, Dr. E. M. Pritchard, Dr. H. J. Woll and W. H. Parry. The students attend classes two days a week and continue their regular responsibilities with RCA on the other three.

Both RCA and the University plan to continue the program in 1957, with a new group of engineers.—*H. E. Coston*

STUDENT ENGINEERS VISIT CAMDEN . . . On June 7, 1956, fifty-seven junior mechanical engineering students from Penn State University visited the Camden Engineering facilities for a tour. They were shown many of the current mechanical engineering projects in both C.E.P. and D.E.P. Members of engineering management planned and conducted the tour in conjunction with RCA Staff College Relations.—*H. Polish*

MOORESTOWN ENGINEERS ATTEND M.I.T. SUMMER PROGRAM . . . The following DEP engineers from the Moorestown plant Missile and Surface Radar Engineering have attended Special Summer Programs at M.I.T. in order to return with the latest and most advanced engineering thinking in their fields.

W. A. Curtin, Control Systems Engineering, started July 30 for two weeks; E. Gaynor, Switching Circuits, June 18 for two weeks; R. K. Gray, Analog to Digital Conversion Techniques, August 13 for one week; M. E. Hawley, Operations Research, started June 25 for two weeks; S. Rich, Recent Developments in Fluid Power Control, July 9 for two weeks; J. A. Sobel, III, Vibration, Shock and Noise, June 18 for two weeks; M. Goldman, Analog-Digital Conversion Techniques, August 18 for one week; G. K. Oister, Modern Communications, August 20 for two weeks, and Dr. G. G. Murray, Switching Circuits, June 18 for two weeks.—*J. A. Bauer*

KRAGER RECEIVES STOLLER AWARD . . . Mr. Joseph L. Krager, Manager Packing Design, DEP Standards Engineering was the recipient of the Stoller Award at the national convention of the Society of Industrial Packaging and Materials Handling Engineers. The award was conferred for the packing of Broadcast Equipment Coaxial Transmission Line which featured Tri-Wall corrugated containers. This is the second time the Stoller Award and Best-in-the-show awards have been won by members of this group, Ralph E. Hawes having been the recipient in 1952.—*H. E. Coston*

LEVY AWARDED GENERAL SARNOFF FELLOWSHIP

Leon Levy—Computer Systems Engineering, BIZMAC Engineering, CEP, was granted the General Sarnoff Fellowship, the only one awarded in CEP. He will attend Harvard to continue work toward his doctorate degree. —*W. K. Halstead*

M. C. KIDD WINS PHOTOGRAPHY MEDAL

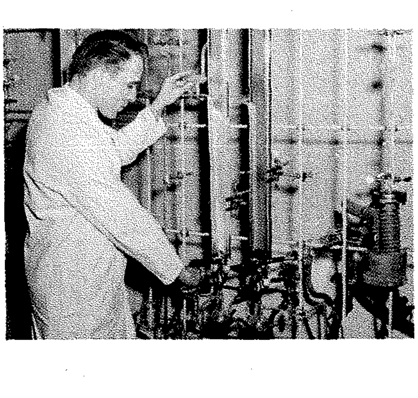
Marshall C. Kidd, Advanced Development Engineering, RCA Victor Television Division, Cherry Hill, has been awarded a bronze medal for the best photograph of the year, Class B competition, by the Miniature Camera Club of Philadelphia. The club, consisting of approximately 100 members, annually awards a bronze medal for the best photograph submitted by a member who has not entered international competition.—*R. W. Sonnenfeldt*

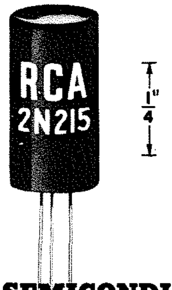
RCA WEATHER RADAR SYSTEM FEATURED AT WEATHER BUREAU SHOW . . . A weather-detection radar system (RCA AVQ-10) which enables pilots to "see" storms and cloud formations up to 150 miles ahead was exhibited June 6, 1956 by RCA at the opening of the U. S. Weather Bureau Show, in the Chamber of Commerce Building, Washington, D. C.

The show, which features weather-detection equipment and techniques of the U. S. Weather Bureau and of industry, continued through June 30 and attracted approximately 100,000 visitors.

The RCA exhibit features a model of the nose and cockpit of an aircraft, with the antenna of the weather radar system installed in the nose, and a radarscope, with storm picture, mounted in the cockpit. The exhibit enables visitors to observe how the antenna picks up storm formations ahead to provide the pilot with early storm warning. *See article by A. W. Vose, this issue.*

MARION PHOSPHOR LAB ADDS NEW EQUIPMENT . . . A BET (Brunaur-Emmett-Teller, originating scientists) system for measuring surface area of solids by nitrogen adsorption has been built and is now in operation in the Phosphor Laboratory of Advanced Development, Marion. The photograph shows the system and Doctor John F. Kircher, who supervised the installation. Advanced Development is using this method to determine the surface area of phosphor particles in order to correlate performance characteristics with light output and adherence to the glass face plate.
—*J. deGraad*





NEW RCA SEMICONDUCTOR AND TUBE TYPES

RCA-2N215, 2N217, 2N218, 2N219 and **2N220** are germanium p-n-p junction transistors utilizing flexible leads which may be soldered or welded into the associated circuit. They are equivalent to the following linotetrar types: 2N215=2N104; 2N217=2N109; 2N218=2N139; 2N219=2N140 and 2N220=2N175.

RCA-21AXP22-A is a new color picture tube of the metal shell type and is capable of producing either a full-color or black-and-white picture measuring 19-1/16" x 15-1/4" with rounded sides. This new type is unilaterally interchangeable with the 21AXP22 and supersedes it.

RCA-21AXP22-A has the unique feature of an internal neck coating having high resistance which eliminates the need for an external resistor between the ultor power supply and the tube. The resistance of the neck coating also permits use of a tube insulating boot having an external conductive coating which with the metal envelope of the tube forms a supplementary filter capacitor.

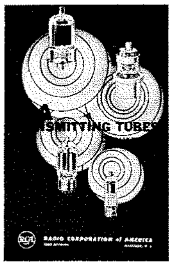
RCA-5AHP7 and **-5AHP7-A** are 5-inch magnetic-deflection oscillograph tubes featuring low-voltage electrostatic focus and a long persistence characteristic. The 5AHP7-A differs from the 5AHP7 only in that it has an aluminized screen to give increased brightness and improved image contrast. These tubes are intended particularly for pulse-modulated applications, such as radar indicator service, but are also useful in general oscillographic applications where a temporary record of electrical phenomena is desired.

The low-voltage electrostatic-focus gun featured in the 5AHP7 and 5AHP7-A facilitates use of these types in lightweight equipment; assures good uniformity of focus over the entire screen, and permits focus to be maintained automatically with variation of line voltage and over a wide range of adjustment of image brightness.

Other features of the 5AHP7 and 5AHP7-A include a deflection angle of 53°, a maximum overall length of 11-3/8", and a minimum useful screen diameter of 4-1/4".

ENGINEERING DATA AND CATALOGUES

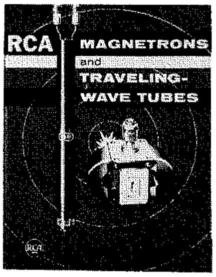
RCA TRANSMITTING TUBES, TECHNICAL MANUAL TT-4



The new manual RCA TRANSMITTING TUBES is a comprehensive and authoritative book containing technical data on 112 types of power tubes having plate-input ratings up to four kilowatts and on 13 types of associated rectifier tubes. Maximum ratings, operating values, characteristics curves outline drawings, and socket-connection diagrams are given.

Covering basic theory of power tubes and their application in an easy-to-understand style, RCA TRANSMITTING TUBES contains information on generic tube types; tube parts and materials; tube installation and application; rectifier circuits and filters, interpretation of tube data; and the step-by-step design of af power amplifiers and modulators, rf power amplifiers, frequency multipliers, and oscillators. Simple calculations are given for determining operating conditions for Class C Telegraphy Service, Plate-Modulated Class C Telephony Service, Frequency Multipliers, and Class AB and Class B af amplifiers.

RCA MAGNETRONS AND TRAVELING-WAVE TUBES



This publication has been prepared to assist those who work with microwave tubes and circuits. It includes information on the operational theory of magnetrons and traveling-wave tubes, their operating considerations and applications, and techniques for measurement of their important electrical parameters.

RCA APPLICATION NOTES

RCA Application Note

AN-164

Conversion Factors
for
Tube Characteristics

This Note describes a method for determining the approximate characteristics of an electron tube when all the electrode voltages are changed in the same proportion from the published or measured values. Conversion factors for the principal characteristics are given in a nomograph which is easy to use and provides direct reading. Although these conversion factors have been available in curve form for some time, the nomograph is more convenient to use than the log-log curves.

The conversion factors obtained from the nomograph are applicable to triodes, tetrodes, pentodes, and beam power tubes when the plate voltage, grid-No.1 voltage, and grid-No.2 voltage are changed simultaneously by the same factor. They may be used for any class of tube operation (class A, AB_1, AB_2, B, or C).

CONVERSION FACTOR NOMOGRAPH

AN-164 *Conversion Factors for Tube Characteristics*—This note describes a method for determining the approximate characteristics of an electron tube when all the electrode voltages are changed in the same proportion from the published or measured values. Conversion factors for the principal characteristics are given in a nomograph which is easy to use and provides direct reading. Although these conversion factors have been available in curve form for some time, the nomograph is more convenient to use than the log-log curves.

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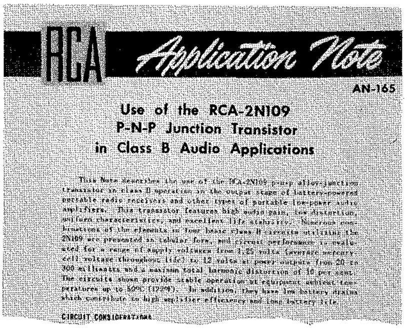


RCA Application Note

AN-165

Use of the RCA-2N109
P-N-P Junction Transistor
in Class B Audio Applications

CIRCUIT CONSIDERATIONS

AN-165 *Use of the RCA-2N109 P-N-P Junction Transistor in Class B Audio Applications*—This note describes the use of the RCA-2N109 p-n-p alloy-junction transistor in Class B operation in the output stage of battery-powered portable radio receivers and other types of portable low-power audio amplifiers. This transistor features high audio gain, low distortion, uniform characteristics, and excellent life stability. Numerous combinations of the elements in four basic Class B circuits utilizing the 2N109 are presented in tabular form, and circuit performance is evaluated for a range of supply voltages from 1.25 volts (average mercury-cell voltage throughout life) to 12 volts at power outputs from 20 to 300 milliwatts and a maximum total harmonic distortion of 10 percent. The circuits shown provide stable operation at equipment ambient temperatures up to 50°C (122°F). In addition, they have low battery drains which contribute to high amplifier efficiency and long battery life.

REGISTERED PROFESSIONAL ENGINEERS

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

Tube Division, Lancaster

Name	*RCA Section*	*State*	*Licensed As*	*License No.*
A. C. Grimm	990	Penna.	Elec. Eng.	12399

RCA Communications, Inc.

Name	*State*	*Licensed As*	*License No.*
W. Lyons	N.Y.	Prof. Eng.	25871
J. L. Finch	N.Y.	Prof. Eng.	25864
J. B. Moore	N.Y.	Prof. Eng.	20360
C. G. Dietsch	N.Y.	Prof. Eng.	14233
J. M. Walsh	N.Y.	Prof. Eng.	24590
E. D. Becken	N.Y.	Prof. Eng.	21033

NEW RCA PRODUCTS ANNOUNCED

COMPONENTS DIVISION INTRODUCES THREE NEW RADIO AND TV TEST INSTRUMENTS

Introduction of three new instruments especially designed for use in installing and servicing television receivers has been recently announced by the RCA Components Division.

RCA WA-44B Audio Signal Generator is designed for general audio and radio work, and other applications which require a sinusoidal audio-frequency voltage up to 15 volts rms. Having a range of 11 cps, to 100 kc, it is adaptable to a wide variety of applications including the measurement of frequency response characteristics of audio amplifiers and the testing of loudspeakers and enclosures.

RCA WR-46A Video Dot/Crosshatch Generator is designed for checking convergence in color TV sets, as well as deflection linearity in black and white sets. The WR-46A produces a stable dot, bar or crosshatch pattern with high-level output sufficient to drive the picture tube directly.

RCA WR70A RF/IF/VF Marker Adder is designed for r-f, i-f and video sweep-frequency alignment of both black and white and color TV receivers. The WR-70A provides a choice of four sharp, narrow differently shaped markers for TV receiver alignment. The new instrument is designed to be used with existing TV marker generators, such as the WR-39 and WR-89 series, and with sweep generators of the WR-59 series.

NEW LOUDSPEAKER AND AMPLIFIER FOR HOME-ASSEMBLED HI-FI MUSIC SYSTEMS . . . The Theatre and Sound Products Department, CEP, has announced two new hi-fi electronic components for home-assembled music systems—a 12-inch dual loudspeaker with a frequency response of 40 to 18,000 cycles, and a 10-watt amplifier unit which incorporates pre-amplifier and input selector.

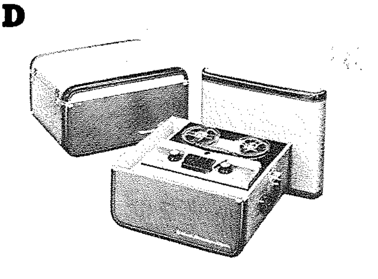
The new components are electrically matched and complete with fittings for direct plug-in use with associated RCA hi-fi sound units.

The 12-inch hi-fi loudspeaker (Type SL-123) features a smooth frequency response over the range of 40 to 18,000 cycles, a power handling capacity of 15 watts, and high reproduction fidelity.

The 10-watt hi-fi amplifier (SVP-10-A) has been designed to meet a need for a single compact chassis which incorporates input selector, pre-amplifier, and power amplifier functions.

RCA NOW USING 750-MESH SCREEN IN TV CAMERA TUBES . . . Two improved image orthicon television camera tubes—the RCA 5820 for black-and-white, and the RCA 6474 for three-tube color cameras—are now being quantity-produced by RCA for the broadcasting industry with Micro-Mesh, a 750-mesh screen, replacing the 500-mesh screen heretofore standard in both tube types. The 750 mesh eliminates all traces of bothersome moire patterns. Although mesh up to 1000 lines per inch has been produced by RCA, requirements of the present 525-line television system are exceeded with camera tubes employing the new 750 mesh. Laboratory and field tests have shown that mesh of 750 lines per inch is more than adequate. See article in Vol. 2, No. 1, *A Ruling Engine for Glass Mesh Masters* by J. D. Herrington.

FIRST STEREO-TAPE PLAYERS UNDER $300 . . . RCA has announced a Stereophonic high fidelity tape player priced under $300 —less than half the price of similar equipment now on the market.



A portable unit (Model 8STP1) will be nationally advertised at $295 while a consolette (Model 8STP2) will be nationally advertised at $350. Both will be complete Stereophonic high fidelity sound systems with two amplifiers, two speaker systems, a Stereo-tape player and 30 feet of cable.

The Stereo-tape transport system may also be attached to three of RCA Victor's New Orthophonic high fidelity instruments. It will be nationally advertised separately at $275. In styling the consolette complements RCA Victor's new high fidelity series. *See article on High Fidelity this issue by R. S. Fine.*

ENGINEERING MEETINGS AND CONVENTIONS

August-October, 1956

AUGUST 20-21
IRE, AIEE, IAS, ISA National Telemetering Conference, Biltmore Hotel, Los Angeles, Calif.

AUGUST 21-24
IRE-West Coast Electronic Manufacturers' Associations, WESCON, Pan Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

AUGUST 24-26
IRE Annual Summer Seminar, Emporium Sect., Emporium, Pa.

SEPTEMBER 10-12
Information Theory Symposium, IRE, MIT, Cambridge, Mass.

SEPTEMBER 11-12
Second RETMA Conference on Reliable Electrical Connections, U. of Pa., Philadelphia, Pa.

SEPTEMBER 14-15
IRE PGBTS Fall Symposium, Pittsburgh, Pa.

SEPTEMBER 17-21
ISA Instrument-Automation Conf. & Exhibit, Coliseum, N. Y. C.

SEPTEMBER 17-21
Symposium on radiation effects on materials, sponsored jointly by the Atomic Industrial Forum and ASTM; at ASTM Pacific Area National Meeting, Los Angeles, Calif.

SEPTEMBER 24-25
Industrial Electronics Symposium, Manger Hotel, Cleveland, Ohio.

SEPTEMBER 26-30
New York High Fidelity Show, New York Trade Show Building, New York

OCTOBER 1-3
12th Annual Conference of the NEC Hotel Sherman, Chicago, Ill.

OCTOBER 1-4
Semiconductor Symposium, Electrochemical Society, Statler Hotel, Cleveland, Ohio.

OCTOBER 8-9
IRE Second Annual Symposium on Aeronautical Communications, Hotel Utica, Utica, N. Y.

OCTOBER 9-10
Conference on Computer Applications, sponsored by Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill.

OCTOBER 10-12
Symposium on Applications of Optical Principles to Microwaves, IRE, George Washington University, Washington, D. C.

OCTOBER 15-17
IRE-RETMA Radio Fall Meeting, Hotel Syracuse, Syracuse, N. Y.

OCTOBER 16-18
IRE-AIEE-APS-AIMME Conference on Magnetism & Magnetic Materials, Hotel Statler, Boston, Mass.

OCTOBER 25-26
Second Annual Technical Meeting of the IRE Professional Group on Electronic Devices, Shoreham Hotel, Washington, D. C.

OCTOBER 29-30
IRE East Coast Conference on Aeronautical & Navigational Electronics, Fifth Regiment Armory, Baltimore, Md.

OCTOBER 31-NOVEMBER 2
20th Anniversary National Time and Motion Study and Management Clinic, sponsored by the IMS, Sherman Hotel, Chicago, Ill.

RCA ENGINEER EDITORIAL REPRESENTATIVES

DEFENSE & COMMERCIAL ELECTRONIC PRODUCTS

P. J. HERBST, *Chairman, Editorial Board*

Editorial Representatives, Defense Electronic Products

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DR. D. C. BEAUMARIAGE, *Airborne Systems, Moorestown, N. J.*

MARY BOCCIARELLI, *Assistant Engineering Editor, Camden, N. J.*

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

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

H. E. COSTON, *Engineering Standards and Services, Camden, N. J.*

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

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

H. POLISH, *Camden Engineering Personnel, Camden, N. J.*

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

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