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VOL. 2, NO. 3 · OCT-NOV., 1956

RCA ENGINEER

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

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.

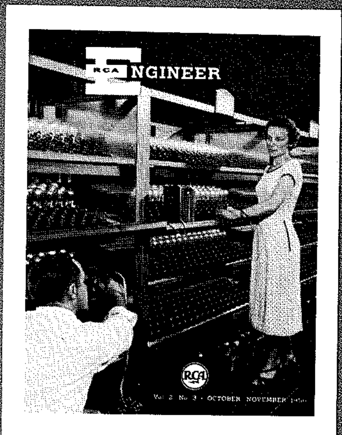
To serve as a medium of interchange of technical information between various engineering groups at RCA.

To create a community of engineering interest with 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

Manufacturing engineering at the Woodbridge (N. J.) Tube Plant is the subject of our cover this issue. Manufacturing Engineer Bernadine Biaza is shown checking the supply voltage on the stabilizing rack for type 5651 voltage reference tube, while Manufacturing Engineer Frank Juarez checks the panel for socket continuity. See article "Manufacturing Engineering in the Woodbridge Plant", by H. R. Snow in this issue.

PROOF OF PERFORMANCE

The goals of today's electronics engineer are: (1) to develop products which meet a vital need of the intended customer, and (2) to design products which can be manufactured and merchandised at a price the customer will want to pay.

To accomplish these objectives in a pattern that conforms with the fast tempo of modern technical activity is challenging—to say the least. Why is this so? The reason is that there is always danger of inadvertently putting the "proof of engineering performance" to one side in favor of the pressures of deadlines. The engineering tests are the most important part of the deadline requirement—because they are necessary to confirm that the product *can be manufactured and will perform as intended* in the hands of the ultimate user.

The "proving-in" process requires that the engineer have an intimate knowledge of the conditions imposed on the product by the user. A stringent testing program, including simulation of extreme operating and environmental conditions may be necessary. Frequently, the method of proof must be as ingenious as the idea itself. Before completion, it may involve factors of temperature, humidity, windload, altitude, shock, over-load and vibration. Regardless of how new or ingenious the idea may seem at the moment, the engineering proof is a "must". Inadequate proof or omission of any of these steps could result in either poor quality or delays that might ultimately jeopardize an entire product program.

Only by satisfying all the exacting performance requirements, can the product design always be at a high competitive level. It is our assurance of maintaining RCA's high standards of quality. Only in this way can we safeguard RCA's position in electronics as leader!

Vice Presiden
Product Engineerin
Radio Corporation of Americ

OPPORTUNITIES FOR ADVANCEMENT OF ENGINEERS

By
M. C. BATSEL,
Chief Technical Administrator
Defense Electronic Products, Camden, N. J.

THE PROGRESS OF groups or individuals, with respect to job satisfaction and compensation in a corporation, is determined by the contributions they make to their company's financial success and contributions to the welfare of the community.

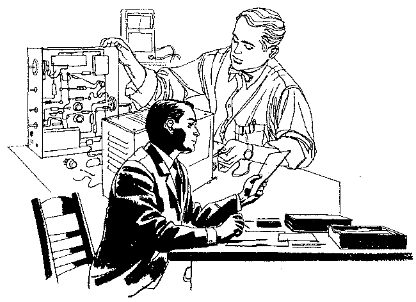
BROAD OBJECTIVES

Engineers, as well as all others, are employed to help the management accomplish its objectives. These objectives are finally defined as jobs to be done by the various groups or individuals. Each engineer is expected to do the job assigned to him in the best way, at the lowest cost, and in the shortest possible time. While management has obligations to the employees and to the community in which the company carries on its operation, it is also essential that the share holders receive an adequate return on their investment in the company. By making profit, the company is able to attract the capital needed to operate the business, otherwise there would be no jobs for engineers or others.

ENGINEERS ARE VITAL PART OF MANAGEMENT

Engineers play a vital part in the job of managing and operating the business so as to make a profit, because they plan the technical services and design the products sold to customers. For example, the customer's desire for RCA products is determined, to a large extent, by the excellence of the engineering design in terms of customer satisfaction and cost of the product.

The engineering management staffs (at all operating levels in a company) not only participate in planning overall programs; but they must be responsible for developing and designing the products. Whether or not individual engineers are qualified for general management work, there is great opportunity for their advancement in every phase of the business.



OPPORTUNITIES AND QUALIFICATIONS

In a specific field, the greatest opportunity for an engineer certainly lies in the area where he exhibits the greatest aptitudes and qualifications. Just as one engineer will find that his greatest opportunity lies in continuing and increasing his output of creative work, so will another find that his greatest forte may be in management activities. In either case, it is possible for the engineer to make a contribution of extreme importance and obtain a great measure of satisfaction in his achievements. The job in which the engineer will reap his greatest reward is the one providing the most personal gratification and pleasure.

There is nothing more wasteful than to place an engineer with great creative ability into a managerial position where he is not qualified to work. Conversely, an engineer with strong managerial qualities might be helpless in coping with certain design problems. Therefore, it is up to the individual engineer to examine carefully his own characteristics and obtain an evaluation from others so that he will be in a position to pursue his course of greatest opportunity.

Only after the engineer has settled in his own mind the question of "qualifications," will he know where he can make the greatest contribution in the corporation's progress.

PLAN COURSE OF MAXIMUM CONTRIBUTION

Each engineer should plan a personal program which will enhance his ability to make the maximum contribution in the type of work in which he excels. Preparation for pursuing his goals usually requires that he continue some kind of formal educational program. To receive recognition for his work and his ability, he should participate in societies and associations whose scope of interest corresponds to his own. Recognition is obtained among his associates through discussions of subjects of mutual interest and through papers which the individual may write and have published. To advance to positions of greater responsibility, it is necessary for the individual to acquire a well rounded knowledge, not only of technical subjects but also general knowledge, which enhances his ability as an engineer or as a leader who secures the cooperation of others.

ENGINEERS AND "ENGINEER-MANAGERS"

Many writers have emphasized the fact that as industry becomes involved in more complex technical products and processes, (and these in turn require larger organizations to carry on the operations) that certain engineers possess the knowledge—or are particularly fitted to assume managerial positions. Technical knowledge alone does not necessarily insure one's success as an engineer or as a manager. The engineer who desires to branch into management must first possess or develop a managerial attitude towards his job.* He must be capable of influencing and leading his associates as a first step, always guiding the work so as to make the greatest contribution to his company's over-

* "THE ENGINEER AND ENGINEERING MANAGEMENT" By C. A. Gunther, Vol. II, No. 1, June-July 1956, *RCA ENGINEER.*

all objectives. He must learn to select people on the basis of their abilities and characteristics and to match these with the job requirements. This is perhaps the most vital requirement for the successful management of any enterprise. The creative ability of an organization will depend upon all its engineers having and using the ability to think creatively.

Engineers must be trained to think logically, and to identify adequately problems and define them in terms which can be subdivided into other problems until the individual parts of the overall problem can be solved. They should, if they exhibit these aptitudes and apply themselves, be best equipped to assume managerial responsibilities in large and complex operations. It is from the engineering staff that a corporation is most likely to be able to find managers and planners who can insure the success of that company in the future.

NEED FOR SPECIALIZATION

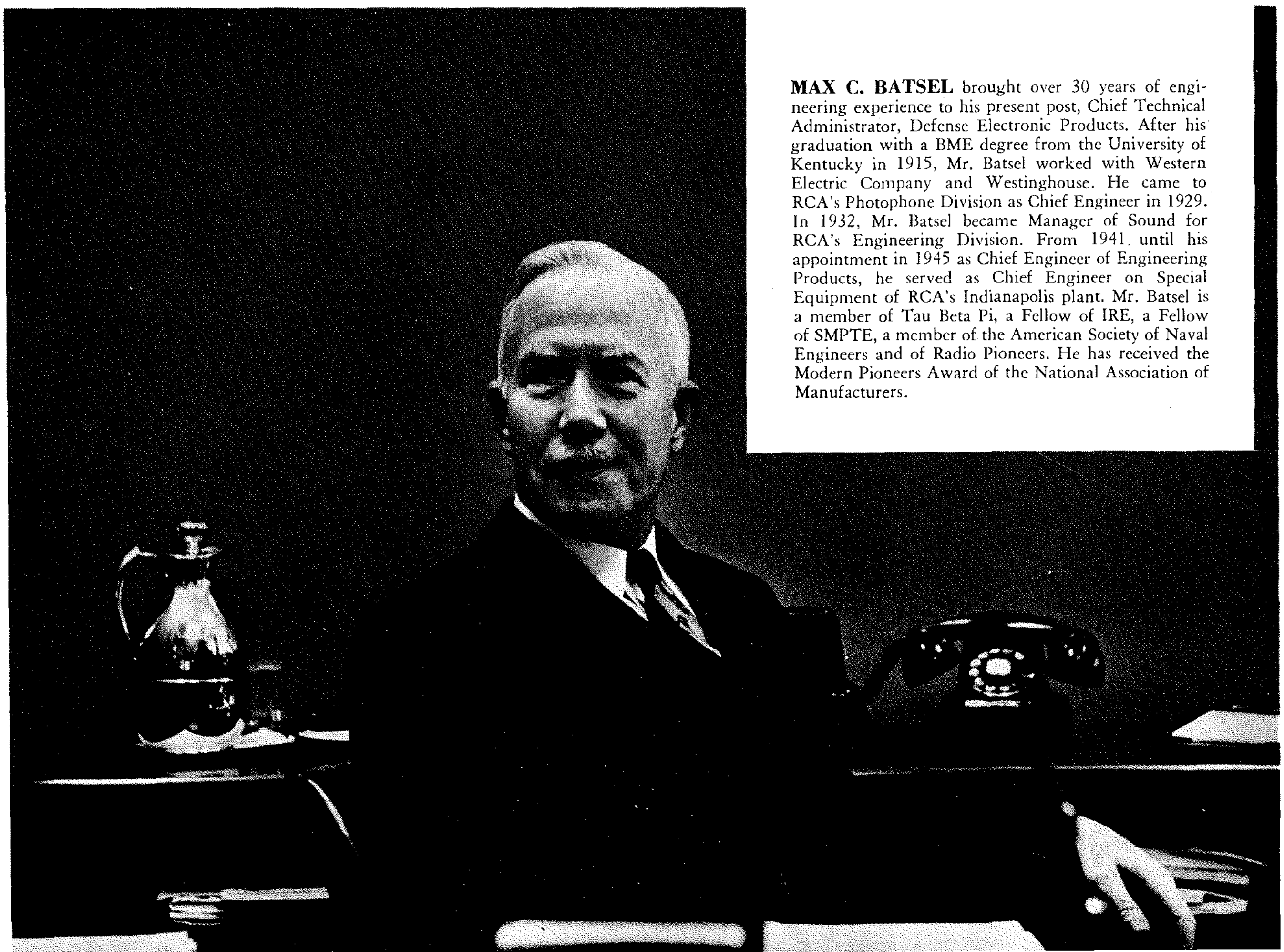
The complexity of the technological work in the electronics field has increased to such an extent that specialized fields of interest are often necessary for individuals to acquire the detailed knowledge and experience to become proficient in technical work. Specialization does not prevent individual engineers from maintaining the perspective to understand the relation of his work to the broad advances in his field. It is essential that a clear understanding be maintained of the services to be performed and how the development will result in a greater satisfaction to proposed customers for the products and services that are planned. The engineer should also understand how, as a result of his activities, his company will be in a better position to provide customer satisfaction, more effectively than competitors can.

VALUE OF BASIC ENGINEERING TRAINING

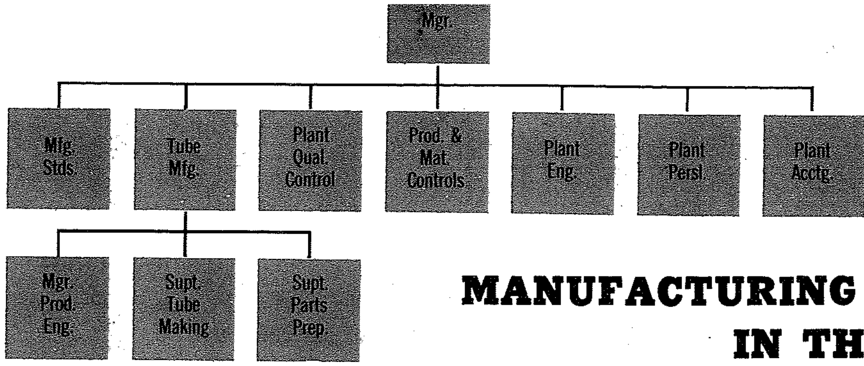
As the size of corporations has increased, competition has become more keen between managements. Good management complements good technical knowledge and design abilities. The success of one large corporation, in competition with another, must depend upon the alertness and the acuity of management in sensing situations which provide opportunities for progressive moves. The abilities and characteristics required on the part of management do not necessarily require engineering abilities. However, individuals who possess the required characteristics for successful management of large enterprises and in addition have engineering training should be able to make decisions more confidently than those who do not have basic engineering knowledge and training.

CONCLUSION

In conclusion, every engineer should determine his qualifications, then decide whether he wants to proceed on a course leading to management responsibilities or whether he desires to make his contribution through technical competency, as would be demonstrated through his own creative ability. *It is possible that the contributions that can be made can be of equal value whether they are in the managerial field or in the field of creative engineering.* In any case, an engineer should make this choice early in his career. In the case of either choice, the individual must be prepared to devote some of his time and effort to programs intended to prepare him for the next step towards his ultimate goal.



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



MANUFACTURING ENGINEERING IN THE WOODBRIDGE PLANT

by

HOWARD R. SNOW, Mgr.

Production Engineer
Tube Division
Woodbridge, N. J.

MANUFACTURING ENGINEERING is one of the most challenging and yet one of the most rewarding activities in the Tube Division. I welcome the opportunity to introduce the Woodbridge plant engineering organization and to describe various aspects of its operation to other product engineering groups.

A tube manufacturing engineering organization has three main functions; (1) to establish correct processing schedules and controls for the manufacture of the product; (2) to sustain product quality and (3) to maintain a constant effort without endangering quality to reduce manufacturing costs by introducing more efficient, less costly methods, materials, and processes. For the accomplishment of these functions, the Manufacturing Engineering Activity at Woodbridge has a staff of 24 people of whom 18 are engineers and/or supervisors; engineering aides and glass technicians complete the staff. Because the problems encountered in tube making are of such a varied nature, it is necessary to have chemical, electrical, and mechanical engineers in the activity.

A Manufacturing Engineer has full responsibility for the tube types that are manufactured. In an average month he may spend 60 to 70 per cent of his time in setting up manufacturing processes and controls and determining whether existing processes are adequate. Another 20 per cent of his time may be devoted to quality problems and contact work with quality and field engineers on satisfying customers with the performance of our tubes in equipment. The rest of his time is devoted to cost reduction items and special assignments. In addition to these duties, each engineer in Woodbridge is given a special plant assignment such as safety engineer for electrical equipment, plant chemical expert on parts and product cleanliness or plant expert on mechanical designs and other related assignments.

From the organization standpoint, manufacturing engineering in the Tube Division is separated from the Product Design and Development Engineering Activity. Each manufacturing plant in the Tube Division has its own Manufacturing Engineering. In the Woodbridge Plant, as in all Tube Plants, the Manufacturing Engineering Activity reports to the Manager of Manufacturing along with the Superintendents of Parts Preparation and Tube Making. Chart (1) gives the organizational structure of a typical Tube Manufacturing Plant, such as the Woodbridge Plant.

Before describing the organization of manufacturing engineering at Woodbridge, it would be well to explain the unique role that Woodbridge has in the manufacturing set-up of the Receiving Tube Operations Department in the Tube Division.

In Woodbridge, our tube manufacturing is divided into three groups. First, Glass Tubes, which manufac-

Fig. 1—Parts Preparation Engineer Paul Zell is observing an automatic grid lathe being operated by Helen Ratcliffe. The Parts Preparation Engineer often has to work closely with the operator, especially after installation of some new device or equipment.

Fig. 2—Glass Engineer Marshall Holland is checking the operation of a 24-head GT stem machine. The Glass Engineer spends much of his time observing machines such as this in order to establish better control of glass strain pattern.

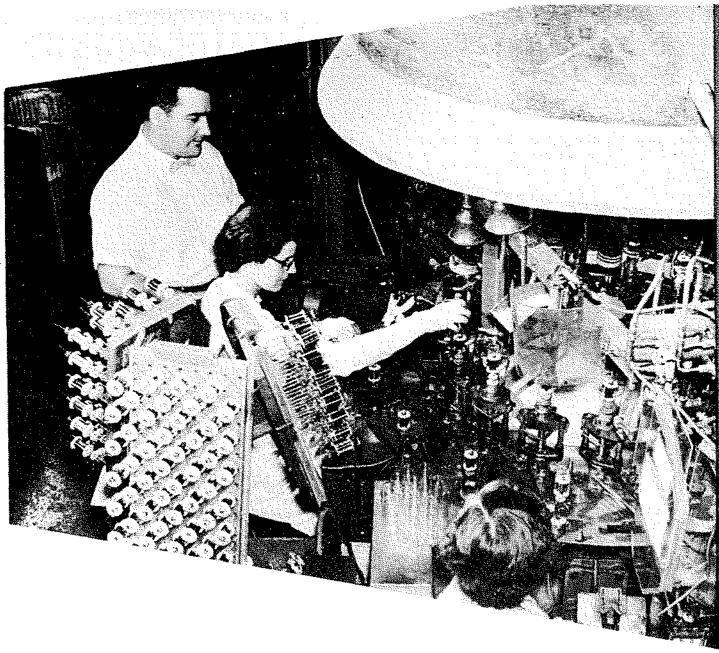


Fig. 3—Manufacturing Engineer Robert Nearhoof is supervising a Sealex test on the 6CD6-GA Sealex Machine with the help of operators Helen Keeshan and Elaine Litchfield.

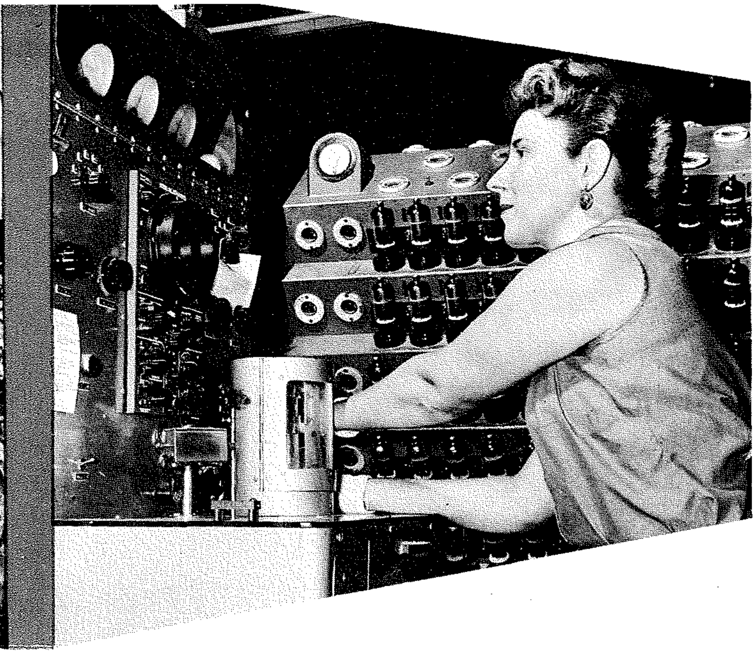


Fig. 4—Helen Opalack, a test operator on the 6CD6-GA, is looking at the oscilloscope pattern on an RCA High-Voltage Breakdown Test Set in order to observe any breakdown or streaking in the raster as a 7000-volt pulse is applied to the plate of the 6CD6-GA under test.

tures standard glass and the so-called GT types. All of the horizontal deflection, damper, and high-voltage rectifier tubes manufactured by the Tube Division are made at the Woodbridge Plant in this activity. Second, Short-Run Types, which includes glass tubes primarily for the replacement market such as the "magic-eye" family, and converters, detectors, and a-f and r-f amplifiers for old-model radio sets. The third group, Special Purpose Types, manufactures the widest variety of tube types. This group is the source of gas-filled receiving-type tubes for industrial and military use. Products of this group range from mechano-electronic transducers to miniature thyratrons for computer use and special premium tubes for uhf oscillators in aircraft communication equipment.

It is easiest to describe our function and duties by outlining the operations in tube manufacture and describing the function of engineering in each area.

Fig. (2) sketches the main functions in tube manufacture, all of which involve engineering.

PARTS MANUFACTURE AND PROCESSING

In the Parts Preparation Activity the manufacturing engineer has a number of responsibilities. The manufacturing engineer who is assigned to a particular tube type must determine the specifications and the allowable manufacturing tolerances and cleaning processes to be used on the parts in the mount assembly. It is also the manufacturing engineer's function to help design and set up the jigs and cleaning equipment necessary to manufacture the tube parts to meet these rigid specifications. In the Glass Stem activity, the glass technician applies his knowledge and experience in the properties of glass and the equipment needed to produce glass tube parts. Through years of experience, the glass technician has determined the proper way to work glass in stem making and on the Sealex machine in order to reduce to a minimum the thermal shocks and stresses placed on the tube during its assembly and sealing operations.

In spite of his daily manufacturing problems, the engineer in parts preparation must never lose sight of his most important goal—better ways to produce parts faster and more economically without sacrificing quality. The judicious use of new materials and newly designed production equipment will often enable the engineer to turn out parts at a higher production speed and a resultant lower unit cost.

The manufacturing engineer, in co-operation with the purchasing people, and the standardizing, quality and product design engineers, sets the incoming inspection specifications on all materials and parts used in the finished tube assembly. The problems of the purchasing agent and the inspector of incoming materials are shared by the manufacturing engineer and his decisions and advice frequently determine whether production is to start, continue, or stop.

TUBE ASSEMBLY (MOUNTING OPERATION) AND SEALEX AND EXHAUST OPERATION

The determination of the correct procedures in the assembling of parts into a finished mount are the responsibility of the methods engineer and the product design engineer. The manufacturing engineer, however, will frequently set up any special mount or parts inspections in the mount assembly and specify any unusual mechanical operations that may be employed in order to make a satisfactory product for special tube applications.

The operation of the Sealex machine is where the manufacturing engineer bears the full responsibility. A Sealex machine performs several important functions. It seals the glass envelope to the stem, thoroughly degasses the tube parts, reduces the carbonates on the cathode or filament, evacuates the envelope, and seals off the tube from the atmosphere. For gas-filled tubes, the Sealex machine also provides "dosing" or inserting of the inert gas at the required pressure into the glass envelope.

The manufacturing engineer sets the optimum indexing speed for the Sealex machine for the manufacture of a particular tube type. This speed is determined primarily by the life tests and design checks made on the product. Because a Sealex machine is a key facility, the maximum number of tubes that the machine can process is of paramount importance. However, too high a speed may not allow the pumps on the machine to evacuate the tube thoroughly. Inadequate evacuation can result in serious quality problems.

The heating of the metal parts within the glass envelope to drive out occluded gases is accomplished by radio-frequency induction-coil furnaces that operate at about 550 kilocycles. Each Sealex machine has four 5.0-KVA or 7.5-KVA units available for heating the tube. Each furnace is connected to r-f coils in two positions, so that it is possible to heat the elements of the tube in eight different indexing positions. In order to reduce the carbonates sprayed on the cathode or filament, the Sealex machine applies a-c or d-c voltage to the heater or filament leads to bring the cathode or filament up to a temperature of 1200° or 1300°C. At these temperatures the carbonates are reduced to oxides and the cathode is partially activated.

Sealex speeds vary from as low as 180 tubes per hour to 1100 or 1200 tubes per hour. For an average speed of 600 tubes per hour, with only 8 r-f heating positions and only 9 filament or heater voltage positions, a mount assembly must be evacuated and have sufficient cathode activation in less than 50 seconds of r-f heating and only a total of about 90 seconds of pumping.

The manufacturing engineer, with the help of the glass technician and unit foreman, also sets the sealing cycle on the Sealex machine. This operation is a critical one because bulb fires in the sealing cycle that are too high or too low may cause oxidation of the cathode, flaking of the cathode coating, or improper glass strains. Because oxidation of parts during sealing must be kept to a minimum, forming gas (usually a mixture of hydrogen and nitrogen) is frequently used to flush the bulb during the sealing cycle.

Fig. 5—Manufacturing engineer William Dibble is observing Marge Grubel as she inserts and welds the heater on a 117Z3 mount assembly.

AGING AND STABILIZATION

In the short period that a tube is on the Sealex machine, the electrical characteristics of the tube cannot be stabilized. During manufacture tubes are aged or stabilized by the passage of varying amounts of current through the cathode or filament. In this process the plate, grid, and heater of the tube are placed in series with an electric light bulb and an a-c or d-c voltage is applied to the various tube elements (see cover, this issue). The manufacturing engineer establishes an aging schedule for each type which will result in stable operating characteristics and consequently, good performance in the customer's equipment.

TESTING AND LIFE TESTING AND SHIPMENT

The testing specifications and quality levels for a tube type are proposed by the test engineers with the assistance and advice of the engineer in the Application and Design Engineering and Quality Control Activities. It is up to the manufacturing engineer to devise processing schedules and parts changes in order to meet these testing specifications. He must keep the tube characteristics within control limits and manufacture the tube to meet all design-check, quality-test, and life-testing limits. If any tube lot fails the prescribed tests, the engineer, with the help of the quality and design engineers in Harrison, determines the status of the rejected lot and its ultimate disposition. Problems, such as the rescreening of lots to tighter test limits, complete factory reprocessing or reworking of lots, scrapping of the lot, are determined with the manufacturing engineer's guidance.

Tubes must also stand the rigors of mechanical impact incurred in drop tests, in which tubes are packed in cartons of 50, 100, or 400 tubes and dropped from a specified height. If the product does not pass these tests, the packaging engineer and the manufacturing engineer must resolve the problem.

Fig. 6—Nancy Weins is holding a pair of helical coils about two 6012 thyratrons being exhausted on a "trolley station". The coils are used for r-f heating of the tube's outer shield.

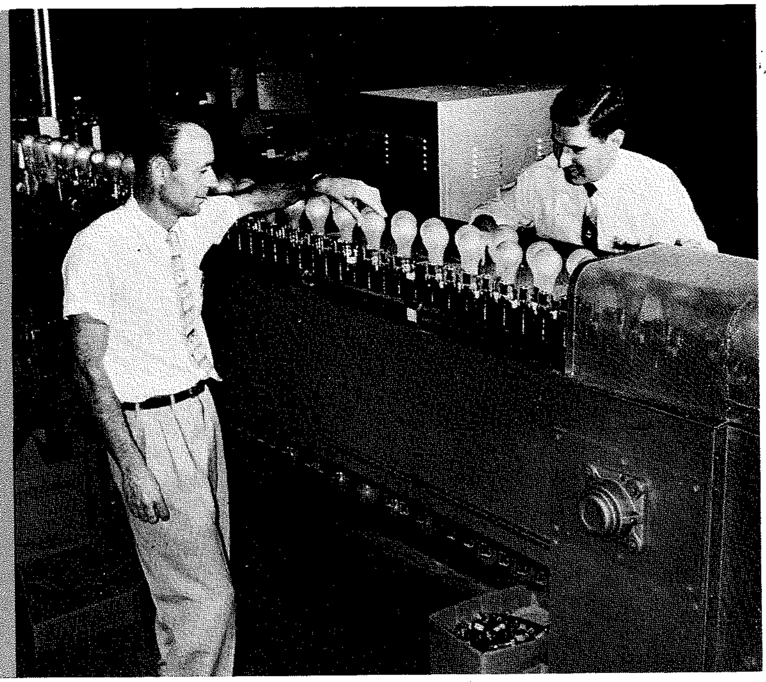


Fig. 7—Foreman Fidel Dunne (left) is checking aging panel for socket and continuity as Manufacturing Engineer Milton Nachbar operates the spot-knocker controls on the continuous ager-spotknocker-tester for type 6AX4-GT damper tube.

CUSTOMER ACCEPTANCE

Customer relations frequently requires that the manufacturing engineer work in close cooperation with the field engineer and the application engineer. After the Tube Application Engineers have verified a customer quality problem, it is frequently up to the manufacturing engineer to determine what process or design changes may be necessary to solve the problem. This type of activity is an important and responsible part of the manufacturing engineer's job because he must help to give the customer satisfaction and yet keep the manufacturing costs to a minimum consistent with good quality.

Throughout the making of receiving tubes, from parts preparation to customer acceptance of the finished tube, the manufacturing engineer finds each day a challenge. The engineer in manufacturing who can devise the most economical and best way to manufacture a product that meets with widespread customer approval is forwarding his company's objectives and goals in the field of electronics.

HOWARD R. SNOW received the B.S. degree in Electrical Engineering from Cornell University in 1947, and the M.S. degree in Electrical Engineering from Newark College of Engineering in 1953. From 1948 to 1950, he was engaged in transformer design work at the American Transformer Company in Newark, N. J. He joined RCA in 1950 as a Manufacturing Engineer in the Receiving Tube Operations Department of the Tube Division in Harrison, N. J. He became a Supervising Engineer in 1952, and since 1954 has been Manager of Production Engineering at the Woodbridge plant. Mr. Snow is a member of Eta Kappa Nu and the Cornell Society of Engineers.

PREMIUM TUBES AT RCA

by
H. E. STUMMAN
Tube Division
Harrison, N. J.

Experience gained from the application of tubes in many specialized equipments during the war indicated that both Industrial and Military applications required tubes having extensive controls and much higher reliability than that of tubes designed primarily for the entertainment field. Various types of such tubes, designated premium tubes, have been designed to satisfy the requirements of particular applications. In 1948, RCA announced a line of "Special Red" tubes for applications in which 10,000-hour life, rigid construction, uniformity, and stability are required. This line includes the 5690, a full-wave rectifier; the 5691, a high-mu twin triode having characteristics similar to those of the 6SL7-GT; the 5692, a medium-mu twin triode having characteristics similar to those of the 6SN7-GT; and the 5693, a sharp-cutoff pentode having characteristics similar to those of the 6SJ7. The 5690 is a T-12 glass type, the 5691 and 5692 are T-9 glass types, and the 5693 is a metal type.

Soon after the "Special Red" tubes were announced, an organization known as ARINC (Aeronautical Radio, Inc.) surveyed the performance of several miniature types used extensively in aircraft equipment, and proposed that tube manufacturers improve the reliability of these types to satisfy the requirements of the aircraft industry. This survey was made under the sponsorship of the commercial aircraft industry. RCA is presently producing seven of the ARINC types: the 5654 r-f pentode to replace the 6AK5, the 5726 twin diode to replace the 6AL5, the 5727 thyratron to replace the 2D21, the 5751 high-mu twin triode to replace the 12AX7, the 5814A medium-mu twin triode to replace the 12AU7, the 5725 sharp cutoff pentode to replace the 6AS6, and the 6201 medium-mu twin triode to replace the 12AT7.

Within the past several years, the military services have also become concerned about the reliability of electron tubes, and have sponsored improvement programs for tube types intended for Government end use only. The Air Force "A Program" was primarily concerned with the improvement of a group of miniature tubes. Because of the urgency to obtain tubes of high reliability at that time, the Air Force sponsored "production development" contracts in which tube companies continually worked toward an objective or "target" specification while tubes were being produced. Periodic waiver meetings were held with the Air Force and equipment manufacturers to review the progress in meeting these specifications and to review waivers required to enable the tube companies to supply tubes. The degree of cooperation and coordination between the military, the equipment manufacturers, and the tube companies during this program contributed greatly to the development of more reliable tubes and circuits. RCA's participation in this program resulted in the development of the 6101 and the 6099, medium-mu twin triodes having characteristics similar to those of the 6J6.

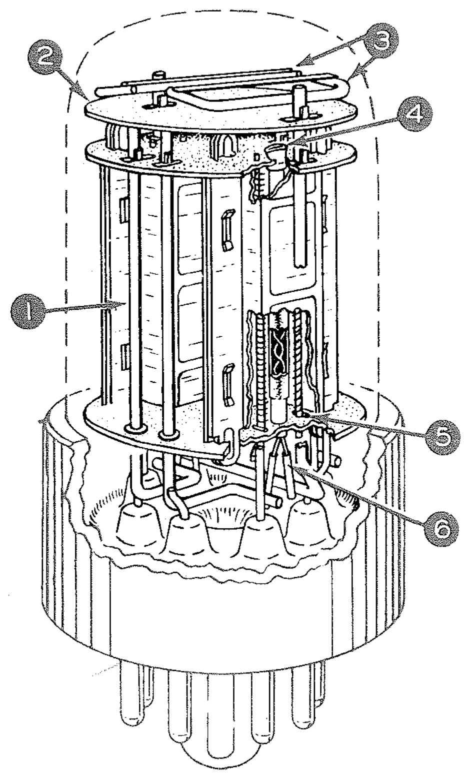


Fig. 1—Cutaway drawing showing design features of RCA "Special Red" tube types.

The Navy "WA" program was similar in many respects to the Air Force program. Production development contracts were granted to the tube companies to improve the reliability of certain types while tubes were being produced. During the period of the contract, the tube companies were to revise the tube specifications to reflect the improvements made in the tube. RCA's participation in this program resulted in the development of the 6J4-WA miniature medium-mu triode, and the 6080-WA low-mu octal twin triode for voltage-regulator service. Coordinated military specifications for these types have been proposed to ASESA (Armed Services Electronics Standards Agency).

During the last war, sub-miniature tubes were developed for military applications. RCA is currently producing five premium sub-miniature types: the 5718, a medium-mu triode similar to the 6C4; the 5719, a high-mu triode similar to one triode unit of a 12AX7, the 5840 and 6205, r-f pentodes similar to the 6AK5, and the 5636 sharp-cutoff pentode similar to the 6AS6.

As a result of these various tube-improvement programs, many improvements were made in tube design and in control and test procedures. In some cases, however, several different specifications resulted for one basic tube type. The Services have recognized the complications of this situation and have attempted to combine the special features and controls of the various modifications into one specification. This procedure has led to multiple-number specifications such as the 5654/6AK5-W/6096. The services are continuing their attempt to simplify this tube-numbering situation, and to combine any multiple specifications for a basic type remaining in the Military specification books.

There are numerus examples of various versions of a basic type having multiple type numbers or "WA" numbers in the RCA line. In all cases, RCA is supplying types to the latest Military specifications. The RCA line now also includes these latest combined Military types: the 6186/6AG5-WA replacement for the 6AG5 r-f pentode; the 6189/12AU7-WA replacement for the 12AU7; the 12AT7-WA replacement for the 12AT7; and the OA2-WA and OB2-WA voltage-regulator tubes.

This paper will discuss the areas of construction, materials, and specifications of premium tubes. Quality-control methods, which are an important feature, will not be covered because they would warrant a separate paper.

CONSTRUCTION

An analysis of the construction of premium tubes would show a very apparent difference in the amount of "ruggedness" between types. There are valid reasons for this difference.

Because the RCA "Special Reds" are designed to withstand very severe environmental conditions, no efforts have been spared to make these tubes extremely rugged. This line of tubes was not limited by the requirement of interchangeability with any existing prototype, although the characteristics are similar to existing types. Some of the design features incorporated in the "Special Reds" are shown in Fig. 1.

1. The mount is secured by support rods welded to eyelets in the mica.
2. An extra mica insulator shields the getter from the tube elements, eliminating leakage due to getter contamination.
3. Two getters are used for long life.
4. The cathode is locked to the mica insulator to eliminate movement of the cathode during shock or vibration.
5. "Stops" are welded to the grid legs to prevent vertical movement of the grid.
6. Sleeves are used on the heater legs to insure a good mechanical and electrical bond between the heater legs and the stem leads.

The Military and ARINC types, with the exception of the subminiatures and a few miniature types, often limited the tube designer by imposing the restriction that the premium tube had to be interchangeable with the prototype. Many of the ruggedization features described above could not be used because of their effect on critical capacitances and, therefore, on interchangeability. In other cases, it was not possible to increase heater power because the tubes were intended for use in series-string applications. Increased heater power permits a tightening of the cathode in the mica to improve performance under vibration without interfering with other requirements such as low voltage operation.

Fig. 2 shows a premium tube in which it was possible to increase heater power so that the cathode could be held rigidly and in which capacitance was not important in the application so that a rugged design could be used. The tube on the right is the 12AU7, a medium-mu twin triode; the tube on the left is the 5814-WA, its premium derivative. The following constructional differences can be seen in the 5814-WA:

1. Double micas are used at top and bottom to hold the parts firmly and to lengthen leakage paths between elements.
2. A shorter mount structure is coupled with a U-frame support to provide a compact, rugged structure.
3. A getter-shield mica is added to protect the tube elements from getter deposit.
4. The cathode hole in the mica is slightly smaller than the cathode, resulting in a "force fit."

The results of this construction can be illustrated by consideration of the Military specification for the 5814-WA. The vibration test for this type

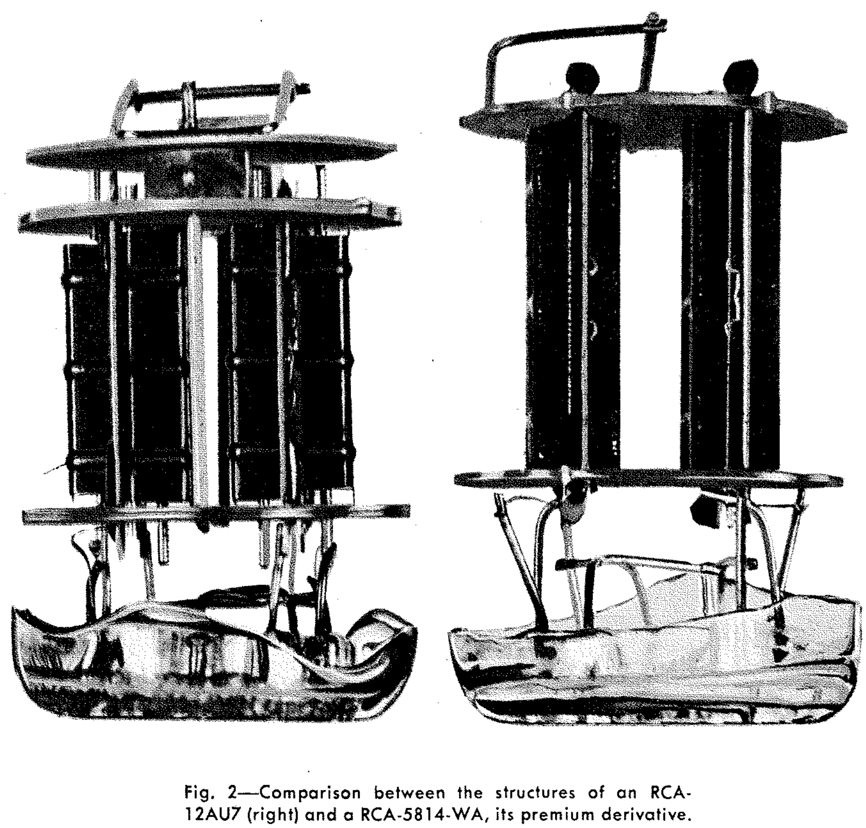
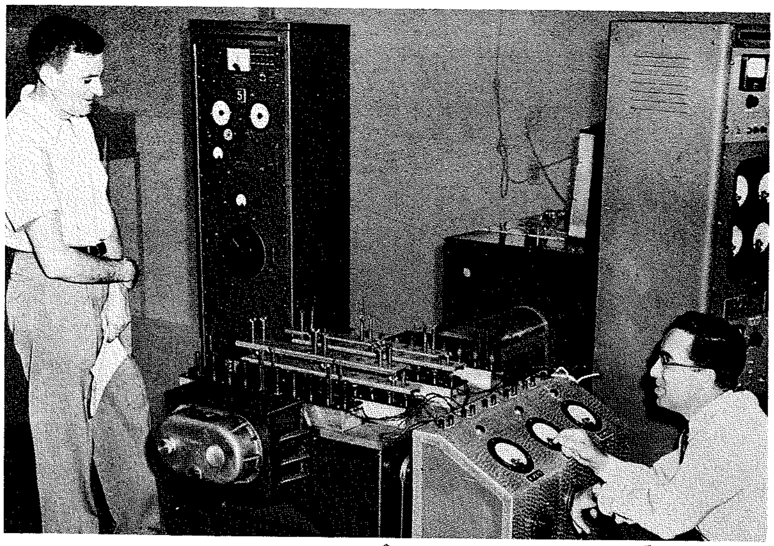
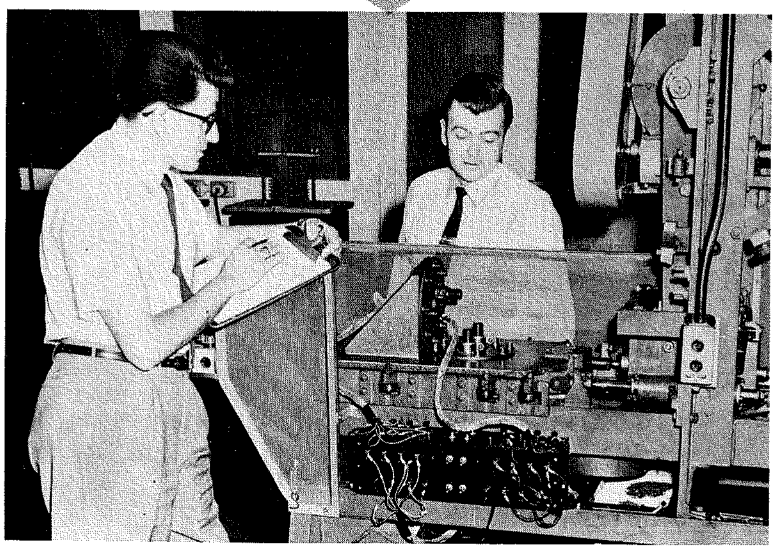


Fig. 2—Comparison between the structures of an RCA-12AU7 (right) and a RCA-5814-WA, its premium derivative.





At top: Design engineer Richard Brooks *(right)* and Daniel Pidgeon *(left)*, supervisor of the Mechanical Test Laboratory, setting up fatigue vibration equipment.

In center: The author *(standing)* conducting a design review meeting on a new premium tube type with personnel of the premium Tube Development group. *Left to right:* F. Gusler, J. McGrory, J. Triano, D. Scher and R. Brooks.

At bottom: F. Gusler *(left)*, design engineer, and the author *(right)* performing an impact test using the Taft Pierce shock machine.

calls for a vibrational output limit of 100 millivolts at an acceleration of 2.5 G's and a frequency of 40 cycles per second. Data taken at an acceleration of 10 G's up to a frequency of 500 cycles per second have shown no readings above 5 millivolts.

This case may be compared to that of the 5654 and its prototype, the 6AK5. These tubes are rf amplifiers in which capacitances are critical. A close look at the construction of these tubes indicates only two differences, the use of heater connectors and slightly tighter cathode and grid holes for the 5654. The specification for the premium tube includes a vibration test similar to that specified for the 5814-WA except that the limit is 150 millivolts. Data taken on the 5654 at an acceleration of 10 G's up to a frequency of 500 cycles per second has shown readings in the hundreds of millivolts. Other factors add to this relatively poor vibration performance compared to that of the 5814-WA. The 5654, which has very high transconductance, requires a fine-wire grid having a high number of turns per inch. In general, a high frequency or high-perveance tube is poor for vibration and ability to withstand high impacts because fine grids and close spacings are required to obtain this high performance. In such tubes, strengthening supports are often ruled out because their use results in higher capacitances and is detrimental to high-frequency performance.

The premium subminiature tubes are inherently rugged because of their very small mount structures. In addition, the mica holes in these tubes which hold the cathode and grids are usually slightly smaller than the cathodes and grids themselves, resulting in an extremely tight fit. The specifications for these tubes call for 15-G vibration tests at 40 cycles per second with limits of 25 millivolts for the 5718 and 5719, and 60 millivolts for the 5840, 6205 and 5636.

MATERIALS

RCA premium tubes use only the highest quality materials available. Tungsten heater wire is used for all types because of its high strength. Grids are plated with silver or gold to minimize variations in contact potential and to minimize grid emission.

Plates are made of nickel because of its resistance to contamination, and for many types the plates are carbonized to increase heat-dissipation properties. The micas are sprayed with aluminum oxide to minimize formation of leakage paths on life. Leakage slots are designed in the mica wherever possible to break up leakage paths.

The subject of cathode materials deserves a more detailed discussion. When conventional tubes are operated under plate-current-cutoff conditions, a high failure rate may occur as a result of the formation of a cathode interface, which may be thought of as a resistance layer, between the nickel sleeve and the cathode coating. The most important contributing factor in the formation of this interface is the amount of silicon activator present in the nickel sleeve material. A minimum of silicon is necessary to enable the cathode coating to be activated. All RCA premium tubes use a special sleeve material which has a very low, carefully controlled level of activator. Before each cathode sleeve melt is used, it is sampled for cutoff life tests on critical tube types, and the tubes are analyzed for interface before the melt is approved.

The specifications for premium military tubes (except the 12AT7-WA), do not call for a cutoff or stand-by life test to accelerate this cathode interface formation. The Military Services have indicated plans to add an accelerated interface life test to several premium-tube specifications in the future. When an application requires stand-by operation for long periods of time, it is desirable to use a tube which has a control specification for cathode interface.

SPECIFICATIONS

As mentioned earlier, many new specification control techniques have been developed within the past few years. The Military Services have combined these techniques into one specification which is known as the Military control specification. It is designed to be an acceptance specification, and does not include any process controls such as 48-hour stabilization. Until recently, this Military control specification was associated with the triple-brand types and the "WA" types. Now, however, the Military is starting to incorporate this type specification into the double and single-brand specifications and eventually eliminate the triple brand specifications. The Military control specifications feature the following:

1. *Variable Frequency Vibration*
   This test is usually a "type approval" test, i.e., the tube manufacturer must perform the test on the initial design submitted to the Government for approval and on subsequent major design changes. Tubes are vibrated over a range of frequencies from 10 to 50 cycles per second at an acceleration of 10 G's. The highest output reading is observed, and the tubes are vibrated at the frequency at which this output occurs for 3 minutes. The limit for this test is in the order of 100 to 300 millivolts.
2. *Fatigue Vibration*
   This test is performed on a sampling basis. The sample is operated at a frequency of 25 cycles per second at an acceleration of 2.5 G's for 32 hours in each of three positions. Vibration output, heater-cathode leakage, grid current, and transconductance are measured after this test.
3. *Shock*
   This test is also performed on a sampling basis. The tube is clamped in a specially designed machine and subjected to 5 blows in each of 4 positions at an acceleration of about 500 G's. The same characteristics are measured after this test as after the fatigue vibration test.
4. *Shorts and Continuity*
   This test is specified with an AQL (acceptable quality level) of 0.4 per cent. The test is performed on a polyphase shorts tester having a minimum sensitivity of 50,000 ohms.
5. *Major Electrical Tests*
   The major electrical characteristics are tested to an individual AQL of 0.65 per cent and a combined AQL of 1 per cent. These characteristics are usually heater current, heater-cathode leakage, grid current, plate current, transconductance, and screen-grid (grid-No. 2) current. In addition, the centering and dispersion of these characteristics are closely controlled. In order to meet these tight limits, it is necessary to perform these tests in the factory on each tube.
6. *Minor Electrical Tests*
   Minor electrical characteristics are tested to AQL's ranging

Design Engineers Fred Gusler *(left)* and Richard Brooks *(right)* with Daniel Pidgeon *(center)* supervisor of the Mechanical Test Lab, inspecting the variable frequency vibration test equipment.

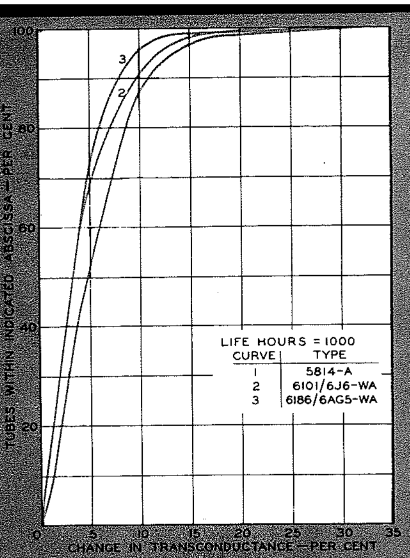


Fig. 3—Curves of typical life-test data on types 5814-A, 6186, and 6101.

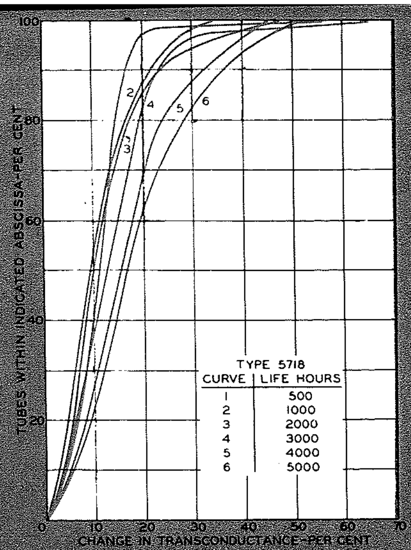


Fig. 4—Percentage of survivors as a function of change in transconductance for the 5718.

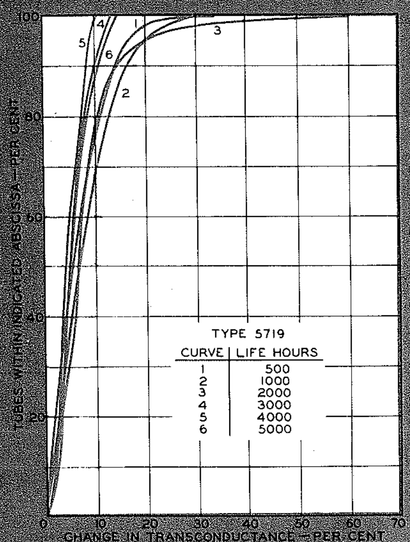


Fig. 5—Percentage of survivors as a function of change in transconductance for the 5719.

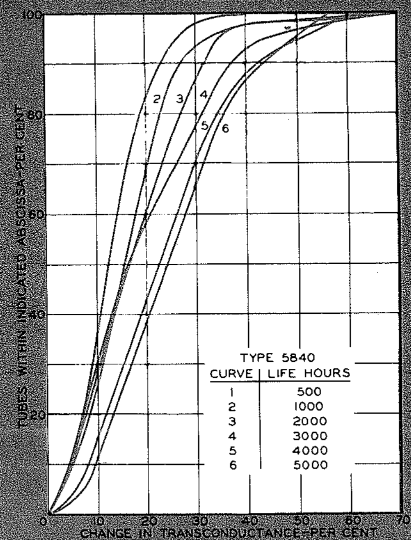


Fig. 6—Percentage of survivors as a function of change in transconductance for the 5840.

from 2.5 to 6.5 per cent. These items include such tests as electrode insulation, cutoff plate current, slump transconductance, amplification factor, and voltage breakdown. The application requirements for a given tube type usually dictate whether a characteristic requires a major or minor test.

7. *Heater-Cycling Life Tests*

   A sample from each production lot is subjected to an accelerated heater-cycling life test, usually at a heater voltage approximately 20 per cent greater than the rated heater voltage and with the maximum heater-cathode potential applied for 2000 cycles. A tight AQL is applied for open heaters, open cathodes, heater-cathode shorts, and heater-cathode leakage above the stated endpoint.

8. *Stability Life Test — Survival Life Test*

   The 48-hour stabilization test included on many earlier specifications has been replaced by a survival-rate and stability life test. The stability life test is performed for one hour, and the major characteristic (usually transconductance) is tested to a maximum change of about 10 per cent to a 1 per cent AQL. The survival-rate life test is run for 100 hours, and inoperatives are checked to a 0.65 per cent AQL. These tests check the product on an acceptance basis for the two purposes of a stabilization period: 1) low early-hour inoperatives, and 2) stability of characteristics. Although most premium tubes are stabilized for an extended period of time in order to meet these life tests, the time is left to the discretion of the tube manufacturer. The quality levels specified for these tests are much more severe than those used on previous specifications which incorporated a stabilization plan.

9. *High-Temperature Life Test*

   A sample of 20 tubes from each lot of tubes produced is life-tested at maximum rated conditions for a period of 1000 hours in an oven maintained at the maximum bulb temperature. The premium miniature tubes are tested at a bulb temperature of about 165°C, and the subminiatures at 230°C. This sample must meet very stringent requirements for inoperatives, heater current, grid current, change in plate current or transconductance, heater-cathode leakage, and insulation resistance at 500 hours and 1000 hours.

Fig. 3 shows curves of typical life-test data on types 5814-A, 6186, and 6101. In these curves, the percentage of survivors is plotted as a function of change in transconductance from 0 to 1000 hours. For type 5814-A, 90 per cent of the tubes show less than 7½ per cent change in transconductance at 1000 hours.

Data have been taken on the subminiature types 5718, 5719, and 5840 to 5000 hours. Fig. 4 shows the percentage of survivors as a function of change in transconductance for the 5718 at 1000, 2000, 3000, 4000 and 5000 hours. Although the data used for plotting these curves were obtained from limited quantities of tubes, the curves serve to indicate the degree of change to be expected when these types are operated under the specified conditions.

Many otherwise excellent circuit designs are basically unreliable because their performance falls off rapidly or complete failure occurs as a result of slight changes in tube characteristics. For example, a particular circuit using type 5718 will not function properly if there is a change of 10 per cent in the transconductance of the tubes. The curves of Fig. 4 show that approximately 47 per cent of the tubes in this circuit would require replacement by 1000 hours; 77 per cent would require replacement by 5000 hours. However, if the design is modified so that a 25 per cent change in transconductance can be tolerated, only 5 per cent of the tubes will require replacement at 1000 hours, and 25 per cent will require replacement at 5000 hours. If 40 per cent change is allowed, no tubes will require replacement at 1000 hours and only 6 per cent of the tubes will require replacement by 5000 hours. There is an obvious improvement in circuit reliability when allowances are made for changes in tube characteristics with life.

The curves for the 5719, shown in Fig. 5, are very similar to those of the 5718. The curves of the 5840, shown in Fig. 6, have a more severe change in transconductance than the 5718 or 5719. This increased change is due to the fact that the 5840 cathode temperature is lower than that of the 5718 or 5719 because a cathode tab is welded to the top of the cathode and the suppressor grid (grid No. 3) to improve high-frequency performance. This extra cathode tab conducts heat from the cathode, resulting in a cooler cathode temperature.

APPLICATION

It is important to remember that good circuit-design practice should be followed to take full advantage of the high degree of reliability built into premium tubes. The circuits should be designed so that the tubes never exceed their maximum ratings. The majority of premium tubes are rated to their full capabilities, and little safety factor is incorporated in these ratings. For this reason, it is good practice to operate tubes as conservatively as possible, particularly for:

1. *Heater Voltage*
   The reliability of tubes is affected to a large extent by the degree of regulation of heater voltages. It is recommended that the heater voltage be regulated within plus or minus 5 per cent. Operation of the heater at a lower voltage may reduce the cathode temperature below normal to the point where electron emission may be inadequate. Low-temperature operation may also cause damage to the cathode because of gas absorption or ion bombardment. Operation of the heater at a high voltage may cause rapid evaporation of cathode material, resulting in grid emission, leakage, or noise. High-temperature operation will also accelerate the formation of cathode interface. The resulting increase in heater temperature is detrimental to the insulation properties of the heater coating and the strength of the heater wire. For maximum reliability, it is also recommended that heater power be applied slowly to minimize heater surges.
2. *Heater-Cathode Voltage*
   It is recommended that the heater-cathode potential be kept as low as possible. A large potential between the heater and cathode increases the possibility of leakage or shorts between the heater and cathode.
3. *Grid Circuit Resistance*
   It is advisable to use the smallest practical value of resistance in the control-grid (grid-No. 1) circuit. Whatever reverse grid current exists in a tube as a result of gas, grid emission, or leakage flows through the grid resistor, causing a shift in bias proportional to the value of resistance.

FUTURE DEVELOPMENTS

At this time, RCA has in development many additional premium tube types. In the miniature field, these types include the 6005, a premium 6AQ5: the 5749, a premium 6BA6; the 6136, a premium 6AU6; and the 5670, a premium 2C51. In the subminiature field, types in development include the 6021 and 6111 medium-mu twin triodes, and the 6112 high-mu twin triode.

The requirements for premium tubes of the future will place special emphasis on environmental conditions. For example, tubes will be required to operate at ambient temperatures up to 500°C. This temperature will require the use of relatively new materials in the receiving tube industry, such as ceramics. Increased requirements of impact and vibration will lead to new methods of construction and the use of stronger materials. The problem of cathode interface will require the use of very pure cathode-sleeve material. Because this material is very difficult to activate, it will require improved methods of tube exhausting. Other areas in which new methods are being developed are in the fields of particle shorts testing and pulse testing and ratings.

Present tubes are capable of achieving reliability in the order of failure rates of 0.1 per cent per 1000 hour. A worthy objective for the future is reliability in the order of 0.01 per cent per-1000-hour failure rates.

HENRY E. STUMMAN received the B.S. degree in Electrical Engineering from Syracuse University in 1948 and his Masters degree from Stevens Institute of Technology in Hoboken, N. J. in 1953. In 1948 Mr. Stumman entered the RCA Specialized Training Program and, upon completion of this program, joined the Receiving Tube Development activity of the RCA Tube Division at Harrison, N. J. His work has been concerned primarily with the development of computer and premium tubes. At present, he is leader of Computer Tube Development.

CAPACITANCE MULTIPLIERS

by
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THE SO CALLED "Miller effect" which causes so much trouble in high-frequency amplifiers and in high-gain amplifier stages with variable gain may be put to a useful purpose as a capacitance multiplier. Capacitance multipliers of this type are often used as integrators, charging capacitors in slow-sweep generators, electronic timers of various types in the milli-second to second range, or to simulate large amounts of compliance or mass in analog computers, to mention a few applications.

It is the purpose of this paper to discuss some of the actual operating requirements imposed on the amplifier and associated circuitry. The basic circuit of the capacitance multiplier is shown on Fig. 1.

THEORY OF OPERATION

If E volts are applied to the input terminals of the circuit, $-EG$ volts will appear at the output terminals of the amplifier. Hence, the voltage appearing across the capacitor will be $E(1+G)$ volts and the current flowing into the input terminals will be $(1+G)$ times the current that would flow without the amplifier. That this is equivalent to multiplying the capacitance by a factor $(1+G)$ may be seen from the following. The current flowing through a capacitor is:

$$I = C\frac{de}{dt} \qquad (1)$$

where e is the voltage across the capacitor.

If the voltage across the capacitor is increased to $(1+G)$ and if G is constant, equation (1) becomes:

$$i = C\frac{d}{dt}[e(1+G)] = C(1+G)\frac{de}{dt} \qquad (2)$$

Equation (2) is the equivalent of (1) with the capacitor multiplied by $(1+G)$.

LINEARITY AND RANGE

The first requirement is amplifier linearity. The derivation of equation (2) above assumed that G was independent of both input voltage e and time.

Second is the requirement of dynamic range of the amplifier. If a multiplication of $(1+G)$ is required, the amplifier must be capable of delivering a voltage eG where e is the peak input signal expected. Thus, if the input signal is one volt peak-to-peak, and a capacitance multiplication of 100 is desired, the amplifier must have a dynamic range of 99 volts peak-to-peak. If the input voltage may reach 10 volts peak-to-peak, the amplifier must be able to develop 990 volts peak-to-peak. This limits the possible multiplication in high-level circuits.

TIME CONSTANT

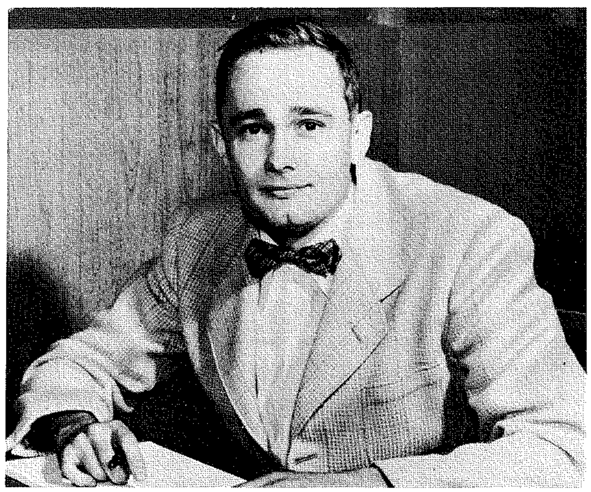
A third requirement on the capacitance multiplier is that the time constant of the output circuit of the multiplier must be very short, as compared to the time constant composed of the capacitor C and the output impedance of the driving source. That is:

$$R_oC \ll R_{gen}C(1+\frac{1}{G})$$

where R_{gen} is the output impedance of the source driving the multiplier, and R_o is the output impedance of the multiplier amplifier. This is required since the operation of the multiplier assumes that the voltage at the output terminals of the amplifier is "G" times the input voltage. In other words, the amplifier output voltage must accurately follow the input voltage.

CURRENT CAPABILITY

A fourth requirement placed on the capacitance multiplier is the current capability of the amplifier output



JOHN J. NAGLE received his B.S. in Electrical Engineering from the University of Maryland in 1950 and his M.S. in Electrical Engineering from the same institution in 1954. During World War II he worked for the National Bureau of Standards in Washington, D. C. as a laboratory technician. After graduation, he worked for the National Bureau of Standards, the Ahrendt Instrument Company in College Park, Maryland, and NEMS-Clarke, Inc. in Silver Spring, Maryland. Mr. Nagle joined RCA in Moorestown in May 1955 where he worked in the servo-Sub Unit prior to his present assignment in the Modulator Sub Unit. He is currently studying for a Master's degree in Business Administration at Drexel where he is also an instructor in the Electrical Engineering Department. Mr. Nagle is an associate of the I.R.E. and a member of the Audio Engineering Society.

stage. The amplifier must be capable of supplying a current

$$i = C\frac{de_{in}}{dt}(1+G)$$

$$= C(1+G)\frac{de_{in}}{dt}\ amperes$$

Thus, the high-frequency response will be limited by the current capability of the multiplier output stage.

FEEDBACK EFFECTS

In addition to the above requirements, the shunting effect of the multiplier amplifier input must also be considered. The importance of this will depend upon the particular application of the multiplier.

If a conventional amplifier is used, or an amplifier wherein the output is *not* fed back to the input grid, the input impedance of the amplifier is shunted across the capacitor. This impedance may be made quite high by well-known methods.

If feedback is obtained by feeding the output back to the input grid (computer type amplifier), the value of the resistance shunting the capacitor is not as obvious. Fig. 2 shows a typical operational type feedback amplifier. If A is large, the closed loop gain G is

$$G = \frac{R_2}{R_1}$$

The capacitance multiplier circuit then becomes that of Fig. 3. It may be seen that resistors R_1 and R_2 shunt the capacitor C. The impedance at the input terminals of the capacitance multiplier may be calculated by assuming a current of one ampere flowing into terminal 1 and calculating the voltage across terminals 1 and 2 (Fig. 4).

$$Z_{in} = \frac{E_1}{I_{in}} = \frac{E_1}{1}\ ohms$$

Setting up nodal equations

$$1 = \frac{(E_1 - E_2)}{R_1} + PC(E_1 - E_3)$$

$$0 = \frac{(E_2 - E_1)}{R_1} + \frac{(E_2 - E_3)}{R_2}$$

$$E_3 = -AE_2$$

The second equation assumes the input impedance of the amplifier is infinite. Solving for E_1 gives

$$E_1 = \frac{R_1 + \frac{R_2}{1+A}}{1+PC(R_1+R_2)}\ volts$$

since

$$Z_{in} = \frac{E_1}{1} = \frac{R_1 + \frac{R_2}{1+A}}{1+PC(R_1+R_2)}\ ohms$$

Dividing numerator and denominator by R_1 and setting $G = R_2/R_1$ gives

$$Z_{in} = \frac{\left(1+\frac{G}{1+A}\right)R_1}{1+PC(1+G)R_1}$$

If $1+A \gg G$,

$$Z_{in} = \frac{R_1}{1+PC(1+G)R_1}$$

This is the impedance of a capacitor $C(1+G)$ and a resistor R_1 in parallel. Hence, the equivalent circuit of Fig. 4 is as shown in Fig. 5.

DEMONSTRATED CHARACTERISTICS

From the above, it may be seen that the capacitance multiplier has the following characteristics:

1. It is capable of multiplying a capacitor by a factor G, where G is the gain of the amplifier.
2. The amplifier must be linear over a range of output voltage from zero to $(G)\ e_{in}$.
3. The amplifier shunts a resistance across the capacitor which must be considered.
4. The time constant of the capacitor and the amplifier output resistance must be much less than the time constant composed of the capacitor and the signal source output resistance.
5. The amplifier must be capable of supplying sufficient current to charge the capacitor at the fastest rate of raise of input voltage expected.

CONCLUSION

From the above, it can be seen that the capacitance multiplier may be used to increase the effective capacitance of a capacitor. In cases where capacity variations are desired, it is possible to obtain the variation by changing the gain of the amplifier by either electronic or mechanical means.

The capacitance multiplier has the disadvantage that the circuitry is much more complicated than that of the equivalent capacitor it replaces. In cases where a large value of capacitance is specified, the capacitance multiplier can substantially reduce the size and weight normally required by the component.

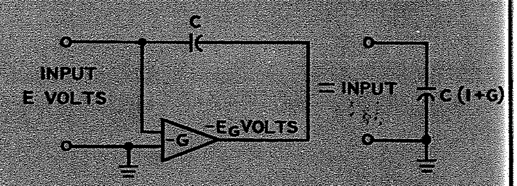


Fig. 1—Basic circuit of the capacitance multiplier.

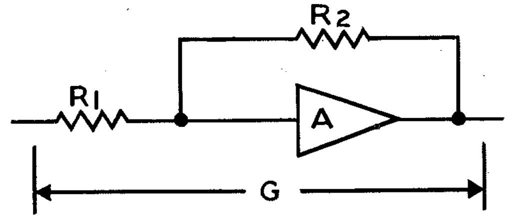


Fig. 2—Typical operational-type feedback amplifier.

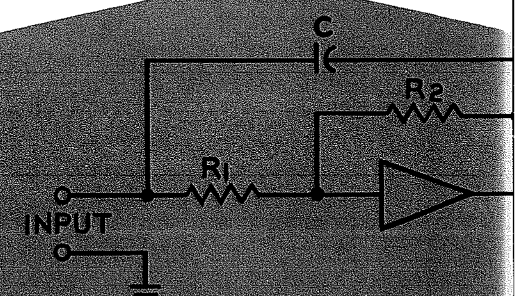


Fig. 3—Capacitance multiplier with feedback.

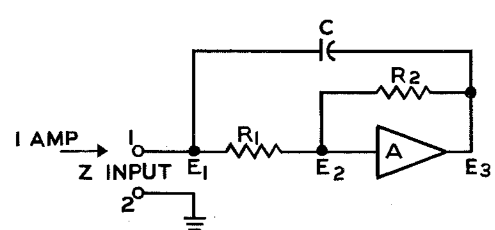


Fig. 4—Method of calculating impedance at the input terminals.

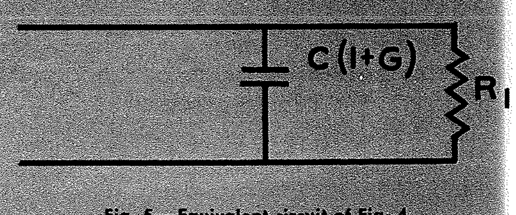


Fig. 5—Equivalent circuit of Fig. 4.

HUMAN ENGINEERING THE BIZMAC SYSTEM

by
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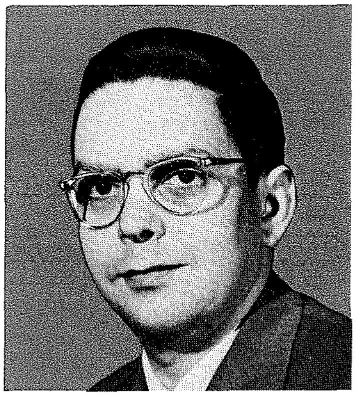


JAMES LEE OWINGS received his BSEE degree from Lehigh University in 1948, and his MSEE degree from the University of Pennsylvania in 1954.

In 1948 Mr. Owings joined the Advance Development section of RCA where he worked on circuit development, analog computer design, and system studies for automatic air navigation systems. In 1953 Mr. Owings became Project Engineer in this work.

In 1954 Mr. Owings transferred to the System Central design and development group in Bizmac Engineering where he assisted in developing the centralized control concept for Bizmac. In 1955 Mr. Owings became Leader of that group.

Mr. Owings is a member of Eta Kappa Nu, and the IRE Professional groups on Engineering Management and Electronic Computers.

The term human engineering is currently applied to nearly any work which is concerned with people and working conditions. This very general use of the term is the result of a growing interest in improving machine designs by studying them from the point of view of the person who will push the buttons and make them do work. Such an approach is a valuable tool for the engineer because it gives him a more complete concept of equipment design. It is also true that the performance of large systems may be critically dependent upon the effectiveness of the operators. Here too, human engineering can lead to better performance, better working conditions, and more economical system operation.

Much of the early work in this new field was done with finished designs of military equipment where operating conditions were poor. The human engineer, in this case usually a psychologist, was given the task of improving the operating conditions so that the equipment capabilities could be realized more fully. This was often a difficult task, because suggestions for improving operating conditions which involved equipment modifications were seldom received enthusiastically. The job of convincing people that the capabilities of the operator should be planned for early in the design of equipment was hard to accept. However, the good results obtained in this early work led to planning for operation at earlier stages in the design of equipment, when more could be done. Ultimately, a field called human engineering was established to solve the problems of designing equipment for the severe operating conditions of the military.

RECENT APPROACHES

In recent years, human engineering has been expanded to include other aspects of system design as well as operator adaptation problems. It is now finding application in commercial systems in which people are important contributors to system performance. The designer of equipment for a commercial application may see little resemblance between the operating conditions for military equipment and his design problems. How then, can human engineering help him? The answer lies in a different point of view of what constitutes an acceptable operating situation for commercial equipment. The customer's long range impression of a system will be largely influenced by such things as: fast, efficient, and effective system operation; simple, straightforward operating routines for the operators to learn, and the low cost, availability, and short training periods for operators. The system designer therefore wants to have the tools at hand to provide these advantages in his design. Human engineering can help to give him these tools.

The questions which the human engineer has to answer when he approaches his part of the design of a system are these:

1—What do people have to do in order to operate this system?
2—What sort of background and training is required for the job?
3—How should the people be organized so that they will work efficiently as a team?
4—How many people are needed to do the job?
5—What are the duties, responsibilities, and specific activities of each member of the operating team?
6—What signals do the operators need for monitoring, and what controls do they need for operating?
7—How should the operator control panels be laid out so that the equipments are easy to operate?

To answer these questions requires a thorough understanding of the capabilities and limitations of people, as well as methods for applying this knowledge to the design of a system. One of the objectives of human engineering is to provide this particular know-how.

The RCA Bizmac System is one example of a fully integrated and human engineered product line of electronic business machines. A review of the human engineering for the Bizmac system which was built for the Ordnance Tank and Automotive Command will show how the questions just outlined were approached in this case. This will give the engineer an appreciation of the usefulness of human engineering without going into the details of methods used.

This particular system consisted of twelve major electronic machines and approximately 200 other fully automatic or semi-automatic equipments. The job for the system was stock control on approximately 250,000 catalog items. People were needed to plan the work for the system, to prepare the data for processing, to operate and maintain the machines, and to collect and distribute the processed data. Large quantities of data

HUMAN ENGINEERING THE BIZMAC SYSTEM

—continued

were processed through the system each day and it was very important that this work be done rapidly and accurately. To do this, the operators had to keep many machines going at once and control the processing of many different batches of data on these machines at the same time. It is easy to see that incorrect or slowly executed machine setups, and the loss or mixup of data could have serious effects on the performance of this system. Human engineering furnished the tools needed to study this system from the point of view of the people who had to run it, to design the machines so that they were easy to set up, and to specify operating procedures which would enable the operators to work quickly with little danger that the mistakes they might make would cause serious damage to data or loss of time.

ORGANIZATION OF SYSTEM

Because the operators were to be major contributors to the overall performance of the system, consideration of them was introduced before equipment designs were solidified. To answer the question, "What do people have to do to operate the system?", performance objectives, function design, and implementation were reviewed, starting at a broad system level and continuing all the way down to the detailed requirements for setting up and operating each machine. This study resulted in organizing the system on the basis of centralized control of operation and establishing a System Central as the integrating element. All system activity was to be directed and controlled from a System Central Control Room. All machines in the system were to be used for processing data whenever they were available. No machines were pre-scheduled for work. The operation of the four major electronic data processing equipments, i.e. the Computer and the Sorters, was directly controlled from the System Central. The other major machines were manually set up and operated on the floor. However, all data processing on these machines was strictly coordinated through the control center. The minor machines, i.e. the tape stations, were operated by the major machine to which they were connected, but the connecting of tape stations to major machines for operation was done from the Control Room. Fig. 1 gives an overall impression of the inter-relationship among all the elements in the system, and suggests how much good system performance is dependent upon successfully integrating the operators into the system. Functional organization, combined with knowledge of machine requirements for set-up and operation made it possible to establish what people had to do in order to run the system. It also supplied a partial answer to the question, "How should the people be organized to work as an efficient and effective team?"

ORGANIZATION OF PEOPLE

To complete the answer to this question, and to gain some idea of how many people are needed to operate the system, the requirements for speed, accuracy, and volume of operator activity were studied. This led to establishing the number of operators needed and determining the duties and responsibilities of each. The personnel were divided into three major groups, i.e. a planning or work preparation group, an operating group, and a maintenance group. The task of the planning group was to specify the data processing job and prepare a detailed and specific set of operating instructions. The task of the operating group was to receive

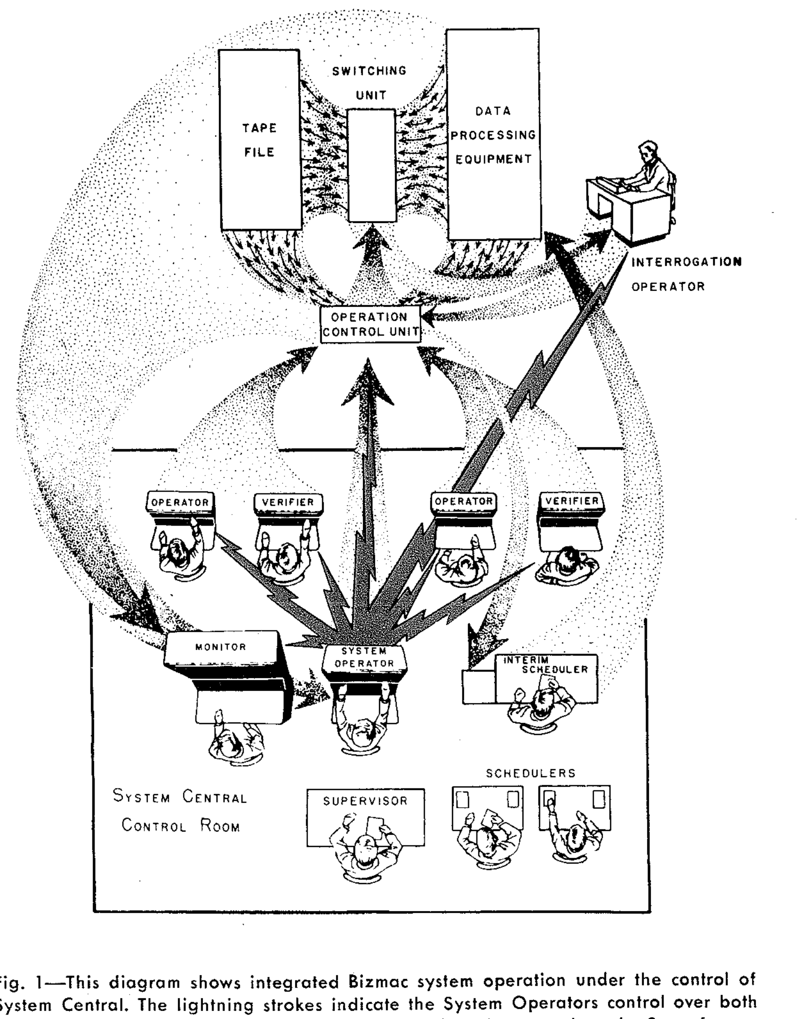


Fig. 1—This diagram shows integrated Bizmac system operation under the control of System Central. The lightning strokes indicate the System Operators control over both the operating team and the Bizmac machines. The broad arrows show the flow of operating instructions from the operating team to the equipments and the feedback from the system to the operators. The Schedulers receive preliminary instructions from the planning group and complete the preparation of operating instructions for the operating group.

the operating instructions, direct, and control the processing of data through the machines. The task of the maintenance group was to repair the equipment.

The operators were further divided into two groups. One group consisted of the System Central operators who directed and controlled the operation of the system from consoles located in the Control Room. The other group operated the Input, Output, and auxiliary machines. The activities of both groups were coordinated through operating procedures, and signals from the machines. A suitable management organization was provided for the supervision of this operating force. This completed the overall organization of the system.

WHAT THEY DO

The System Central control room was the center of all system operating activity. The planning or work preparation group forwarded detailed plans for data processing to the control room, where they were put into effect by the System Central operators. This was a very critical control point for the system because the operation of all machines and the location and processing of all data was directed from this location. It was important that these operators work quickly, keep as many machines busy as possible, and direct the processing of data in an orderly and efficient manner. To do this they needed a pleasant working environment, and a way of working which was simple and straightforward. On the other hand, the system had to be protected from the consequences of errors which the operators might make, and this had to be done without slowing down the rate at which data was able to be processed by the machines in the system. The task for the human engineer included supplying procedural methods for doing work, console designs for operation and monitoring system activity, the proper assignment of responsibility among operators, the proper division of work load among the operators, and the design of the entire working environment.

SCHEDULERS

Fig. 1 shows how the control room was set up for operation. The supervisor was the management representative who directed the operation. The Schedulers received, from the planning group, sets of detailed instructions for processing batches of data; and, from the operating group, both status indications on the progress of work already in process on the machines and indications of tape stations which were available for handling new data. With this information, they completed the preparation of operation cards for all the operators. To avoid the consequences of human error in doing this work, two schedulers were used. They worked independently at filling out identical decks of operation cards and the correctness of their work was checked by the Interim Scheduler, who inspected completed cards for identity and rejected cards containing errors. This procedure, called verification through independent duplication, is a powerful tool for checking the accuracy of operator performance. It enables the operators to work quickly at simple tasks and is quite effective for spotting errors made by either of the two people who do identical work.

The Interim Scheduler controlled the distribution of operation cards to all operators. He had to make sure that the system was ready for each operation before he released the cards. To do this he received operation cards for completed operations from the operators and checked them off against a list of prerequisite operations. Each operation card had a list of prerequisite operations which had to be completed before it could be released. This list was prepared by the planning group and forwarded to the control room as part of the operating instructions. The purpose of the list was to provide a routine procedure for controlling the order in which operation cards were released to the operators and thereby control the order of processing data through the system. When the cards were delivered to the system operators, the system was ready to handle the data as soon as machines were free. The work described thus far required judgment and decision making on the part of the schedulers. Also, there was a considerable time lag between the release of operation cards and the actual set up and operation of the machines. This time lag was a very important factor in allowing plenty of time for judgment in filling out the cards, checking them, and determining when to release each card.

SYSTEM OPERATORS

The actual setup and operation of machines was done by the system operators. These people consisted of a System Operator who selected machines for operation and directed all operation; a Monitor who kept track of the progress of operations in the system as well as the operating status of machines; two teams of Operator-Verifiers who set up machines and

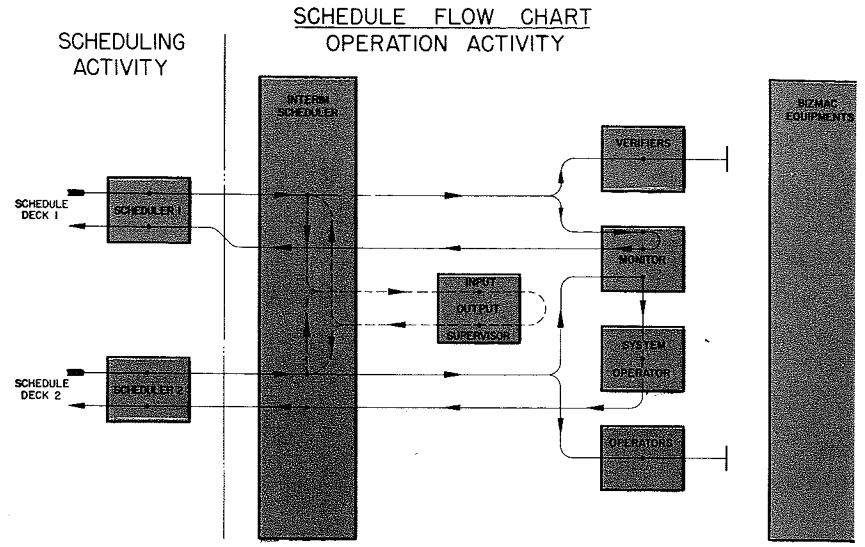


Fig. 2—Schedule Flow Chart—This diagram shows the flow of Operation Cards among the people in the System Central control room and the Input-Output supervisor. The dots on the flow lines indicate points where decisions are made with regard to completing the preparation of the cards or using the cards.

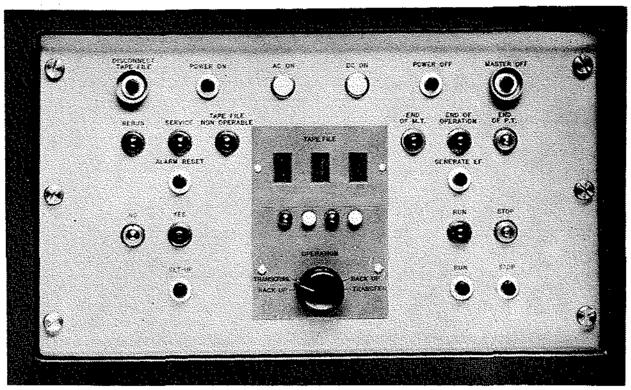


Fig. 3—The control panel for the Paper Tape Transcriber before human engineering design. This is one of the Input machines for the system.

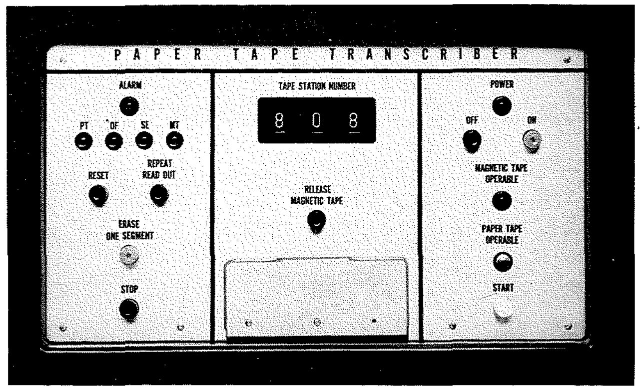


Fig. 4—The control panel for the Paper Tape Transcriber after human engineering design. The organization of the controls and indicators into three areas and the simple sequential arrangement of controls and indicators is repeated on the control panels of all Input, Output, and Auxiliary machines in the system to make learning and operation simple and straightforward.

connected tape stations to machines for operation; and a group of Input, Output, and auxiliary machine operators who set up and operated the machines which were not directly operated from the control room. All the operators worked from operation cards.

The Monitor received operation cards from the Interim Scheduler and checked to make sure that the prerequisites had been met for each operation before he released the card to the System Operator for action. This checking procedure, called double checking, is useful to pick out errors in very simple tasks. It is not so effective as verification through independent duplication, but it is faster.

The System Operator received cards from the Monitor, selected machines for operation, and released the set up to an available Operator-Verifier team. The selected Operator-Verifier team, referred to their operation cards, and proceeded independently to make identical set ups on different consoles. Equipment was provided to check the identity of the set ups, reject errors, and transfer correct set ups to the machines in the system. This was another form of verification through independent duplication, only this time a machine was used to check the identity of the work of the operators. This not only checked the Operator and Verifier but also provided a second check on the identity of the work of the schedulers. When the setups were complete, the Monitor operator checked his displays to make sure that the equipment functioned properly, then signalled the System Operator that the operation was ready to proceed. The System Operator started the machine and then went on to other work. At times of peak activity in the system, the System Operator would have both Operator-Verifier teams busy making setups for different operations at the same time.

The activities of the operators of the Input, Output, and auxiliary machines were coordinated with the control room through the handling of the operation cards. The operation cards contained detailed instructions for machine set-ups and each operator had to supply a written record of certain critical information with regard to how he did his work. This was checked by a floor supervisor before other dependent operations were allowed to go ahead. Fig. 2 shows the flow of Operation Cards among the system operators.

All these operating procedures were reduced to simple routine actions and the procedures were made similar for all operations. This made them easy to learn, and easy to do. The operators at the consoles had very simple decisions to make and could work fast to keep machines busy. The procedures used and equipment checks provided the necessary safeguards to protect the system against the consequences of mistakes made by both the schedulers and the operators. Thus, human engineering provided the know how for operating the equipments and controlling the processing of data through the system in a manner which was easy for operators to learn and do.

EQUIPMENT DESIGN

Further studies were needed to establish how each equipment would provide the signals needed for monitoring and the controls needed for operating the system. The specific requirements for intercommunication among the machines and the System Central was also established at this time. This part of the design was an important factor in meeting the objectives of designing a system which is easy to operate and easy to learn to operate. A brief review of the results of this study will show how human engineering principles lead to good equipment design.

The controls and indicators needed for the operation and maintenance of

Fig. 5—Paper Tape Transcriber—The control panel for the Paper Tape Transcriber has been located at "eye" height for easy viewing, and all the controls for operating the machine are easily accessible to the operator.

each machine were first divided into two classes, i.e. operation and maintenance. Where possible, those needed for operation were grouped on an operating panel and those needed for maintenance on a maintenance panel. The operating panel was made easily accessible to the operator and the maintenance panel accessible to the maintenance man. On the operating panels, controls were limited to a single design of push-button which had a light inside the button. This push-button light was specially designed for the Bizmac system. Indicators were limited to three colors: green, amber, and red. Throughout the system green generally meant go, the situation is normal, or proceed with the operation. Amber indicated normal operation—no operator action required. Red indicated trouble, an operating status which was not normal. The names of similar controls and indicators were made the same on all control panels. Directness of meaning, common usage, and avoiding the use of abbreviations were important considerations in choosing names. Wherever possible, names were placed directly on controls rather than near them on the panel, and words were chosen which directed the operator to take the particular action for which the control was designed; for example, STOP; START; RELEASE MAGNETIC TAPE; RESET; DESIGNATE, etc. Indicators showed the status of the various functions, i.e., AVAILABLE; SELECTED; OPERATING; OUT; LOCAL, etc. All control panels were designed with large readable letters and good contrast between letters and background. Careful attention was paid in the selection of material to avoid glare.

The control panels for the Input, Output, and auxiliary machines were all similar in design and laid out so that an operator could easily learn to operate any machine. The panels were divided into three sections. The section on the operator's right contained all the controls and indicators which were used for normal operation and which were similar among all machines. The section on the operator's left contained all the controls and indicators associated with abnormal, or faulty operation. Wherever possible, the indicators for similar functions on the right and left side were opposite each other to make it easy to notice the cause of trouble. The center section of each panel contained the controls and indicators

Fig. 7—System Operator Console—The System Operator directs the operation of the system from this console. She determines which operations to initiate, dispatches machine set-up tasks to the other members of the operating team and controls the operation of the machines in the system.

which were peculiar to the specific machine or were placed there to focus attention.

The basic pattern for arranging the controls and indicators followed the simple sequence; (1) An indicator to indicate the requirement for operator activity; (2) A control to effect the required action (push-button); and (3) a feedback (light inside the push-button) to indicate the successful accomplishment of the act. Where possible the controls and indicators were arranged in sequences from top to bottom or left to right in the order of normal use to guide the operator and provide simple habit patterns. This procedure makes machine operation simple, straightforward, and easy to learn. When followed on all machines in the system, each operator could easily learn to operate any machine. Operators were interchangeable. New operators could be quickly trained.

An example of the control panel for the Paper Tape Transcriber will illustrate some of the human engineering design features which were just mentioned. Two panels are shown for this machine to emphasize the value of styling, proper panel layout, and lettering. Fig. 3 shows the panel before human engineering design. Fig. 4 shows the panel after the studies had been completed. The basic design shown in Fig. 4 was used on all Input, Output, and Auxiliary machines in the system. Fig. 5 shows the location of the control panel on the machine. The panel was placed at eye height for easy viewing, and all

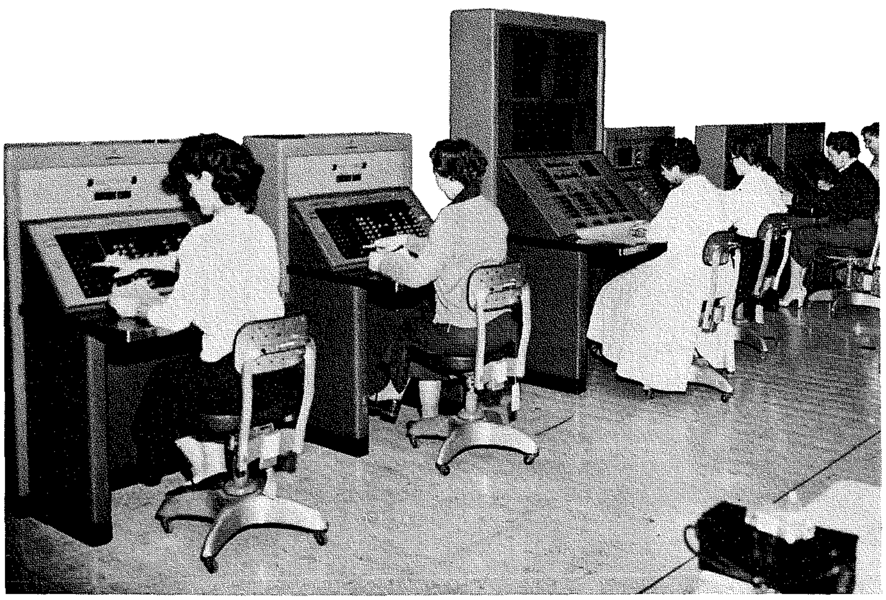


Fig. 6—System Central Control Room—The control room is completely enclosed to provide a quiet working environment for the operators and air conditioned for comfort. Close attention was paid to proper lighting and the choice of colors to make the room pleasant to work in and the consoles faces easy to read. The operator consoles are located on the right and the two corresponding verifier consoles on the far left. The Monitor Console is the large console in the center and the System Operator Console is located to the right of the Monitor. All the consoles were designed for optimum operator comfort in working with the controls and indicators.

the controls for operating the machine are easily accessible to the operator.

DESIGN OF CONTROL ROOM

Because the control room was the center of system activity it was important that the working environment be pleasant. The human engineers, therefore, carefully selected colors and materials for floors, walls, and ceilings; lighting; and the arrangement of all consoles and desks, so that the room would be quiet and pleasant to work in.

CONSOLES

The design of the consoles for the operators who worked in the control room was an important factor in making the work easy for the operators and enabling them to work quickly and accurately. Examples of console designs for the system operators is shown in Figs. 6 and 7. Fig. 8 is a close-up view of the System Operator's console. On the left side of the vertical section are status indications for the most heavily used machines in the system. On the right side of the same panel are control buttons for the more important machine functions. In the center of the sloping panel is a register control for indicating the operation the System Operator wants to initiate, and for selecting the machine he wishes to do the work. On the right and left sides of the same panel are the team control sections. The controls and indicators on these panels are arranged in the sequence of normal use and follow the same design principles mentioned previously in connection with the design of the control panels for the Input and Output machines.

Fig. 9 shows the control panels for the Operator-Verifier consoles. The vertical panel contains directions for action and registers for displaying the number of the operation card which is to be used for the machine set-up. The sloping panel contains the controls used for connecting tape stations to machines and for setting up the Computers and Sorters. The controls are arranged for sequential operation from left to right. Color is used to separate the function of tape connection from machine instruction and indications are provided to tell the operator whether or not his work is in agreement with his partner. A call button is provided to signal the System Operator if there are operating difficulties. To make the work at these consoles even easier, the operation cards were designed so that the information was displayed on the cards in the same arrangement as the controls on the console.

Fig. 10 shows the control panels for the Monitor Console. The vertical panel shows the operating status of each tape station in the system and the sloping panel shows the operating status of the Sorters and Computer and the status of the data processing operation which is in progress on each of these machines. Both the control panels and the size and shape of each console were human engineered for comfort and ease of operation. This completed the design of the System Central control room from the human engineering point of view.

MOCK OPERATION

When this effort was completed, the human engineering of the system was well advanced. It was now necessary to set forth the detailed description of the duties, responsibilities and specific activities of each operator in the system and examine it for completeness, uniformity, and simplicity. The proposed working system was now ready for final test and adjust-

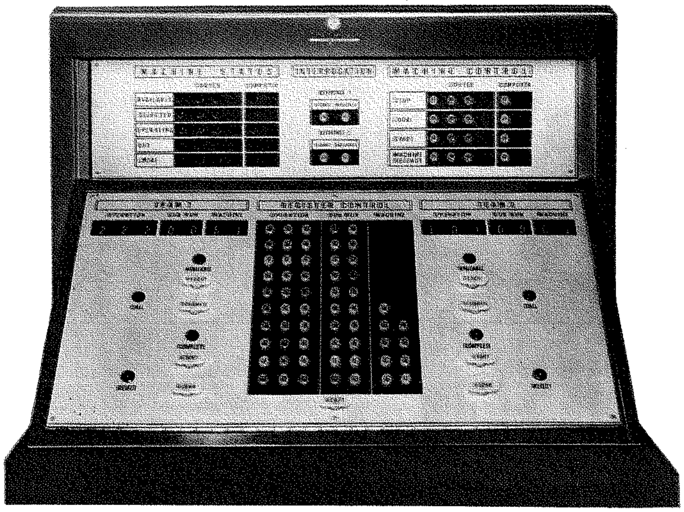


Fig. 8—System Operator Control Panels—These control panels show the location of the controls and indicators used by the System Operator. They have been human engineered and styled to make operation simple, direct, and easy to learn.

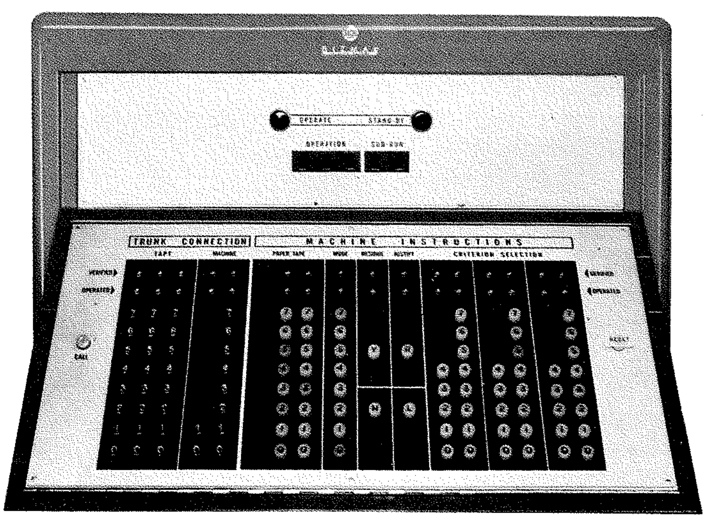


Fig. 9—Operator-Verifier Control Panels—These control panels show the location of the controls and indicators used by the Operators and Verifiers. The information is arranged on the operations cards so that it can be transcribed directly into the controls, knowledge of special codes is not required. All the information necessary to operate this console is supplied on the control panels and operation cards so there is no need for verbal communication.

ment. This was accomplished in several phases. The first phase consisted of setting the system up in mock and simulating operation; (1) to test the operating procedures, (2) To get some measure of operator load at the various operating positions, (3) To see what the effects of equipment breakdown were on overall system performance, and (4) To get an indication of the adequacy of the proposed operator and machine complement.

The time required to process each batch of data on each machine and other operation characteristics had to be based on knowledge of similar machines and on design objectives for this test because none of the machines existed at the time this mock operation was run. However, this technique of operating the system on paper did provide a means for working out rough spots in the operating procedures, and for giving a first approximation of the operating characteristics of the entire system at an early enough stage in design so that misadjustments could be spotted and corrected before the fabrication of equipment was completed. It is true that very little information is available for conducting this kind of a test and great care must be exercised in making assumptions and evaluating test results. However, the economical importance of catching oversights before equipment fabrication is completed is a very important aspect of system design, and warrants considerable attention at this time.

FINAL ADJUSTMENTS

The remaining phases of adjustment are connected with actual operating situations. The human engineer should be on hand throughout the setup and shake down of the system to solve problems and make final adjustments in procedures and equipment provisions. This is a very important phase for the system because the entire system is going through the transition from design objective to actual operation. If this is not a carefully controlled transition, the entire workability of the system can be seriously affected, and even lost.

Fig. 10(a)—Vertical Section of Monitor Console—This control panel provides the Monitor with the information necessary to keep track of the operating status of the Tape Stations in the "Reference 'and' Tapes in Process" files.

SUMMARY

This resume of the human engineering of the particular Bizmac system which was designed for the Ordnance Tank and Automotive Command has shown that human engineering includes many aspects of system design and when undertaken early in the development of a system, can contribute heavily to overall workability, reliability, and economy. The knowledge available in this new field combined with the techniques for applying it to design problems is an important tool for the engineer, because its use leads to a more complete concept of system design. The complete human engineering of this very large system was not the work of one man or even one small group of men. It required the assistance and understanding of all people working on the project. Particular credit goes to the members of management who had the foresight to introduce the concept of human engineering into the design of the RCA Bizmac system, to the members of Dunlap and Associates who spearheaded the design work, and to all the members of the Bizmac Engineering group who supported the effort.

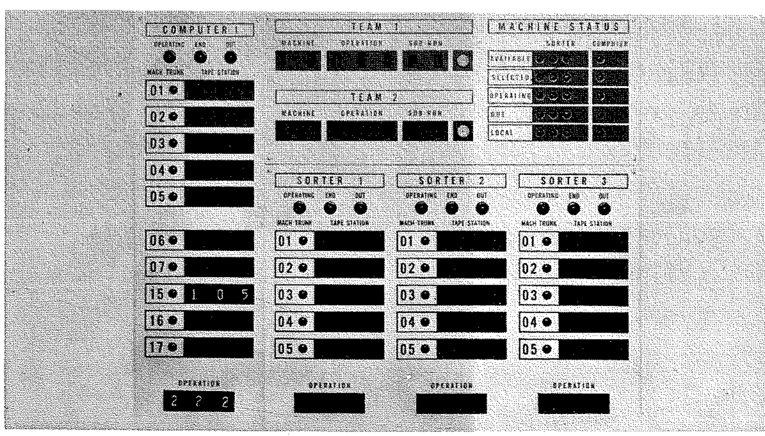
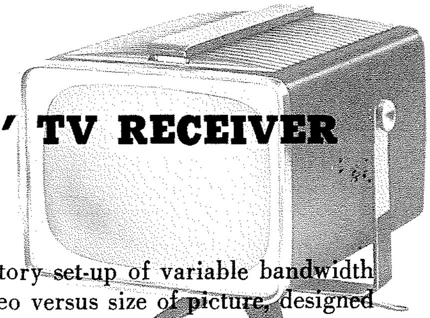


Fig. 10(b)—Inclined Section of Monitor Console—This control panel provides the Monitor with the information necessary to keep track of the operating status of the Operator-Verifier Teams, and of the operations which are in progress in the Computer and Sorters.

DEVELOPMENT OF THE RCA "PERSONAL" TV RECEIVER



by **SIMEON I. TOURSHOU, Mgr.**
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Cherry Hill, N. J.

PROLOGUE—In looking back, the engineering of the Personal TV presents an interesting paradox, which taught us much. We should like to pass this on for whatever benefit other engineers might receive from it.

Our case in point . . . Regression in receiver picture size, in itself, is not difficult for the development or design engineer to accept; but the consequent compacting of a receiver design to the extreme appears, in many ways, to conflict with the evolutionary and currently accepted "axioms of prior art" to which the design engineer is dedicated. The development engineer, while respecting the **cans** and **cannots** of a prior art, is also aware that under their influence he can become addicted to "prior artistry" himself. The Portable TV is quite a departure from currently accepted "state of the art" trends. By compromising in the middle ground of both design and development thinking, a yielding, conservative approach was taken in working within the severe package dimensions and established performance characteristics. The resulting product successfully brings together past experience and a new concept.

It is a credit to the members of the engineering team who worked on the Personal TV design, who realized the problem existed, considered it objectively and used the problem to harmonize their effort, rather than hinder it.

THE RCA EIGHT-INCH "Personal" is believed to be the smallest and the most compact television receiver on the market today. It is the embodiment of a circuit economy in TV design that has never been approached heretofore.

Intended, at the time of its inception, to utilize only 12 tubes, as compared to the 19 tubes plus a crystal of the smallest (at the time) RCA 17-inch receiver, the "Personal" wound up, finally, with 11 tubes, four crystals, and a selenium doubler (the equivalent of 14 tubes) in a package of approximately 1/5 of the 17-inch set in volume, and performance and sensitivity quite comparable to the 17-inch set from the standpoint of normal utility.

The small portable was a challenge from the time it was conceived in a skeletal form. Could high performance be obtained in the small dimensions desired? If so would the Public accept it? After careful study, a prototype was presented to top management, and the project was given their blessing. The continued encouragement and guidance of Engineering management played a very important part in carrying it through to successful completion.

Some conflicting opinions arose in the early design stages of the Personal TV. The smallest RCA receiver at the time, a 17-inch set, represented the minimum standard of performance that was considered to be acceptable. A picture smaller than 17 inches was believed to be a thing of the past; picture brightness lower than that afforded by a minimum of 12 or 13 kilovolts, a resolution below 300 lines, or sound output appreciably less than a watt were considered to be out of the question. The consensus, both within the Company and in the Industry, was that little could be done to advance the state of the art except through small evolutionary changes, on which the Industry had been working very hard right along.

Against this consensus, the Product Development activity of Black and White Television Engineering advanced a supposition that the "Big Boss", the Public, might have a different view. That, having conceded some minor reductions in performance of radios in return for reduction in size, cost, and weight, the Public was ready for a similar step in TV: that a compact, light-weight, and relatively inexpensive package, for use at shorter viewing range than the larger sets, and therefore with correspondingly smaller picture and lower sound volume, could be successfully introduced.

EARLY INVESTIGATIONS

Evaluations and demonstrations of the above points were started with a laboratory set-up of variable bandwidth video versus size of picture, designed by B. E. Nicholson, and of a very narrow, but very high-gain single-stage i-f amplifier by D. A. Comninos. These demonstrations proved quite conclusively that reduced bandwidth on a reduced-size picture meant a loss of only some finer detail, but not of the apparent overall sharpness; provided the overall "square-wave" response was corrected by adequate peaking of the higher video frequencies, and was free of any "smear."

An examination of this picture revealed a certain objectionable behaviour of phase response with adjustment of the fine tuning control. As a result of this analysis, corrective measures were instituted through partial staggering of the i-f circuit responses. When demonstrated to management, the pictures were concluded to be thoroughly satisfactory for commercial usage; particularly in view of the fact that all important transmitted information is generally carried by the lower-frequency end of the video spectrum and that some picture degradation due to loss of high frequencies is not objectionable on the 8-inch screen.

Fig. 1 illustrates the greater importance of adequate peaking and "square-wave" response over that of bandwidth response on the apparent sharpness of the picture.

There were two factors that finally determined the size of the "Personal": (1) the width of the smallest available tuner, which had to be nested beside the kinescope neck, and (2) the qualitative evaluation by management of the picture and package as a whole. The choice of the 8-inch kinescope as the smallest practicable size proved to be a wise one, for even with the small number of tubes and components, this minimum package has little room to spare.

THE CHALLENGE OF CIRCUIT LAYOUT

The various aspects of physical development of the chassis in locating the various functional groups of components were that they should be located: (1) in the most logical positions that the space would permit; (2) in such positions that the heat generated and radiated by some would not be harmful to others, and so that the ventilation in the cabinet would have the greatest cooling effect; (3) in such positions that the effects of the high-power stages, such as the horizontal deflection, on points of high sensitivity, such as the picture detector, could be made negligible, and (4) in such positions as would allow greatest ease of manufacturing, and of serviceability in the field.

KINESCOPE DEVELOPMENT

Since the largest single component was the picture tube itself, it was essential that its contours be designed to provide maximum conservation of space without materially adding to necessary circuitry. This was achieved through the cooperation of Mr. C. W. Thierfelder, Manager of Black and White Kinescope Design at the Tube Division in Marion, Indiana, and whose efforts in every phase of development of the 8-inch kinescope have produced a picture tube of excellent quality and value.

Because the non-aluminized kinescope was used in the final design, a higher ultor voltage was required. This higher ultor voltage was somewhat greater than the value which would have been most economical to utilize.

DEFLECTION PROBLEMS

The problems of horizontal and vertical deflection and high voltage were assigned to H. D. Twitchell, Jr., who first started along the lines of sinusoidal scan, demonstrated by C. M. Hunt of Product Design a few years before. Mr. Hunt had shown that by blanking every other trace of the sinusoidal scan, and discarding the crowded edges, it was possible to obtain a usable picture on a wide-angle tube. But as quality requirements for the "Personal" were raised, it became apparent that standard circuitry would have to be used.

Proceeding along conventional lines, Mr. Twitchell evolved a horizontal deflection transformer and circuit layout that are unique in compactness and shape, to fit the limiting clearances around the bell of the kinescope. Since the +B and filament power consumption of the deflection section of a receiver is generally be-

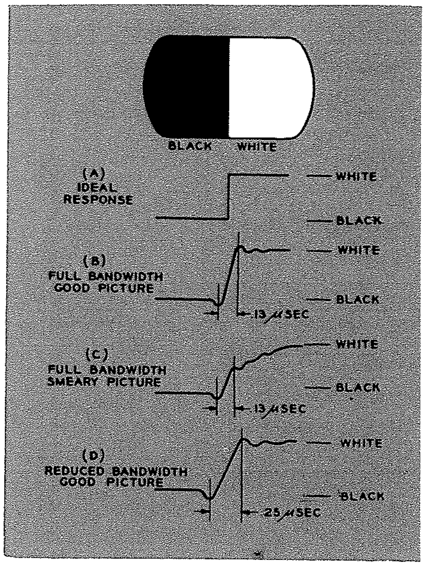


Fig. 1—Illustration of "edge sharpness" of picture detail as a function of receiver square wave response. (a) shows infinite rise time in black to white transition; (b) indicates a rise time close to system capabilities; (c) shows poor rise time due to inadequate high-peaking—transition depends on low frequency response, creating smear; (d) indicates linear transition from black to white (good picture) but with less detail due to longer rise time.

tween 1/3 and 1/2 of total, the overall heat problem of the "Personal" demanded the utmost in power economy, particularly in the horizontal deflection stage. Space limitations and the relatively short arcing distances required extensive overvoltage and altitude chamber tests to insure adequate margins of safety. H. D. Twitchell is shown in Fig. 2, with H. A. Bond, technician, who assisted in preparation of the high voltage transformer samples and did the wiring of most of the "front" chassis units.

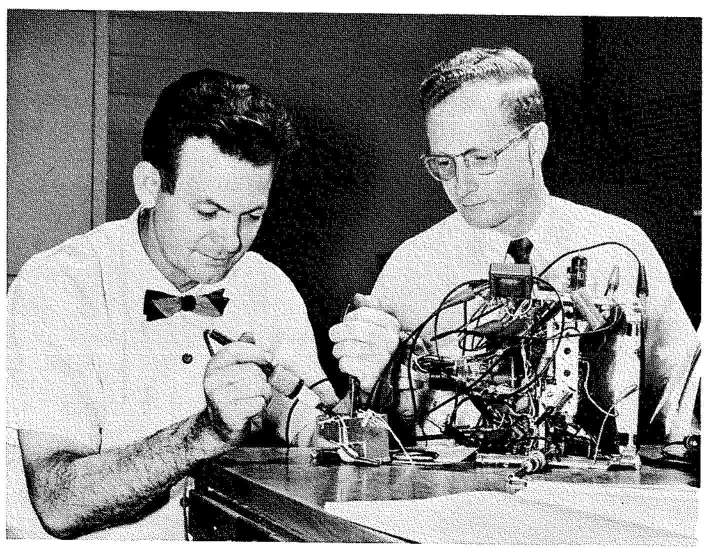
RADICAL SOUND CHANNEL DEVELOPED

Development of what is believed to be the most economical sound channel in any commercial TV receiver was carried out by E. B. Smith (Fig. 3). In spite of space, voltage, and power limitations, he obtained the needed sensitivity and quality using a single dual-function tube and three crystals, and by reflexing the low-level audio through the 4.5 megacycle i-f pentode. This reflexing, or re-using of the 4.5 megacycle amplifier a second time, for audio, brought in some new problems. Intermittent "Holes" in the carrier envelope were caused by excessive plate swing with pulses of audio in series with the tuned circuit. The "Outer grid effect" (electrons returned to the #1 grid region by the negative excursion of the outer-grid, i.e., plate, in this case) also occurred, aggravated by the combination of low plate voltage and high plate impedance, which was needed for the sake of sensitivity. Teaming up with Mr. Comninos, who handled the development of the picture i-f and the second detector, he established the criteria for adequate sound sensitivity without interference of sound with the picture.

I-F PERFORMANCE

A "Sound bump" circuit was added by Mr. Comninos in the first i-f stage, to peak up the sound carrier and to provide additional gain. A boost in sound gain was required because the narrow over-all band width, necessary to achieve the sensitivity for the picture, allowed less gain for

Fig. 2 — H. D. Twitchell (right) and H. A. Bond making wiring changes in the high voltage transformer in a developmental set-up.



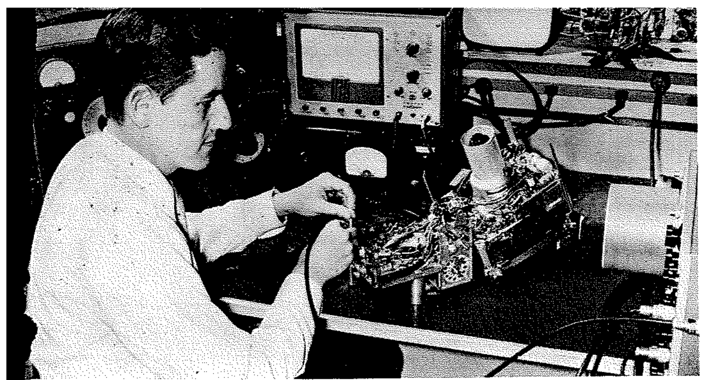


Fig. 3a—E. B. Smith conducting response tests on the ratio detector.

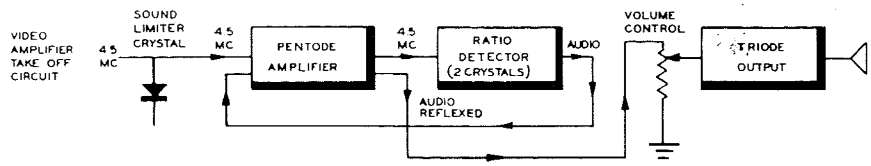


Fig. 3b—Block diagram of the sound reflex amplifier.

the sound i-f carrier. The cost of the "bump" circuit was small compared to that of the full stage that would have been needed for a similar result. The overall i-f curve (composite of the converter, the first i-f on the tuner, and the second i-f on the chassis) is a rather sharply pointed "haystack", and it required extensive studies of a number of possible alignment techniques, with a view of obtaining maximum sensitivity on weak signals, yet allowing maximum shift and widening of the curve as the AGC bias is increased. D. A. Comninos, who handled all these problems, is shown in Fig. 4 checking the overall alignment of a production unit.

R-F PERFORMANCE

The problems of r-f performance were assigned to G. E. Skorup. In a series of carefully planned comparative tests of various types of tuner arrangements, he proved out the advantages of the one proposed by J. C. Achenbach's Tuner group, and was quite instrumental in its final adoption. In its application to the chassis, as well as modifications of the input circuit and filters, extensive coordination between Mr. Skorup and L. A. Horowitz and R. Barone of the Tuner group was required. Mr. Skorup also contributed to the development of the raster centering attachment and mounting, and of the beam bender and its adjustment. The latter was made difficult by the shielding enclosure of the kinescope neck. Fig. 5 shows Mr. Skorup measuring light output versus adjustment of the beam bender.

OVERALL PERFORMANCE AND DESIGN

The overall operation of the receiver, as well as the "square-wave" response, synchronization, and stability of the picture were handled by B. E. Nicholson. Overall receiver operation included the problems of heat, both of the components and the cabinet, and of electrical interferences between functional sections. The compactness of the chassis, and the proximity of high-power deflection circuits to picture detector required the use of a shield over the yoke; the proximity of the power transformer to the kinescope neck required the use of a shield over the neck. The temperature rise of the power transformer, the effect of its heat, and of heat from the deflection tubes on the walls of the cabinet, and the shape and size of ventilation louvers, all required extensive heat runs. Some rearrangement of components was necessary before satisfactory results were finally obtained. In these heat runs he was assisted by R. A. Bowen, technician, who also wired the "rear" chassis, assembled the complete chassis and instrument, and collected the wiring information. Fig. 6 shows Messrs. Nicholson and Bowen with one of the developmental chassis in an unfolded position, examining a problem in wiring.

MECHANICAL DESIGN

E. C. Lick, Mechanical Engineer, was assigned to the mechanical design of the overall instrument, including the chassis and the cabinet. Ably assisted by R. A. Norman, also of the Mechanical Design group, and by J. D. Luber and F. G. Schobel, of Drafting, he faced the very difficult task of meeting the spacing requirements for a number of electrical components in the chassis design, which resulted in a three-level "front" base. The cabinet styling requirements were solved to include a very special shape of louver to ventilate the chassis. The "rabbit-ear" antenna also presented serious problems, particularly of electrical contact between several sets of parts. The interlocking of the power lead-in between the cabinet and the chassis proved to be a problem point because of safety margins required under limited space conditions. The excellence of the solutions to these problems is a credit to the mechanical design team who solved them.

FIELD TESTS

Field tests of the circuits in various stages of development were conducted in a number of locations under various conditions of reception. Evaluation of picture and sound quality, of overload and cross-modulation

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

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

characteristics, of sensitivity, selectivity, noise immunity, airplane flutter, and of the effects of various alignment procedures, and combinations of video peaking on the sharpness of the pictures obtained from various transmitters, was almost a continuous process. Facilites of the RCA Service Company's Browns Mills Laboratory, strategically located as "semi-fringe" for a large number of stations, were used again and again. The assistance of E. A. Hilderbrand and W. G. Manwiller, RCA Service Company Quality Control, and their wide experience in field testing were valuable contributions.

Among other types of tests, particularly exacting were those required by the Underwriters' Laboratories, (see J. W. Fulmer's article in Vol. 1, No. 3, RCA ENGINEER), and in these the guidance of Mr. Fulmer, of the Engineering Services, played a most decisive role. The assistance and guidance of F. B. Stone, the tube coordinator for TV Division, in various problems of tube and crystal application have also been invaluable.

The work of L. T. Fowler and his Components group, particularly of A. C. Thompson and K. G. Weaber, in obtaining and maintaining the uniformly high quality in the new and physically smaller components has been responsible for the relative freedom from trouble in the factory, as also were the efforts of J. M. Wright and his Resident Engineering group in Bloomington, and particularly C. J. Blume in piloting the factory into smooth and uniform production.

In conclusion, the RCA Personal TV presents a relatively new concept in television home viewing. It is the first set on the market to provide true portability and small-set convenience, modestly priced for the "second-set" market. The teamwork that developed in the design engineering phases helped promote a greater understanding between the members of the Produce Development group and between this group and others who contributed their specialized knowledge to the project.

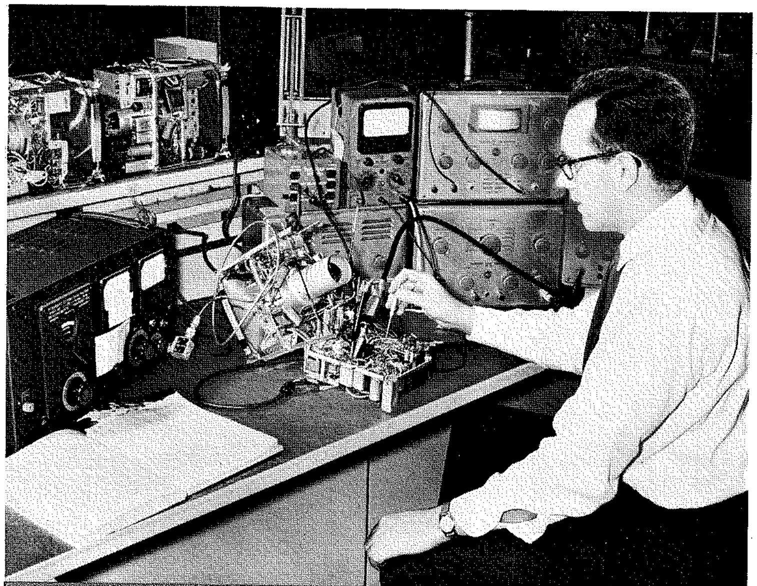
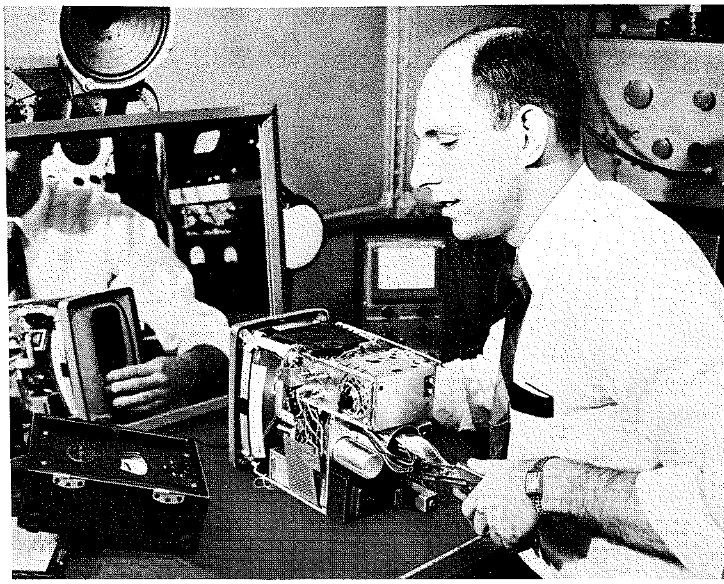


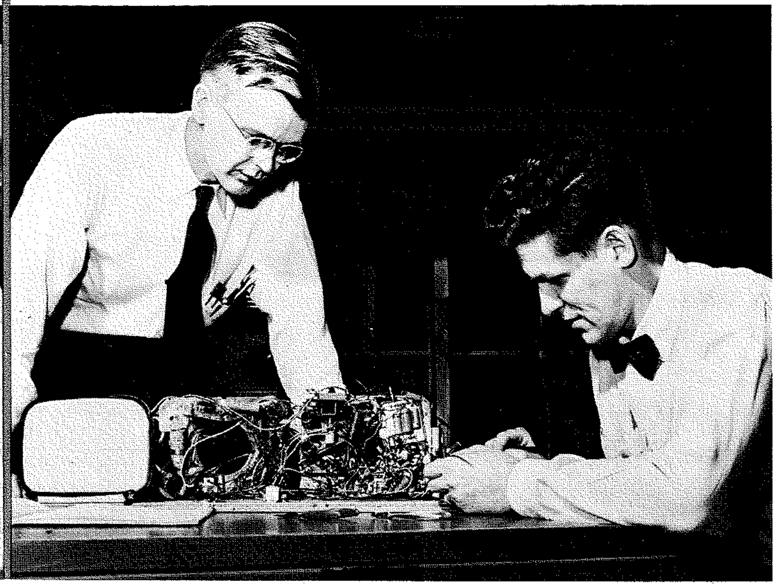
Fig. 4—D. A. Comninos checking overall receiver alignment. Particular care was taken in this phase of design to provide a convenient alignment procedure.

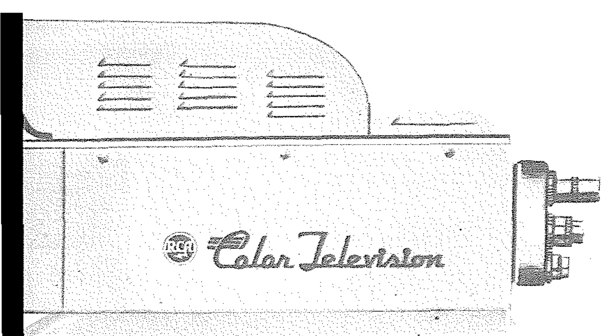
Fig. 7—Group meeting of Product Development, discussing the final design of the Personal TV. Left to right: B. E. Nicholson, R. A. Bowen, D. A. Comninos, H. D. Twitchell, Jr., G. E. Skorup, E. C. Lick, H. A. Bond, F. G. Shobel, J. D. Luber, S. I. Tourshou, Mgr., and E. B. Smith.

Fig. 5—G. E. Skorup measuring light output versus ion-trap magnet adjustment. Notice the special tool for adjusting the ion-trap inside the kinescope neck shield.

Fig. 6—B. E. Nicholson (left) and R. A. Bowen examining an early "breadboard" version of the Personal TV. This "unfolded" set-up provided ease in accessibility to all components for test.







DESIGN TRENDS IN COLOR TV STUDIO EQUIPMENT

by **A. C. LUTHER**
TV Terminal Engineering
Commercial Electronic Products
Camden, N. J.

During the past ten years we have seen monochrome television broadcasting grow into a great and thriving industry. The electronic equipment upon which this industry is based has been developed to the point where high quality picture transmission is commonplace. Now the television industry faces an even greater opportunity with the development of compatible color, which can further broaden the entertainment and advertising possibilities of the medium. However, color brings with it a whole host of new problems of greater equipment complexity, greater operator skill, higher programming costs, and more critical signal transmission requirements. It is the responsibility of the designers and manufacturers of color broadcast equipment to provide cameras and signal handling equipment which can produce the same high-quality performance that we have come to expect from monochrome equipment. This paper will show some of the steps which have been taken toward meeting that goal.

HOW DOES COLOR DIFFER FROM MONOCHROME?

The problems of color broadcasting may be divided into two general areas. These are (1) the pickup of the image and generation of the composite color signal by the camera equipment, and (2) the subsequent handling of that signal by the switching, distribution and transmission equipment. Fig. 1 shows a typical equipment arrangement for a color-originating studio and traces the signal path to the transmitter. It may be seen here that the signal handling problem is enhanced by the great number of units which may appear in series in the signal path for this part of the system. This becomes serious because most of the signal distortions encountered in handling the composite color signal are cumulative. Let us briefly consider the character of the problems in these two areas.

(1) *CAMERA PROBLEMS.* Color television cameras contain three pickup devices associated with the three primary colors red, blue, and green. These signals pass through three parallel channels until they reach the colorplexer, where they are matrixed to form the standard composite color signal. In the camera we then have the problem of generating and handling three separate television signals which must be precisely matched, or in "register." Within the colorplexer, the problems are those of precisely combining these registered signals in accordance with the color signal specifications.

(2) *SIGNAL HANDLING PROBLEMS.* At the output of the colorplexer the color picture information appears as a single composite signal and the problems now are different. In order that the various components of the color signal do not intermodulate with one another and produce color distortions, the system must meet difficult requirements of differential gain and phase. Furthermore, up to and within the switching system, the overall phase shift of the system at color subcarrier frequency must be closely matched through the various paths if the usual programming techniques of lap dissolves and keyed effects are to be possible. In the entire system, the frequency response, both amplitude and phase, must be carefully controlled, (principally because of the color information which appears at the high end of the pass band) and must not become distorted relative to the monochrome information which occupies predominantly the lower end of the frequency spectrum.

The cumulative character of most of these signal handling distortions, and the large number of equipments which may appear in series in a signal path, requires that individual units must be designed, built, and tested for distortions which are near the limit of our ability of measurement. This problem has prompted a considerable amount of activity in development of new test equipment.

COMPATIBILITY

By virtue of the compatible nature of the color signal, it is desirable that all signal handling equipment now being produced (even for monochrome use) should be "good for

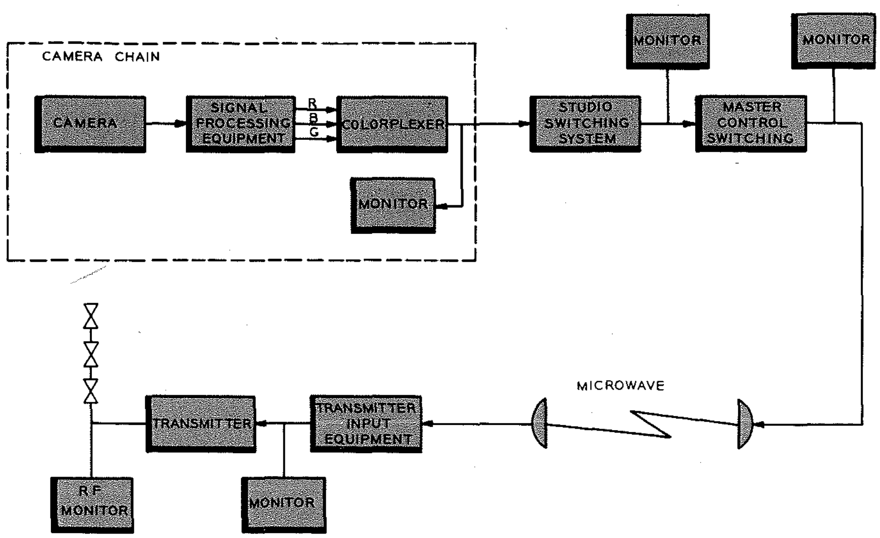


Fig. 1—Block diagram showing the major equipment units of a color signal generating chain and transmission path.

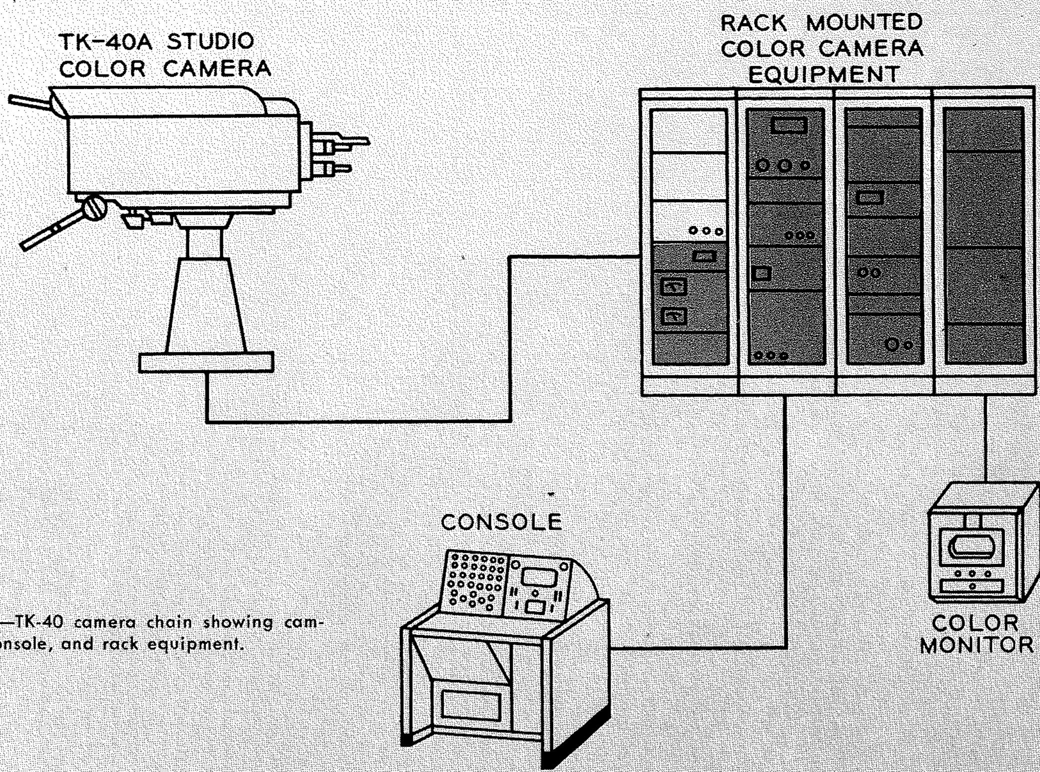


Fig. 2—TK-40 camera chain showing camera, console, and rack equipment.

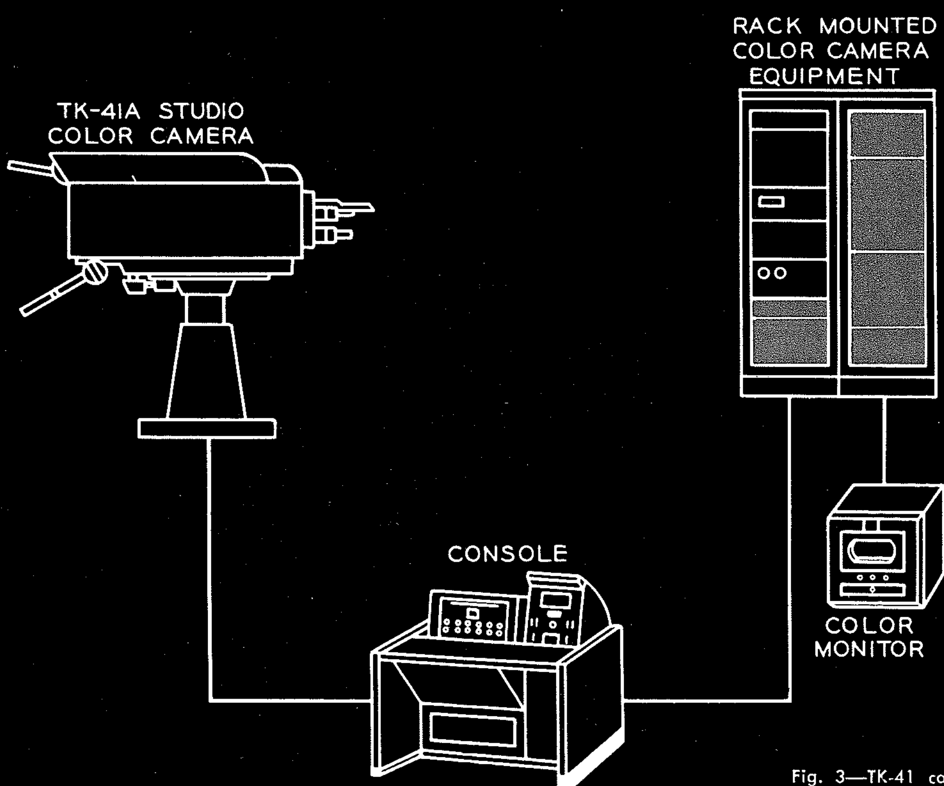


Fig. 3—TK-41 camera chain of the same configuration as Fig. 2. Notice the reduction in rack equipment.

DESIGN TRENDS IN COLOR EQUIPMENT—
continued

color" to the extent that future addition of color to an existing station should not make this equipment obsolete. This factor alone represents a tremendous challenge to the television equipment designer.

CURRENT DESIGN STATUS

As an example of what is being done with the design of color equipment, let us consider the live pickup color camera chain. The first such equipment placed on the market was the RCA TK-40A chain which performed all of the functions shown within the dotted lines of Fig. 1. This equipment is used by the networks and independent stations who pioneered in color origination. It is capable of high quality performance and is in use today for many of the color schedules which are currently being produced. Being the first such equipment, however, it suffered from many problems, which when solved led to a large and complex equipment arrangement. Fig. 2 is a drawing of the TK-40A equipment showing the camera, and the rack and console mounted equipment. Fig. 4 is a block diagram of the same system. The TK-40A is basically a very flexible system in that the various units may be arranged without much regard to location or cable lengths. However, just the fact that there are so many units indicates a serious excess of cables, video output stages, and remote control functions.

The control portions of the color camera system have recently been redesigned with an overall integrated approach. Figs. 3 and 5 are a sketch and diagram for this new system, designated the TK-41A. The simplification of interconnection is immediately evident. Both systems use the same basic camera; in fact, they are physically identical and contain only minor electrical differences. The control functions of the TK-41, however, have been integrated into one unit, called the Processing Amplifier. Referring again to Fig. 4, the dotted lines show the portions of the system which are replaced directly by the processing amplifier. As can be seen from Fig. 6, this unit, which contains all of the electrical processing and monitoring of the red, blue, and green video signals is console mounted, so that remote controls are eliminated. Remote controls for the camera itself are mounted on a matching control panel, which contains no tubes, so that these two units form an integrated control position. Rack mounted equipment in the new system includes only power supplies and the colorplexer.

Although this system provides spectacular savings in number of tubes, power, and size over the previous equipment (which may be seen in Table I), the most important improvement from the standpoint of the customer is the greater operator convenience and equipment stability which has been provided. Particular emphasis was placed on stability in the circuit design in order to eliminate operator adjustments which compensated only for circuit drift. The monitoring system was thoroughly analyzed and revised to eliminate setup adjustments to the extent that only two knobs need be adjusted to calibrate the entire monitoring system. Push-button monitoring switching was provided and two special positions were added which produce a null-type display in order to facilitate making and checking the two setup adjustments. Fig. 6 is a closeup of the processing amplifier panel which shows the push-button monitoring switch and the screw-driven setup adjustments. There are only two other setup adjustments, requiring less frequent attention, which have not been brought to the front panel.

The need for a substantial gain in system simplicity and operational convenience was felt so great in color camera control equipment that some of the trends which have been developing in studio equipment design were actually resisted in order to achieve the overall goal with circuits available at the present state of the art. For example, the goal of camera control equipment for the past several years

ABOUT THE AUTHOR

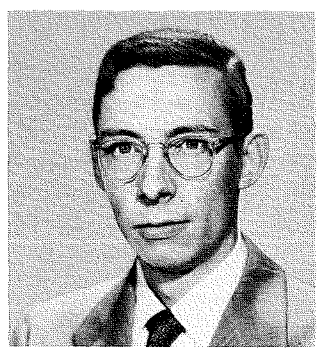
So that the objective of the RCA ENGINEER to publicize the achievements of RCA engineers may be accomplished, it seems in order to comment on the author of the article on "Trends in Design of Color TV Studio Equipment."

Mr. Luther received his college training at M.I.T. and has a BSEE degree. Early in his post-college experience, he participated in the technical operation and maintenance work in one of the Philadelphia stations, WFIL-TV, where he acquired practical acquaintance with equipment and with the operator's point of view. It would be difficult to visualize a more useful background for engineering development and design of studio equipment. Not every embryo engineer has an equivalent opportunity of course, but the value of such practical experience in molding the point of view cannot be overemphasized.

Coupled with this basic training, Mr. Luther has brought to his present job an unusually keen intellect, an excellent "sense of direction" in dealing with circuits, a creative attitude, and an unlimited interest in both the details of circuit performance and the broad aspects of system integration. Thus equipped, he has advanced with unusual rapidity in capability and productivity, and is in constant demand to consult on problems running the whole gamut from circuit design to system planning.

Though it is not revealed in his paper, he is responsible, probably more than any other one person in Broadcast Studio Engineering, for the adoption and expanding use of stabilized circuits in this type of equipment. The simplification of the color camera control equipment, which he has used as an example, is largely a child of his own fertile thinking. His vital interest in the broad application of such circuits has inspired many of his co-workers to enlarge their horizons along similar lines. The resulting influence on the product line has been an important factor in maintaining RCA's leadership in the field.

Mr. Luther's paper is actually a summary of his own typical thinking and planning which led to the developments described. His achievements and recognition are an indication of the possibilities open to every RCA engineer.



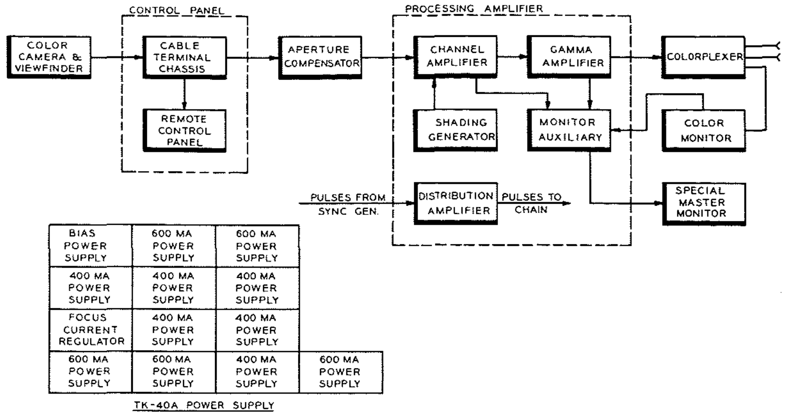


Fig. 4—Block diagram of TK-40 camera chain.

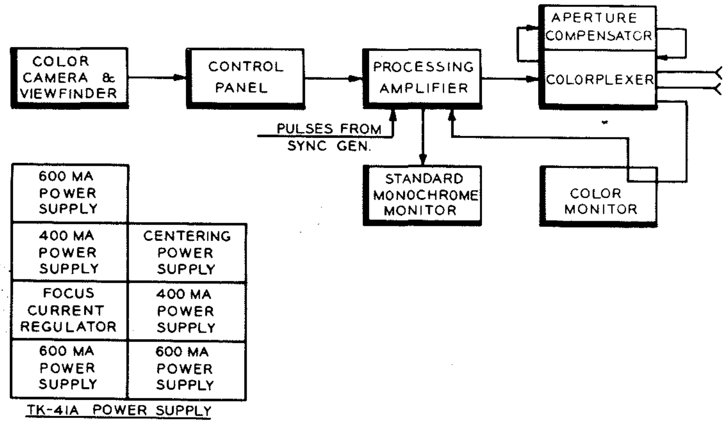


Fig. 5—Block diagram of TK-41 camera chain.

Fig. 6—The author shown at the TK-41 processing amplifier.

TABLE 1

Comparison of Old and New Color Camera Chains

TK-40 (Fig. 4)		TK-41 (Fig. 5)	% SAVING
TOTAL NO. TUBES	390	270	30%
TOTAL POWER INPUT	4.8 KW	3.2 KW	33%
TOTAL SPACE 2-13" Consoles Top and Bottom 254" Rack Space		1-19" Console } Top 1-13" Console } Only 96" Rack Space	60%
NUMBER OF MAJOR UNITS	12	6	50%

has been the elimination of all "hot" circuits (tubes, and power dissipation) from the camera control position. Thus the ideal camera control console would contain only passive controls connected to a remotely mounted amplifier chassis. In the design of the new color camera processing amplifier, it was recognized that this requirement added considerable complexity even to the simple operation of controlling the gain, and became virtually hopeless in the case of shading control circuits. Thus, early in this design, the decision was made to use console mounting of the equipment to obtain the greatest overall simplification. This does not mean that the remote control trend is reversing; the passive control position is still a desirable goal from the standpoint of the most compact control console with good accessibility to the active circuits. However, it does imply that this goal is presently unattainable with a system which would be acceptable on an overall basis.

CONCLUSION

A number of trends in the design of broadcast color equipment have been noted:

(1) Increasing use of stabilized circuits which eliminate setup adjustments and reduce effects of manufacturing tolerances.
(2) More attention given to operational convenience in setup and actual use; provision made for operational and maintenance testing using built-in instrumentation.
(3) System simplification by integrating equipment, and improved circuit approaches.
(4) Generally improved performance, smaller size, fewer tubes, and lower cost.
(5) Development of specialized test equipment for operational and maintenance use.
(6) All signal handling equipment is capable of handling either color or monochrome signals.

It is evident that a system as complex as a color broadcast system does not stop improving with the release of any one particular design. Development will continue to make each equipment more efficient and economical for the accomplishment of its specific purposes. Likewise, the systems development will continue since it represents just as fruitful an approach to overall improvement as specific development.

RESULTS OF "RCA ENGINEER" READERSHIP SURVEY

by **PATRICK C. FARBRO, Mgr.**
Personnel Research, RCA Staff
Camden, N. J.

THE RCA ENGINEER is a magazine "By and For The RCA Engineer." RCA engineers have authored the articles which have appeared in the magazine. The magazine sections "Patents Granted to RCA Engineers," "Pen and Podium," "Engineering News and Highlights"—carry information about RCA engineers and scientists. It has been supposed that the published material has carried information that RCA engineers want and/or need to know.

THE SURVEY

A readership survey was designed to check this supposition and to provide information that could be used in planning future issues of the magazine. Throughout this study it has been assumed that if readership is high and interest is expressed in the magazine content, the magazine is publishing material which engineers want and need.

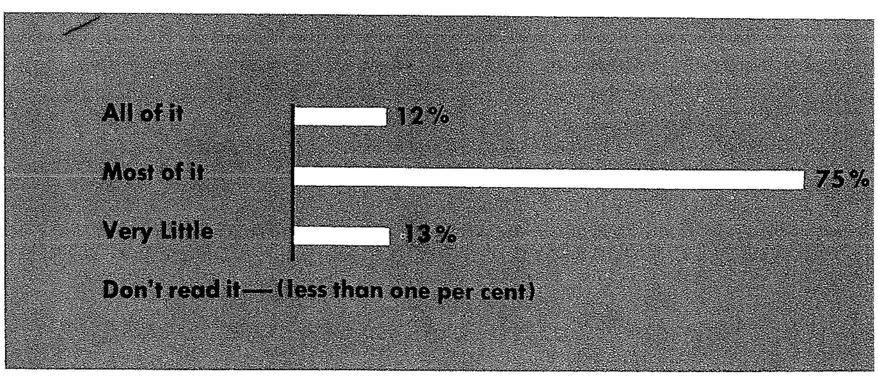
At the time this survey was made the magazine had been in publication for eight months. Four bi-monthly issues had been sent to all RCA engineers.

A two-page questionnaire was enclosed in Volume 1, Number 5, with instructions to return the questionnaire anonymously to the Editor.

Some 4,000 copies were sent out and about 700 questionnaires were returned. A 17% return is considered a good return as far as mailed readership surveys are concerned. The conclusions regarding the acceptance of the "RCA ENGINEER" discussed below are based on this return.

RESULTS

The magazine has been successful in meeting the needs of the RCA engineers. This is based on the readership which the magazine receives. Only one person said he didn't read the magazine. Eighty-seven per cent read "All" or "Most" of the magazine. The following graph shows how these readers answered the item—"Check One Category Below That Best Describes the Extent of Your Readership" (see graph at right). →



There is very little variance among the major operating units on the percentages who say they read "All" or "Most" of the magazine. The percentages vary from 99% to 71%.

In order to get an idea of the types of material that are appealing, several questions were asked:

1. Those people who said they didn't read all of the magazine were asked which classes of articles they did read.
2. All were asked to rank in order of preference the classes of articles of most interest and value.
3. All were asked which class of article they would like to see expanded.

The following classification of the magazine contents was used for this portion of the study:

A. *Technical and Semi-Technical*
(Examples: Issue #1, High-Gain Transistor Amplifier; An Immitance Sweep; Issue #2, The Synchroguide: A Design History; Issue #4, Transistorized Video Amplifiers)

B. *Plant, Engineering Activities, Services*
(Examples: Issue #1, Engineering in the RCA Victor Record Division; Issue #2, Optical Engineering in RCA; Issue #4, Engineering the RCA Bizmac System)

C. *Inspirational, the Engineer, Management Messages, General Information*
(Examples: Issue #1, Why Engineers Should Write Papers; Issue #2, The Engineer and His Professional Society; Issue #3, The Engineer in Civic Affairs)

D. *Magazine Departments*
(Examples: Pen and Podium, Patents Granted, News and Highlights)

All clases of the magazine material have a good audience and enjoy a high percentage of readership.

Even among those who say they don't read "all" the magazine:
76% read the "Technical and Semi-Technical" articles,
66% read the articles on "Plant, Engineering Activities, Services,"
51% read the "Inspirational, the Engineer, Management Messages, General Information" articles,
45% read the "Magazine Departments."

The "Technical and Semi-Technical" articles are the ones in which most interest is shown. However, all the classes of articles receive top ranking by some of the readers. The table below shows the per cent of first-choice "votes" each class received in response to the instruction "Please Rank the Four General Classes of Articles in Order of Interest to You."

A. Technical and Semi-Technical 58%
B. Plant, Engineering Activities, Services 29%
C. Inspirational, the Engineer, Management Messages, General Information 10%
D. Magazine Departments ... 3%

In answer to the question, "Which of of the Categories Would You Like To See Expanded?" all received some votes:
48% wanted more "Technical and Semi-Technical" articles.
31% wanted more articles on "Plants, Engineering Activities, Services."

15% wanted more in the category "Inspirational, the Engineer, Management Messages, General Information."

6% wanted more in the "Magazine Departments."

COMMENTS

Another indication of the acceptance and readership of the RCA ENGINEER is found in the comments written about the magazine. In response to the stimulus "Use back of this sheet for additional comments," 16 per cent took time to write their feelings about the magazine. 90% of the comments were judged favorable or contained constructive suggestions. Only 10% were judged unfavorable.

PLANNING

One of the primary reasons for conducting the survey was to gather information that could be used in planning future issues of the magazine to more closely meet the needs of its readers.

It was felt that a comparison between the classes of articles of interest to the group and the actual pages of space given in publication to these types of articles could indicate needed changes.

It was also felt that a fertile source of articles would be the readers themselves.

The survey has given some indications for change.

BALANCE

The balance among the classes is generally good. The order of rank of the classes of most interest and the actual pages of space given to the classes are similar:

Order of Interest (From "most" to "least")	Rank
Technical & Semi-Technical	1
Plant, Engineering Activities, Services	2
Inspirational, the Engineer, Management Messages, General Information	3
Magazine Departments	4

Amount of Page Space Given to Each Class (From "Most" to "Least")	Rank
129 Pages (50% of total space)	1
50 Pages (19% of total space)	2
32 Pages (12% of total space)	4
48 Pages (19% of total space)	3

From this analysis it would seem that more space should be given to the two classes of articles—"Plant, Engineer Activities, Services" and "Inspirational, the Engineer, Management Messages, General Information."

To more effectively accomplish the balance indicated, it will probably require added space rather than a redistribution of emphasis because it does not look as if the consensus is to reduce the technical and semi-technical articles. Similarly, news coverage in departments, "Pen & Podium" and "Patents Granted" should be complete. Hence, to achieve the balance indicated, the two classes above could be expanded but not at the expense of the other two classes.

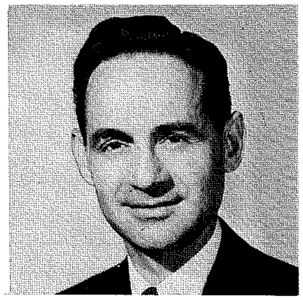
TITLES AND AUTHORS FOR FUTURE ARTICLES

Possibly the most fruitful source of information for future issues of the RCA ENGINEER is in the specific content suggested. In the section of the questionnaire entitled "Planning for Future Articles," the engineer was asked to indicate a title or idea for an article of interest to him. He was asked for an idea for an article about the work he or his group is doing that other engineers might like to read. He was asked if he would write or collaborate on an article about his or his group's work.

510 topics were suggested—

159 engineers volunteered to author articles.

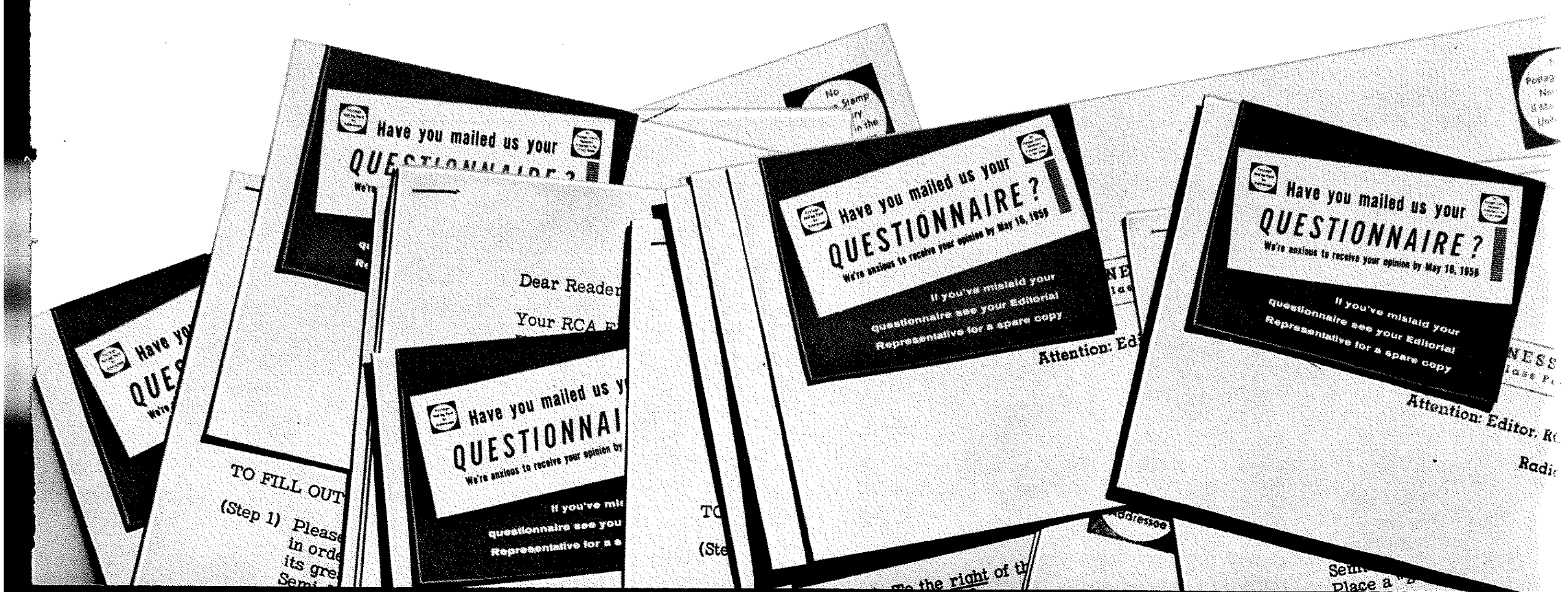
The topics suggested are diversified, interesting, and will serve as a reservoir for forthcoming issues. This information is on file in the Editor's office.



PATRICK C. FARBRO received his AB and MS Degrees in Psychology from the University of Tulsa (1947) and Purdue University (1948) respectively. Mr. Farbro has also completed post graduate work at Temple University and Institute of Pennsylvania Hospital.

His occupational experience includes work as a graduate teaching assistant in Psychology at Purdue University, 1947-1948; Personnel Research Analyst, RCA Victor General Office, 1948-1949; and Employment Supervisor, Lancaster Plant, 1949-1951. In 1951, Mr. Farbro was appointed Manager, Personnel Research, RCA Staff.

Mr. Farbro is a member of the American Psychological Association, the American Association for the Advancement of Science and Sigma Xi.



Editor's Note: This paper is another in our series of articles devoted to the role of mechanical engineering in electronics.

In previous issues of the RCA ENGINEER various aspects of mechanical engineering have been described. This has included a general paper describing the scope of mechanical engineering throughout RCA, a specific mechanical product design on the "Slide-O-Matic" Victrola, the engineering aspects of mechanical development in DEP, and the role of the equipment development engineeer in Tube Division, and mechanical design of a ruling engine. These papers are listed here for ready reference.

1. "The Role of the Mechanical Engineer in Electronic Equipment Design," by T. G. Greene and P. C. Harrison, Volume 1, Number 2, August-September, 1955.
2. "New Slide-O-Matic Victrola Equipment" by E. S. Marris, Volume 1, Number 2, August-September, 1955.
3. "Mechanical Engineer's Role in Development of Electronic Equipment" by L. Jacobs, Volume 1, Number 5, February-March, 1956.
4. "The Role of the Equipment Development Engineer in the Tube Division" by H. V. Knauf, Volume 1, Number 6, April-May-1956.
5. "A Ruling Engine for Glass Mesh Masters" by J. D. Harrington, Volume 2, Number 1, June-July, 1956.
6. "Production Considerations in the Design of Automatic Machinery for Electron-Tube Products" by M. M. Bell, Volume 2, Number 2, August-September, 1956.
7. "Automatic Equipment for Sintering Powder Metal Ingots" by S. I. Reed, Volume 2, Number 3, October-November, 1956.

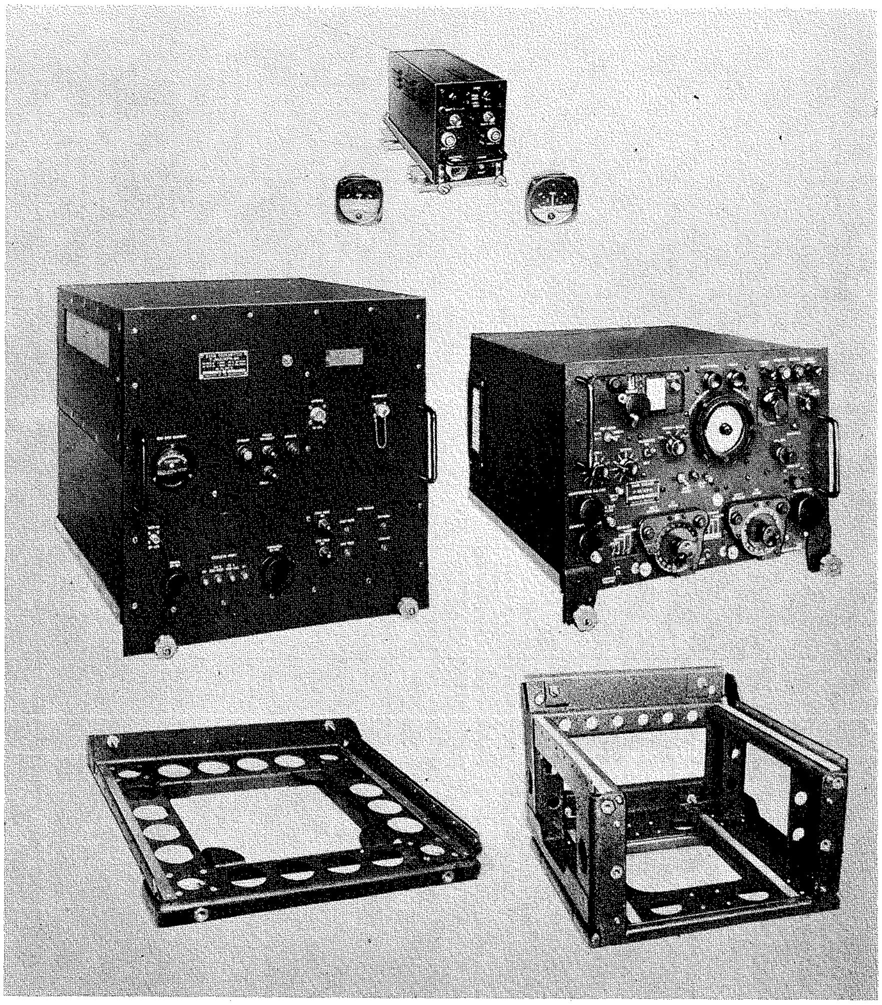
In this paper, the **aspects of mechanical product design** are emphasized by a practical application in the mechanical design of airborne equipment for military use.

While the design considerations are similar when we talk about either commercial or government types of electronic equipment, the weighting factors which are applied and the time and effort devoted to each phase of the work are usually quite different. A specific design approach to a particular military equipment is developed here, so that younger engineers just embarking on their journey in the mechanical design field may see problems typical of those which they may some day have to face.

AUTHOR'S NOTE: Many of the decisions affecting the design of the products illustrated in this article were made after joint consultation with the electronic engineers, and sometimes engineering specialists in other fields, concerning the various equipment aspects discussed. Product design in the electronic field is almost always a joint achievement of electrical and mechanical engineers working together as a closely knit operational team, whose efforts are extended toward one common goal—to produce a piece of equipment which represents the best engineering know-how in all of its product design phases, consistent with low dollar cost, and a delivery schedule based on meeting the customer's requirements.

Fig. 1—The AN/APN-84 equipment is used for precision aircraft navigation and has the capability of giving the planes position to an accuracy of + or — 50 Ft. of actual position. This equipment was designed, and performance checked out, under the following environmental tests:

High Temperature Tests: +55° C and +71° C for a minimum of 4 hours
Low Temperature Tests: —54°C for a minimum of 2 hours
Humidity: +50°C and 95% relative humidity for 72 hours; +50°C and 100% relative humidity for an additional 48 hours
Altitude: 40,000 ft.
Vibration: 10 to 55 cycles per second in each of 3 different planes for a total of 4 hours
Shock: 10 high impact shocks of 15 G each applied in each of the 3 major planes
Explosion-proof Tests: Altitudes between sea level and 40,000 ft.



MECHANICAL ASPECTS OF ELECTRONIC PRODUCT DESIGN

By

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Many complex factors enter into the mechanical design of electronic equipment to be used in military applications. As a matter of fact, some of these factors have facets which in themselves are in opposition to other considerations, so that the net result is usually a compromise leading to an improvement in equipment design.

To best illustrate the effect of the various factors, we will examine the mechanical design procedure on a typical system which RCA has produced for the U. S. Air Force in fairly large quantities—the Shoran High-Precision Blind Bombing System. This system consists of the AN/APN-84 Airborne and AN/CPN-2A Ground Beacon equipments.

MARKETING

There are three possibilities which exist when we consider marketing or marketing research in connection with equipment to be purchased for use by the government.

1. The government may issue a specification which outlines a particular type of new equipment capable of doing a certain job. Each prospective manufacturer then writes a descriptive specification outlining a piece of gear which he believes will meet the specification submitted by the government. An engineering-sales presentation is made to the procuring agency by each prospective bidder, from which the government makes its selection on the basis of price, delivery, suitability of purpose and other factors.
2. A manufacturer may have developed a piece of equipment or wishes to undertake the study of a product or task, which he feels has a potential market with the government.
3. The government may approach industry to bid on a certain product that has been previously designed in order to obtain a second production source.

CUSTOMER SPECIFICATIONS

Now, one may ask, what effect is this liable to have on the mechanical engineer? This may perhaps best be answered by considering the position of the customer, who may be the U. S. Air Force, Navy, Army, Signal Corps or any other branch of the armed forces whose duty it is to protect our country and wage effective war in its defense. Certainly the user wants something designed and built for a low price which will be rugged enough to withstand environmental conditions. The detailed specifications which the government imposes on the contractor of electronic equipment are usually very rigid and in excess of those to which commercial equipments are subjected.

The manufacturer is often permitted to write the equipment specification on the gear which he is going to produce for the government. As a matter of fact, this is what happened in the case of the Shoran equipment. Here, the customer wanted the equipment to perform a certain task which was outlined in detail in the form of a design specification. It then became necessary for the RCA design engineer to write a detailed equipment specification based on the design. In order to accomplish the task, the engineers had to first visualize the external form which the equipment would take, and then broadly plan the details of construction. Consideration of such questions as the following helped the mechanical engineer in this phase of the project:

1. Should this equipment be open type construction, pressurized, or even hermetically sealed?
2. What form factor shall it take?
3. How important are weight and size of the equipment?
4. To what extent will field maintenance dictate the design of the equipment?
5. What kind of life and reliability can be engineered into this gear?
6. To what environmental service and test conditions will the equipment be subjected?

To help answer these and other questions, and to further illustrate the mechanical engineer's role in the equipment design field, a closer examination of the design features of the Shoran equipment will now be considered.

DESIGN CONSIDERATIONS

In designing the AN/APN-84 and AN/CPN-2A equipments, an extremely wide variety of work was encountered by the mechanical engineers associated with this project. The AN/APN-84 Airborne Equipment had to be as light in weight as possible and yet designed in such a way as to withstand rugged operational conditions of vibration, shock, and extreme altitude. In addition, wide variations in temperature and humidity conditions, all of which are normally encountered in high-speed military aircraft, had to be considered. Further, it had to be designed in such a way that ease of servicing would be an important factor. Similarly, the AN/CPN-2A Ground Equipment also had to meet a low-weight requirement because the factor of air transportability had to be taken into account. Fig. 1 shows the AN/APN-84 Airborne Equipment and lists above it the environmental tests which were established to simulate operational service. It was determined through discussion with the customer that plug-in chassis construction would be highly desirable, since it would help to ease the field-servicing problem. Since voltages were limited to approximately 7 KV, it was deemed that semi-open type construction would be used. This eased the forced-air cooling problem and kept both weight and cost to a minimum. This equipment was intended for use in medium-size bomber type aircraft, so size became an extremely important factor. Construction using miniature tubes and components, wherever possible, was therefore decided upon. The ability to withstand vibration and shock in military type aircraft is very important. Special type shock mounts and frames had to be designed to absorb vibration and shock caused by gun-fire, aerodynamic flight conditions, engine unbalance, and landing shock.

Fig. 2 illustrates the electronic units of the AN/CPN-2A Ground Beacon equipment. Here, mechanical engi-

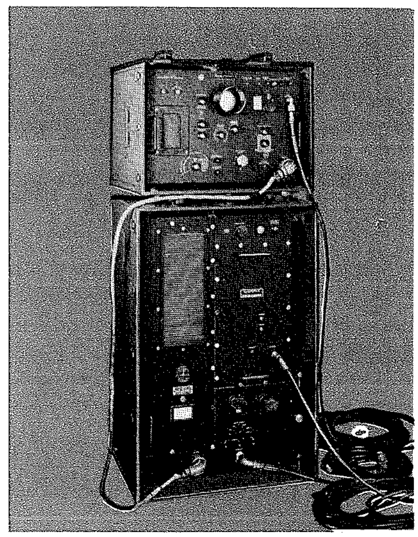

Fig. 2—*The AN/CPN-2A Ground Beacon Equipment.* The transmitter (low unit) and monitor (upper unit) are shown here. This equipment is designed to reply to the aircraft signals which are generated and radiated by the AN/APN-84 equipment. The antenna mast and antenna assembly are not shown here.

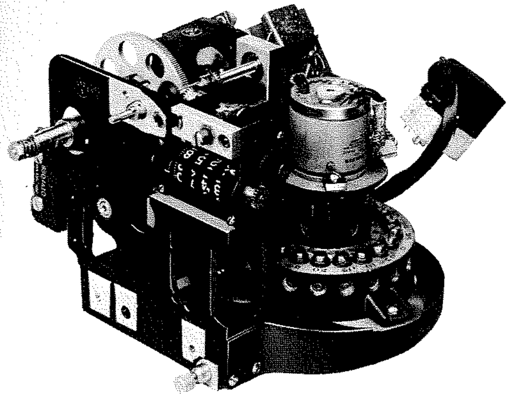

Fig. 3—*Phase Shifter Assembly*. The compactness of this electro-mechanical unit can be seen. The compensator provides a mechanical means of correcting repetitive errors in the Selsyn unit mounted above it. Two other Selsyn's mounted on the back of this unit and driven through the gear train are not visible in the photograph. The mechanical counter provides accuracy of reading distances to + or — 1 ft.

neers were concerned with structural design and electronic packaging. Carrying cases to prevent damage to the equipment were designed for air-transportability and submersion. In order to make them light in weight, thin-walled material had to be used. But, in order to satisfy the condition of transporting the equipment in unpressurized aircraft at altitudes up to 40,000 ft., where the air pressure is about 3 lbs./sq. in. a special two-way air valve had to be devised to allow the case to breathe. This prevents water from entering the cases when brought back to sea level and immersed in water.

Briefly, this was the approach which the mechanical engineers took in arriving at a product which would fit the parameters of the design specifications. Now in some detail, we will illustrate some of the design areas in which the mechanical engineer played an extremely important role.

COMPACTNESS IN PRODUCT DESIGN

In the first place, the design and construction of the various chassis used throughout the equipment was important. Volumetric efficiency, that is the high-packaging density of an electronic equipment, is something which engineers are constantly trying to improve, especially in airborne and air-transportable gear. Therefore, the ability of the mechanical engineer was sorely taxed here, to produce an equipment having chassis and castings as low in weight as possible, with a high component-packaging density and capability of withstanding environmental conditions such as vibration, shock and electrolytic corrosion. Coining operations permitting the use of stamped-in gussets and other stiffeners, together with the use of small bend radii produced chassis and frames which met the conditions imposed. Castings were mostly made of magnesium to insure lightness, and then treated chemically to prevent corrosion. Patented devices such as quarter-turn fasteners, self-locking nuts and an RCA-designed device known as a "quint-nut" were used in large quantity throughout the equipment. The result as shown in Fig. 8 was an overall product having plug-in type of chassis construction thus reducing the servicing problem considerably, since chassis could be interchanged between similar equipment with only minor servicing adjustments.

MECHANISM DESIGN PROBLEMS

Included in the Indicator Unit of the Airborne equipment is a mechanism which translates electrical phase shift, in the form of shaft rotation of synchro units, to a dial and an odometer-type of direct reading counter. Refer to Fig. 3. Because of the system accuracy involved, an allotment of errors was first made between the synchros and their respective visual registers. The make-up of the unit required a certain degree of accessibility to the synchro units for equipment adjustment. Once the tentative arrangement of parts was assumed, and a suitable gear train established, the allowable limits of tolerances on hole diameters, shaft run-out, gear dimensions and dimensional changes due to extreme temperature variations were established by kinematic study.

A mechanical compensator was invented and patented which was capable of reducing certain repetitive phase-shift errors in the most accurate synchro unit employed, to a point where they were substantially negligible. As a result of the error analysis, refinements were incorporated in the compensator to further improve its accuracy. In one case, a change in materials was made to reduce errors due to wear. Backlash was eliminated by the addition of a tension spring across a moving torsion link.

A high-speed odometer type of direct-reading counter was also developed for this unit. A study of bearings and lubricants was necessary to select a combination with the lowest torque over the temperature range. Continued tests disclosed extreme wear on the transfer pinions due to shock conditions imposed by the transfer discs. Changes in type of pinion material used, and the addi-

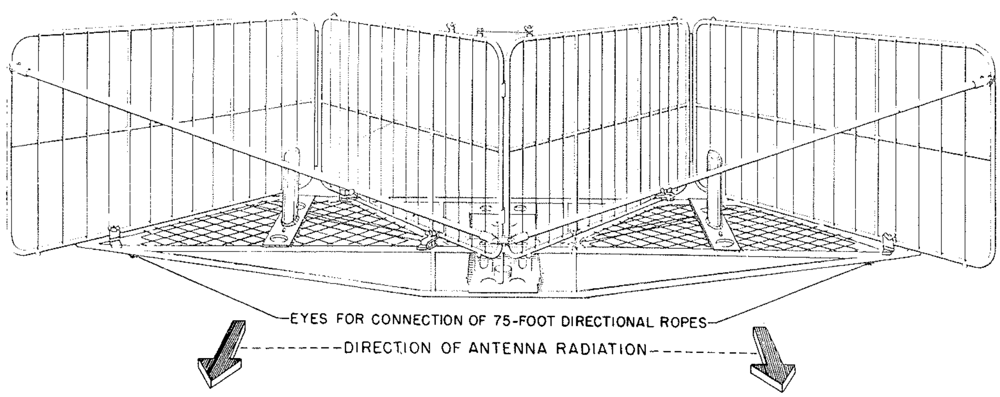

Fig. 4—*Antenna Ground Plane and Reflector*. The tubular aluminum construction of this unit can be seen. It is approximately 10 ft. in overall width and when mounted on a 50 ft. high antenna mast must withstand winds up to 100 miles per hour.

tion of bronze bearings to the pinions brought about the desired improvements. The material used in the design of the transfer discs which meshed with the pinion also had to be changed because wear showed up after selecting the new pinion material.

In the design of both the mechanical compensator and the high-speed odometer, not only was ingenuity involved on the part of the engineer, but also a knowledge of strength of materials, metallurgy and lubrication problems. This mechanism assembly represented the heart of the system so that a very high degree of reliability and long-life were absolutely essential in its design.

STRUCTURAL PRODUCT DESIGN

Two areas of structural design were also represented in this equipment. One of them concerned the design of an antenna ground plane complete with two corner type reflectors. Refer to Fig. 4. Here, a tubular aluminum type of construction was chosen, with the tubing heli-arc welded to prevent the use of corrosive fluxes. Wind, snow and ice loads, as well as handling loads had to be considered. The design, which of course was predicated on both mechanical and electrical requirements, was first completed and then stress analyzed. Modifications were made as necessary and a model then constructed. This model was statically loaded in accordance with the wind, snow, ice and handling conditions. Deflections were measured and important yield points determined. Corrections in design were then made as necessary and the design frozen.

The other area concerned the design of a single, double-deck shock mount for the Airborne Indicator and Computer Units. (This unit is shown in the lower right-hand corner of Fig. 1.) It was constructed of magnesium and built as light in weight as thought practicable. The Indicator and Computer units were mechanically connected through a gear train. This meant building a rigid, substantially deflection-free frame, at the same time maintaining precision tolerances on the location of certain mounting pins both back and front of the two units.

After the design and construction of a shock mount model, vibration tests of 5 to 55 cps at 12 g were run over a long period. Shock conditions were simulated up to 20 g. Broken welds resulted in one place and structural failure occurred in two other places. These tests dictated which members would have to be strengthened and after the necessary alterations further tests insured a safe design.

ENGINEERING SERVICES

After the design and basic rules of structure were laid down, a design guide was formulated in order to coordinate the efforts of several mechanical engineers in designing the complete product. Thus, a high degree of standardization was obtained throughout the equipment by reducing the quantity of different kinds of parts to an absolute minimum. Layouts were made of each chassis by the drafting group, after the overall frame structure was decided upon. From the layouts, detailers drafted the various component parts such as chassis, brackets, panels, frames and so forth; sub-assembly and assembly drawings then followed in order.

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Joining RCA in 1931, Mr. Brelsford has been successively employed in the RCA Tube Division at Harrison, N. J., the Engineering Products Division at Camden, N. J., and presently in Defense Electronic Products at Moorestown, N. J. As a mechanical engineer, he participated in the development and design of both commercial and government types of electronic equipment in the mobile and aviation fields, and particularly in the development of shoran equipment. Promoted to Group Leader in 1947, he was responsible for supervision of the Shoran group which produced the equipment outlined in this article.

Mr. Brelsford holds a Professional Engineering License in the state of New Jersey. He is interested in civic affairs, photography, golf and travelling. He presently has three patents to his credit.

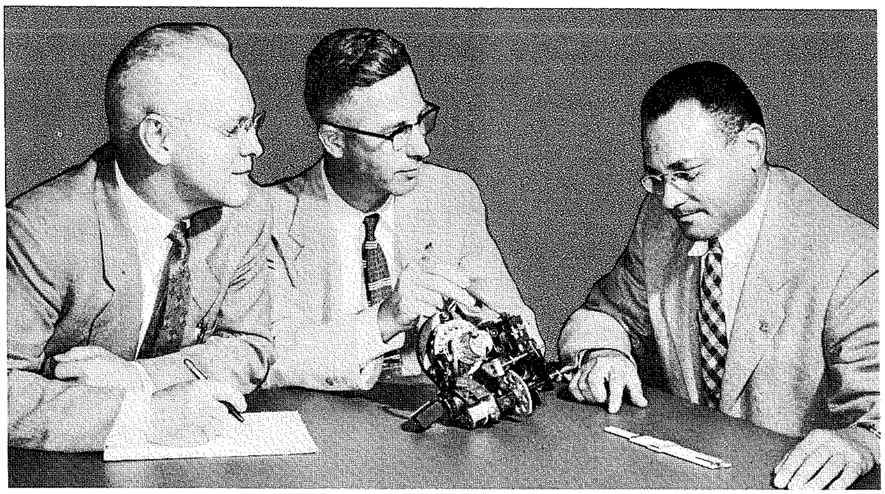

Fig. 5—An engineering conference on the design of the Phase Shift Assembly. Mr. H. J. Mackway on the left is a mechanical engineer in the Missile & Surface Radar Division. The author of the article is in the center. Mr. J. I. Hirzlinger, a mechanical engineer in the Airborne Fire Control Section is at the right. Engineering conferences such as these are frequently held to insure that the design of equipment produced represents the best in opinions and engineering knowledge of those concerned.

Parts lists were assembled for the entire equipment so that each electrical and mechanical part appeared in its proper place on assembly and sub-assembly drawings.

As each detailed part drawing was completed, it was sent to the model shop to permit fabrication of the proper quantity of parts for the assemblies. The various mechanical parts were then assembled, and all electrical components, such as resistors, capacitors, transformers, etc., inserted and wired and each main plug-in chassis was then made ready for electrical alignment and test.

Instruction books play an important part in the maintenance and field

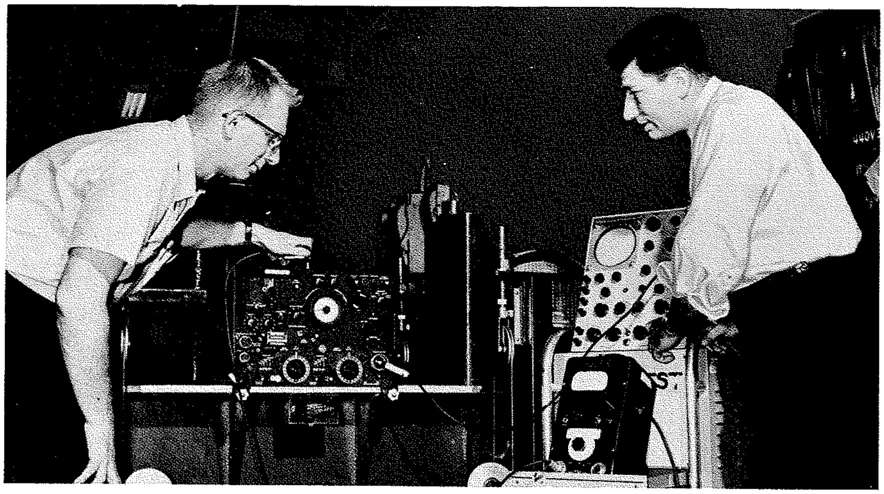

Fig. 6—Environmental testing is an important part of engineering. Here, the electrical engineer, R. W. Lapidos, is shown at the left holding a crystal pick-up which is used to check vibration amplitudes and frequency of the Airborne Indicator Unit which is mounted on a vibration machine. Mechanical engineer, W. P. Melchionni, is shown at the right checking performance.

operation of the actual equipments. The U.S. Government services usually require elaborate instructions to aid armed services personnel in the repair, tests, and operation of equipments used by them. This is natural, since the equipments must be maintained and operated under all sorts of unusual conditions. "In-flight" maintenance is often required, as are test and of course operation under battle conditions. Sometimes parts must actually be hand made or a substitute conceived when no stock of proper maintenance parts are available. Therefore, the manufacturer of the equipment is often requested to prepare separate handbooks for a single piece of gear, which cover such items as Operation, Maintenance, Service, and an Illustrated Parts Catalog.

MANUFACTURING CONSIDERATIONS

Designing a product for mass production is quite different from designing the same item for small quantity production. This is because the engineer, working on mass-produced parts, must consider both tooling considerations and cost. Such questions as the following must be answered:

1. Is it cheaper to make this part a casting, or of sheet-metal construction, or should it be cut from bar stock?
2. Does one of the above methods have fabrication advantages over the other two?
3. How do tool costs for each of the above methods compare?
4. What effect does actual service conditions and environmental tests have on the design of the part?

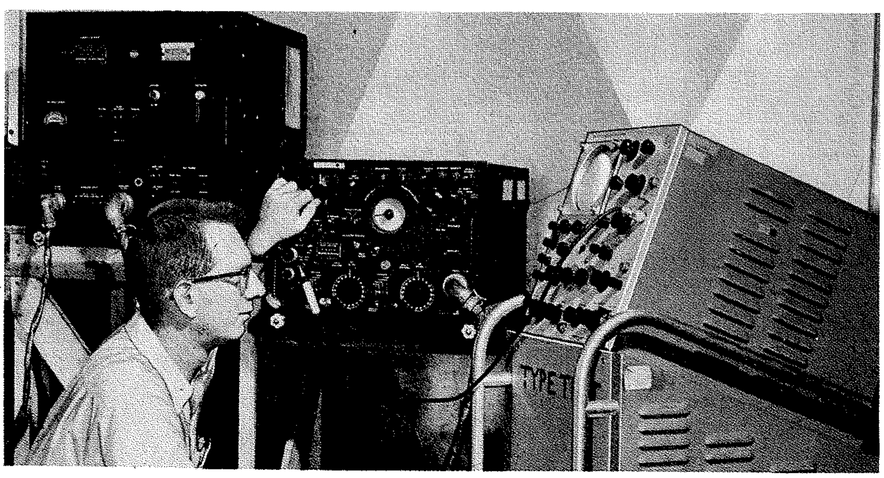

Fig. 7—The AN/APN-84 airborne equipment is shown in humidity chamber being checked out by engineer R. W. Lapidos for effects after submission to high humidity conditions.

From a fabrication viewpoint, it is necessary to consider many items. Examples of some of the more common ones are given here:

A. Use existing standard tools to produce as many operations as possible in each detail part.
B. Use as large a bend radius as possible on sheet metal stock to prevent cracking of bends.
C. Select the best material for the job from both a strength and free machining standpoint.
D. Design the part to avoid costly machine and hand operations, where possible.
E. Give all dimensions as wide tolerances as possible.

Assembly operations are likewise important. Where possible, the design should be such as to eliminate as many pure hand-assembly operations as practicable. This can be done by specifying spotwelding in place of hand riveting, or machine riveting in place of the use of nuts and bolts at assembly.

Quality control in a plant will often mean the difference between a satisfactory product and one which is plagued with field maintenance problems. The degree of quality control which should and must be exercised in the fabrication, purchase material, and assembly inspection of government products is very important. Quality control is rigidly spelled out in government specifications and these specifications have been formulated as the result of many years of experience on all kinds of complicated equipment. A plant which does not have good quality control simply cannot be expected to produce a quality product.

All of the points covered above were closely adhered to in the design of the Shoran equipments. A well-planned manufacturing set-up is important both from a cost-reduction standpoint and production of a quality product.

MECHANICAL TESTING

The testing of mechanical parts for government-type equipment which is built to rigid Military specifications must not be neglected while the equipment is in the model stage. In fact, if adequate tests are not run on component parts and sub-assemblies as the model is being assembled, the design engineer can expect to run into some very serious problems which may come quite late in the schedule and will undoubtedly upset delivery of the final equipments by a matter of weeks or months.

As portions of the AN/APN-84 and AN/CPN-2A models were received from the RCA Model Shops and from vendors, they were tested in accordance with requirements set up by the mechanical engineer. These requirements quite often were in excess of those required by the overall Military Specifications for the equipment.

This can best be illustrated by the following example: A particular cooling motor and blower assembly was located on a certain chassis in the equipment. Since the specifications required that the overall equipment be vibrated from 10 to 55 cycles per second with a total excursion of $\frac{1}{16}''$, it was recognized that there would be some amplification in vibration of this particular blower-motor assembly, due to the resilience of the chassis. The blower-motor combination was therefore vibrated by itself at the increased amplitude long before the final assembly was completed, thus insuring against problems which might have shown up in final test.

Another example was the environmental testing of the electro-mechanical unit which embodied the gear train, synchro units, compensator, and counter previously mentioned as part of AN/APN-84 Indicator. This unit was extensively tested at low-temperature, high-temperature, high-humidity and vibration conditions while the balance of the model equipment was being assembled. Improvements which were found necessary as a result of these tests are shown here:

(1) Bearing lubrication was changed as a result of excessive torque at low temperatures.

(2) Gear centers were altered in one instance because of binding caused by differential expansion at high temperature.

(3) Brush and slip ring problems caused by oxidation as a result of high-humidity conditions meant that double brushes with increased spring pressure were finally installed in the synchros.

After all these individual component and sub-assembly tests were made and conditions properly satisfied for each unit, the overall equipment was then subjected to the Military overall environmental testing program. This program entailed many hours of final equipment testing in the following categories:

(1) Low-temperature tests
(2) High-temperature tests
(3) High-humidity tests
(4) Vibration tests
(5) Shock tests
(6) Altitude tests

In addition, it must be pointed out that since some of the above conditions can conceivably exist as combinations, it was necessary to check the equipment under those extremes, wherever possible. For instance, high altitudes and low-temperature conditions may exist together to say nothing of vibration being added to this combination.

As a result of this very extensive testing, certain design changes were shown to be desirable in both the mechanical and electrical areas. When in the opinion of the design engineer, it was possible to make the change for the production equipments without retest of other component parts or the overall assembly, this was done in the interest of improving the product for quantity manufacture.

FINAL FIELD TESTING

The final question to be asked of any equipment is this: Will the equipment work in the final end environment and do the job it is supposed to do for the customer? The only way to find out is to put one or more of the equipments in actual service for an extended period of time. In the case of government work, this phase is usually handled by the armed service which is buying the equipment. The manufacturer's engineering representatives may be on hand for a short time to properly instruct the Military in the usage and handling of the gear and may assist in servicing the equipment, but by and large, it is up to the Military to put the equipment through its maximum extremes of actual service use in order to determine if any element should be looked at from a re-design standpoint in order to improve any future equipments which may come off the production line. During this service-test phase, it is often found by the customer that there are additional features or additional usages to which this equipment could be put. In some instances, the manufacturer may be requested to make direct changes during the production phase to satisfy these conditions. In other instances, the manufacturer may recommend the delivery of change kits so that, at the discretion of the customer, the alterations may be made in the field as a retrofit, at a time of his choosing.

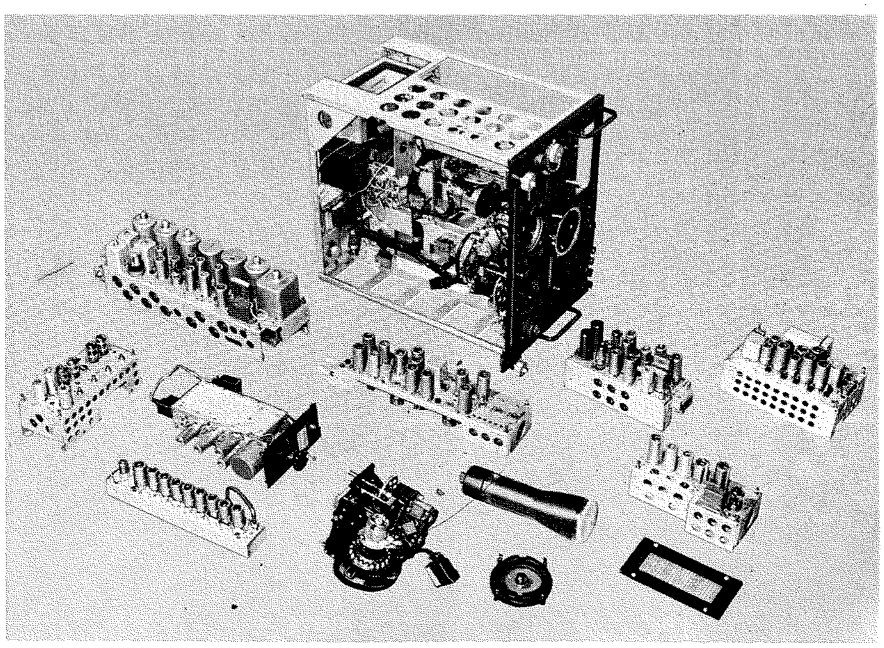

Fig. 8—The compactness of design of the Airborne Indicator Unit is shown here. The design features easy removability of sub-chassis for rapid servicing and maintenance in the field.

INVESTIGATION OF COUPLED CIRCUITS FOR 100 - 1000 MC APPLICATIONS

by

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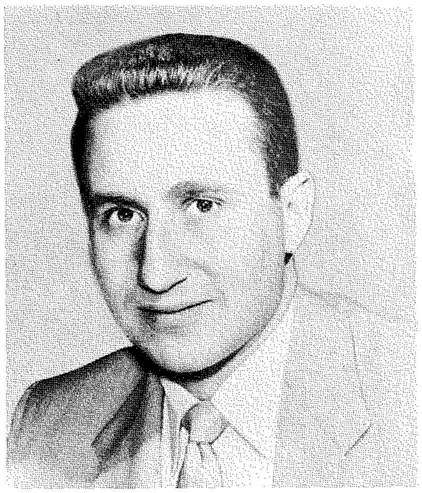


MARVYN E. SIEGAL received a B.E.E. Degree from the City College of New York in February, 1952. He joined RCA as a Specialized Trainee in May of 1954 and was assigned to Advanced Development Engineering, RCA Victor Television Division in October, 1954. His work has included UHF Coupled Circuits, R-F Amplifiers, Diode Mixers and recently Transistor Applications to Color Television Receivers. Mr. Siegel is a Member of the IRE.

FREQUENCIES IN the range from 400-1000 megacycles offer a unique challenge to engineers engaged in coupled-circuit design. These frequencies are too low for the application of standard microwave practices and too high for the application of conventional lumped constant techniques.

Information available concerning UHF coupled circuits has been largely theoretical in nature. Due to the lack of practical data to supplement the theory, design has been based essentially upon experience and intuition. Therefore, new methods and additional data for dealing with these circuits are advantageous.

DATA USEFUL TO VARIETY OF ENGINEERS

This article describes special techniques and presents useful practical data regarding these circuits, which are also applicable at frequencies as low as 100 megacycles. Therefore, the results and curves illustrated should be of interest to a wide variety of engineers whose work involves the design or measurement of coupled circuits for TV tuners, government communications, radar, aviation and navigation aids, transmitting and receiving tubes, and antennas. The technical information presented is applicable to devices and circuits for operation in both the UHF and VHF ranges, although much of the following description applies to all frequencies where a lumped constant equivalent circuit is employed.

FUNDAMENTAL CONCEPTS OF INSERTION LOSS

The insertion loss (ϕ) of a single-tuned circuit shown by Figs. 1a and 1b may be found by straightforward application of the theory.

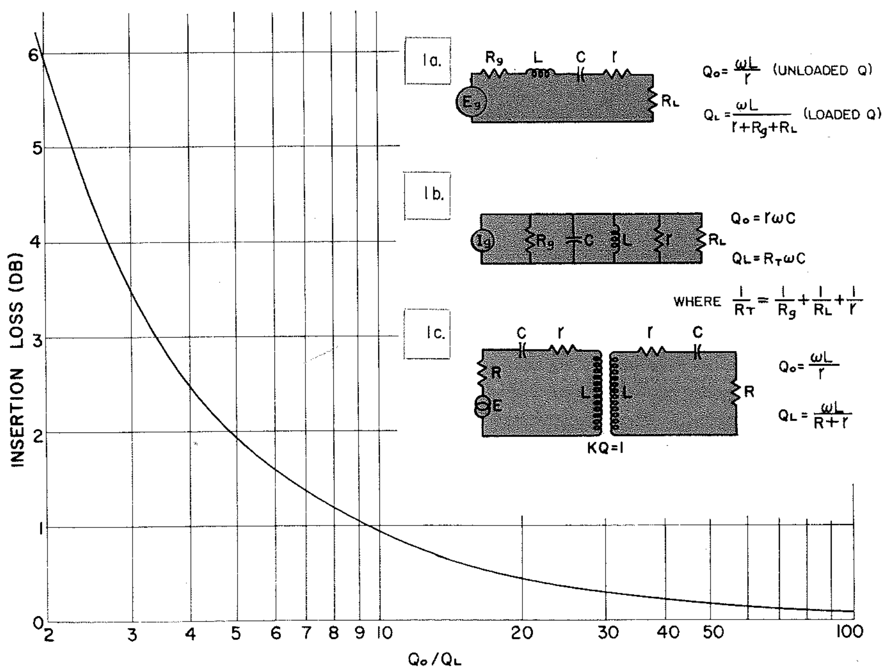


Fig. 1—Insertion loss vs circuit Q's.

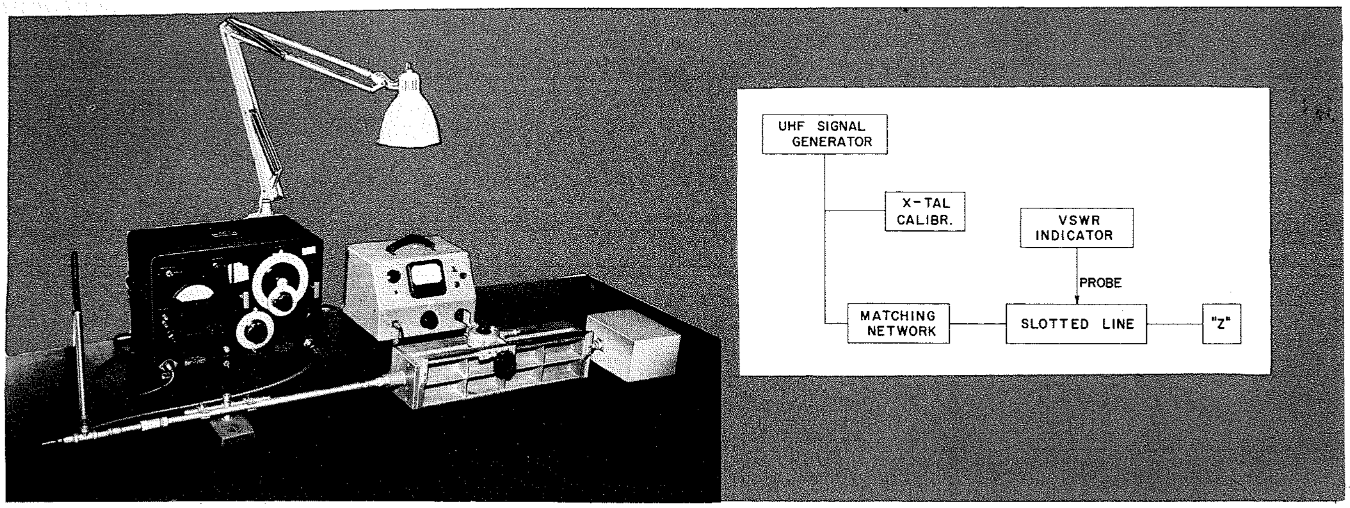


Fig. 2—Block diagram and photo of the test equipment setup for the UHF Measurement of Q. Background (L to R) Signal Generator and VSWR Meter. Foreground (L to R) Slotted Line and shielded circuit under test.

$$\phi=\left[\frac{Q_o/Q_L}{Q_o/Q_L-1}\right]^2$$

where

$$Q_o=\frac{\omega_o L}{r};\; Q_L=\frac{\omega_o L}{r+R_g+R_L}$$

for the series case of Fig. 1a and

$$Q_o=\omega_o rC;\; Q_L=\frac{\omega_o C}{\frac{1}{r}+\frac{1}{R_g}+\frac{1}{R_L}}$$

for the parallel arrangement of Fig. 1b. Fig. 1 is a plot of insertion loss in db as a function of the unloaded to loaded Q ratio (Q_o/Q_L). It is noted that for values of Q_o/Q_L less than 2 matching is impossible.

The insertion loss of the symmetrical double-tuned circuit illustrated by Fig. 1c at critical coupling and equal primary and secondary Q is identical to the expression given above with the exception that Q_L is defined differently. In this case

$$Q_L=\frac{\omega_o L}{r+R_g};\; R_g=R_L.$$

Accordingly for a large Q_o/Q_L ratio the operating Q_L of the circuit is twice the Q_L of a single-tuned circuit. The corresponding insertion loss can again be obtained from the curve of Fig. 1 with the correct Q_L value.

Since Q_L may be quite easily determined from the transfer characteristics of the network, there remains only the determination of the unloaded Q or Q_o in order to establish the insertion loss. When the Q_o value is high, as is often desired for small insertion loss, conventional methods of Q measurement fail to give accurate results. Special techniques suitable for such measurement have been developed. The method described below proved to be most satisfactory.

MEASUREMENT OF HIGH Q

The laboratory setup is shown in the photo and block diagram. The measurement procedure is as follows:

(1) A reference point is established by terminating the slotted line with a short circuit for measuring a series-tuned circuit or an open circuit for a parallel-tuned circuit, and then a voltage minimum is located along the line. It is best to use the voltage minimum closest to the load as a reference to minimize the effect of the line losses.

(2) The termination is replaced with the tuned circuit under test.

(3) Tune the circuit until the voltage minimum occurs at the reference point previously established.

(4) Measure the voltage standing wave ratio ($VSWR_o$). Since the resistance of the tuned circuit is very small, the $VSWR_o$ is very large and cannot be measured directly. The method used is to find the distance (y) between two points on either side of and 3 db above the voltage minimum; then

$$VSWR_o=\frac{\lambda}{\pi y}$$

where λ is the wave length. This measurement is performed with a vernier, micrometer or dial indicator depending upon the degree of accuracy required. The resistance at resonance (r_o) may be calculated from this measurement.

(5) Vary the input signal frequency in convenient increments on each side of resonance and record the position of the voltage minimum at each frequency. The distance over which the voltage minimum, occurring at the load at resonance, moves from the load at frequencies around resonance is the phase shift (Δ). The normalized phase shift (Δ/λ) may be plotted as a function of frequency.

The resistance of a simple series-tuned circuit is constant and independent of frequency over a narrow band for all practical purposes. The "half power" points occur at

$$Z=r_o\pm jr_o.$$

For low Q tuned circuits the phase shift required for the "half power" points ($|\Delta/\lambda|_\delta$) can be found graphically. However, the graphical solution is not practical for high Q circuits since r_o is necessarily very small. In the latter case it is necessary to calculate the phase shift ($|\Delta/\lambda|_\delta$) from the transmission line equations. This results in the following:

$$|\Delta/\lambda|_\delta=r_o/2\pi Z_o$$

where Z_o is the characteristic impedance of the slotted line. The plot of phase shift as a function of frequency is linear for small phase shifts, therefore the bandwidth may be calculated from the slope of the curve and the known value of $|\Delta/\lambda|_\delta$, or

$$\delta=K|\Delta/\lambda|_\delta$$

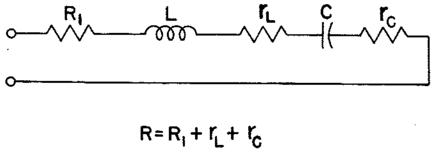


Fig. 3—Series tuned circuit.

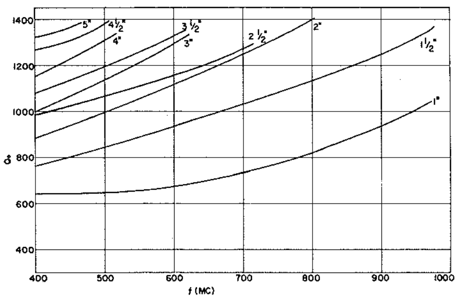


Fig. 4—Q_o vs f for ⅛ inch diam. rod tuned with Johanson Capacitor with inductor length as parameter.

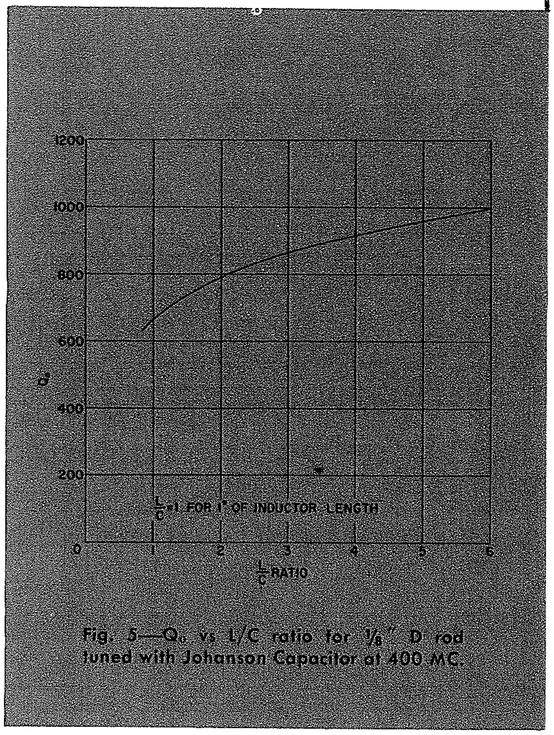


Fig. 5—Q_o vs L/C ratio for ⅛" D rod tuned with Johanson Capacitor at 400 MC.

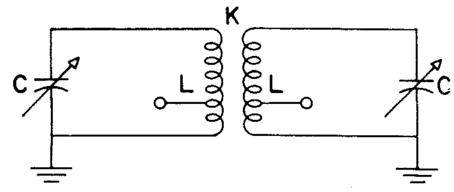


Fig. 6—Double tuned tapped circuit.

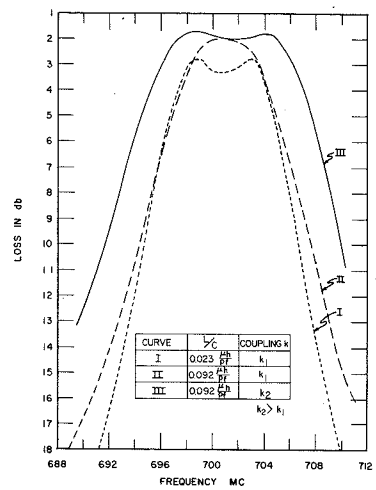


Fig. 7—Insertion loss vs frequency.

where $\delta = \frac{1}{2}$ bandwidth and K is the slope of the Δ/λ vs. frequency curve. Finally, Q_o may be calculated:

$$Q = f_o / 2\delta$$

where f_o is the resonant frequency.

This procedure is not as tedious as it appears since only two points on each side of resonance need to be taken in most cases. If many measurements are planned $|\Delta/\lambda|_\delta$ may be plotted vs. r_o for the slotted line being used.

FACTORS AFFECTING Q_o

We are now in a position to investigate the factors affecting the unloaded Q of these circuits. The factors of importance are: frequency, L/C ratio, enclosure size and components used in the tuned circuits.

For the simple series circuit of Fig. 3:

$$Q_o = 2\pi f L / R.$$

According to this equation, Q_o varies directly with L and with f provided L and R are independent of frequency and of each other. However, in the actual circuit, R is composed of the resistance of the inductance element (r_L), the capacitive element (r_c) and all other resistances (R_1). The total resistance (R) and all of its components are not independent of frequency in the UHF band. On the other hand, the inductance (L) is independent of frequency over the UHF band for all practical purposes. Therefore, the Q_o of a given circuit is not a linear function of frequency at UHF.

In the UHF band skin effect plays a prominent role. Assuming small dielectric loss, the resistance is approximately related to frequency by:

$$R = R_o \sqrt{f}$$

where $R_o = R_{o1} + r_{oL} + r_{oc}$

and is a constant. Q_o may now be written:

$$Q_o = \frac{2\pi\ L\sqrt{f}}{R_{o1} + r_{oL} + r_{oc}}.$$

To change the resonant frequency the circuit capacitance C and hence r_c or the inductance L with its resistance r_L, or both must be varied. For that reason it can be seen that Q_o can be almost any function of frequency. For example, Q_o of a circuit tuned by varying the capacitance would have the form:

$$Q_o = K\sqrt{f} \text{ if } r_c \ll r_L + R_1.$$

Generally, however, the loss in the capacitor at UHF represents a considerable portion of the total circuit loss. In order to determine the actual behavior of typical UHF circuits, Q_o was measured as a function of frequency for a ⅛-inch diameter rod tuned with a Johanson high ratio air capacitor from which the glass had been removed. The results of these measurements are shown in Fig. 4.

The effect L/C ratio has on Q_o may be found in a similar manner:

$$Q_o = \frac{2\pi\ fL}{R} = \frac{\sqrt{L/C}}{R_1 + r_c + r_L}.$$

If the circuit is tuned by the capacitor and $R_1 + r_L \gg r_c$, the variation of Q_o with L/C ratio is very similar to its variation with frequency or $Q_o = K\sqrt{L/C}$. Since the capacitor loss is

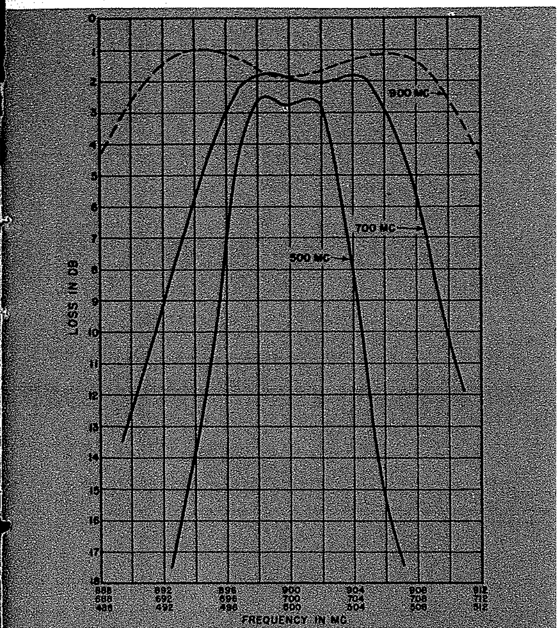


Fig. 8—Insertion loss as a function of frequency.

not negligible, the variation of Q_o with L/C ratio depends upon the manner and magnitude of the changes in r_L, R_1 and r_c. Fig. 5 is a plot of the Q_o as a function of L/C ratio measured with a typical UHF circuit.

The measured variation of Q_o with frequency and with L/C ratio is in the range predicted by the theory.

Generally, the inductors of lumped constant UHF circuits are homemade whereas the capacitors are commercially available. It is therefore advisable to investigate the relative performance of several of the most commonly used capacitor types. The following table shows the dependence of Q_o upon the capacitor type used in the tuned circuit. The resistance of the capacitor (r_c) depends upon the dielectric, the contact between the rotor and the stator, and the length, shape and material of the stator, rotor and supports. It is very easy to understand why the VC-11G capacitor is much more lossy than the Johanson capacitor since a steel screw is used as rotor support, whereas the latter has a silver plated screw.

Q vs. Type Capacitor Tuned with 1½"x⅛" Silver-Plated Strap at 700 Mc Except as Noted

Capacitor	Q_o
829-6 TV trimmer	360
Erie trimmer	450
Johanson trimmer	500
VC-11G trimmer	140
3μμf ceramic with ⅛"x1" strap	340
1μμf ceramic with ⅛"x2¼" strap	700

INSERTION LOSS OF DOUBLE-TUNED CIRCUITS

In order to establish the design of UHF coupled circuits on a firm foundation, some practical data on their behavior is necessary. The circuit used for this investigation is shown in Fig. 6. There are several degrees of freedom involved in this type of circuit such as tap, coupling (k) and L/C ratio, therefore measurements were made under three different conditions:

1) Inductance (L) and capacitance (C) were varied maintaining constant tap and center frequency. The observed results are illustrated in Fig. 7.

2) Frequency was varied by changing the capacitance of a Johanson high ratio air capacitor while inductance and tap were held constant. The corresponding insertion losses are indicated in Fig. 8.

3) Fig. 9 shows the results when inductance and capacitance are varied with bandwidth and shape held constant by changing coupling and tap.

Insertion loss was obtained by the usual method of measuring the power delivered to the load (P_1) with the network and (P_2) without the network between the generator and the load. The loss in db is:

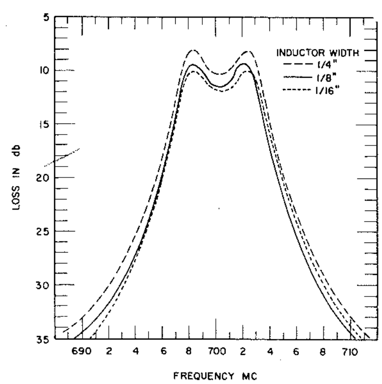
$$\phi = 10 \log_{10} P_2/P_1.$$

The curves of Fig. 9 are very closely related to practical designs and are therefore extremely useful, because the desired passband characteristics for a given application are usually known. However, there may be a compromise necessary between loss and bandwidth, in which case the results given by Figs. 7 and 8 yield much useful information.

CONCLUSIONS

It is possible to predict the insertion loss of UHF coupled circuits by knowing the desired passband characteristics and the unloaded Q. The unloaded Q requirements may be met by the correct choice of components and circuit arrangement. This choice may often be compromised by the cost or size of the desired components. Much more practical information is now available to the UHF design engineers.

Fig. 9—Insertion loss as a function of $\frac{L}{C}$



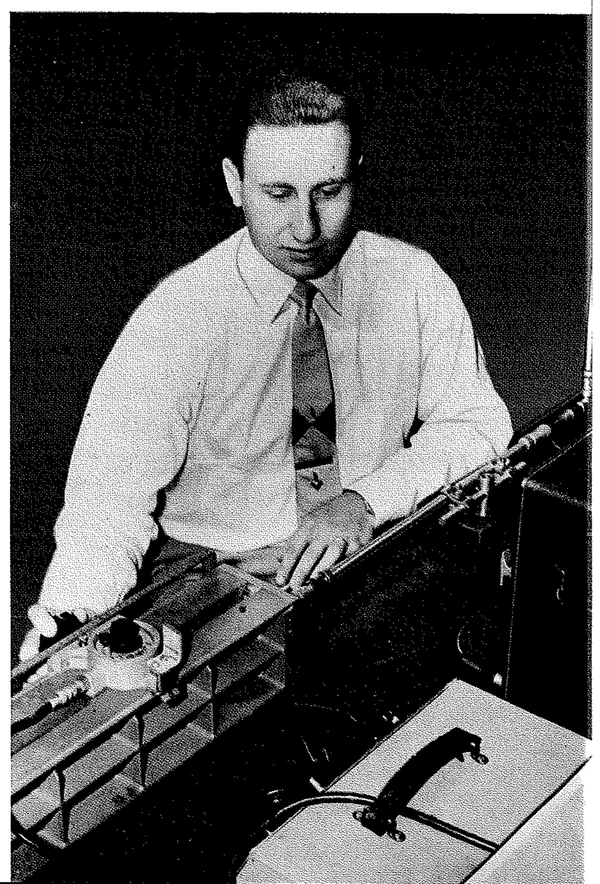


Fig. 10—The author is shown adjusting the slotted line during the process of making VSWR Measurements.

RCA TRAINING PROGRAM FOR NEW ENGINEERS

by
BETTY ANN DUVAL, Mgr.
Training, RCA Staff
Camden, N. J.

ENGINEERS HAVE always been an integral part of RCA's business. Throughout its history they have been responsible for the design, development and manufacture of commercially sound products. The ability of these products to provide consistent high-quality performance for the customer has contributed to the leading position which RCA enjoys in the electronics industry.

Much of RCA's expansion in electronics is dependent upon its ability to direct the talents of its many engineers to assure an increasing number of better products and services. Our business pattern indicates that an increasing number of professionally trained and experienced engineers will be required in the future to maintain our leadership position.

THE NEED

RCA has always provided training to assist engineers in furthering their job knowledge and experience. With the increase in the number of engineers hired in recent years, it was decided that a more formal training program should be developed to assist engineers in their professional development. Results of interviews, the engineering attitude survey and utilization studies further substantiated the desirability of expanding our training programs. The need was expressed for more training on company policy, practices and procedures, technical developments, information regarding other company functions and the development of skill in working with others. This was the background for the development of the *RCA Training Program for New Engineers* initiated in 1956. This training program is available to all new engineers. From a training standpoint, the engineer is "new" when he is hired or transferred to a specific location after the first phase of the Specialized Trainee Program. The Specialized Trainee Program is designed for students recruited and employed directly from college.

THE PROGRAM

The program covers a two-year period and consists of seven units.

First Year

UNIT I—*Job Introduction* (6 sessions, ¾ to 1 hour)

This begins when an engineer is assigned to his section. His immediate supervisor discusses such information as the engineer's responsibilities, procedures in obtaining needed equipment and services, record keeping, engineering and manufacturing standards, the economic situation of the product line, and future opportunity for professional development.

Discussions of these topics are generally accomplished during the first three months of employment.

UNIT II—*Human Relations* (4 to 6 sessions, 1½ hours)

This series of sessions is conducted by the Training Activity and is designed to give the new engineer some insight into working relationships with others, as an individual and as a group member.

UNIT III—*Orientation* (23 or more sessions, 1 to 1½ hours)

This is a series of lectures and tours to acquaint the new engineer with activities and procedures outside his own engineering section, and their relationship to him.

Second Year

UNIT I—*Problem Solving* (6 to 8 sessions, 1½ hours)

The purpose of this unit is to give the engineer practical principles for applying his academic knowledge and techniques to assist in the solution of engineering problems.

UNIT II—*Report Writing* (6 sessions, 1½ hours)

Through a series of practice sessions, the engineer becomes acquainted with the various kinds of written media required and receives practice in effective preparation of these materials.

UNIT III—*Business Topics* (4 sessions, 1 to 1½ hours)

Lectures are presented to help the engineer understand the effect of customer requirements on the product, and the cost factors and budgetary principles involved in manufacturing and sales.

UNIT IV—*Technical Course* (As many sessions as required, 1½ hours)

Through lectures, basic theoretical and practical information is presented on materials, processes, and techniques related to the engineer's general field of work.

(Detailed copies of the program are available at each location.)

The RCA Training Program for New Engineers, developed and conducted with the assistance of engineering management, should create an environment and provide the kind of leadership which will encourage the new engineer to continue to grow professionally and to be prepared for ever-increasing responsibilities. The units of study assist in his orientation from the academic to the industrial situation. The program is designed to present in an orderly and logical fashion information on the non-technical aspects of his work and the various functional relationships which will enable him to move quickly and smoothly into our Company organization. The continuing stimulation and challenge of the sessions should encourage the new engineer to strive for more responsible technical and administrative positions within the Company.

This program which emphasizes the engineering fundamentals and broader educational basis important to the new engineer follows the *Induction Program* developed by this committee which serves to introduce him to our organization and policies.

ADMINISTRATION

Each location is responsible for the administration of the program to its new engineers. The units of study enumerated represent the minimum amount of desired training. The training manager at each location with his engineering training committee or representatives is responsible for modifying the plan to include particular requirements of the specific location and product lines. The units in the program are so designed that they need not be given in exact numerical order as they are listed.

REPORT ON THE PROGRAM TO DATE

Camden Engineering—Since April 30, 1956, when the program was started in this location, over one hundred and forty engineers have participated in

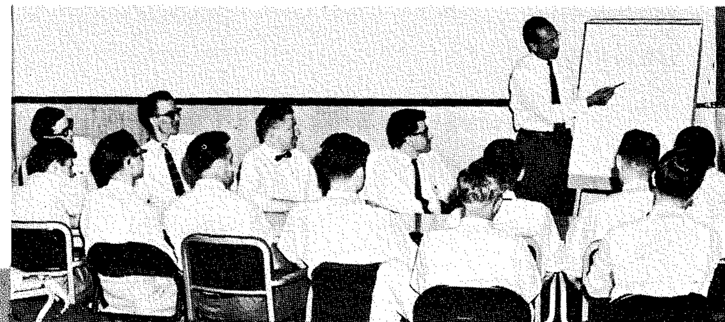
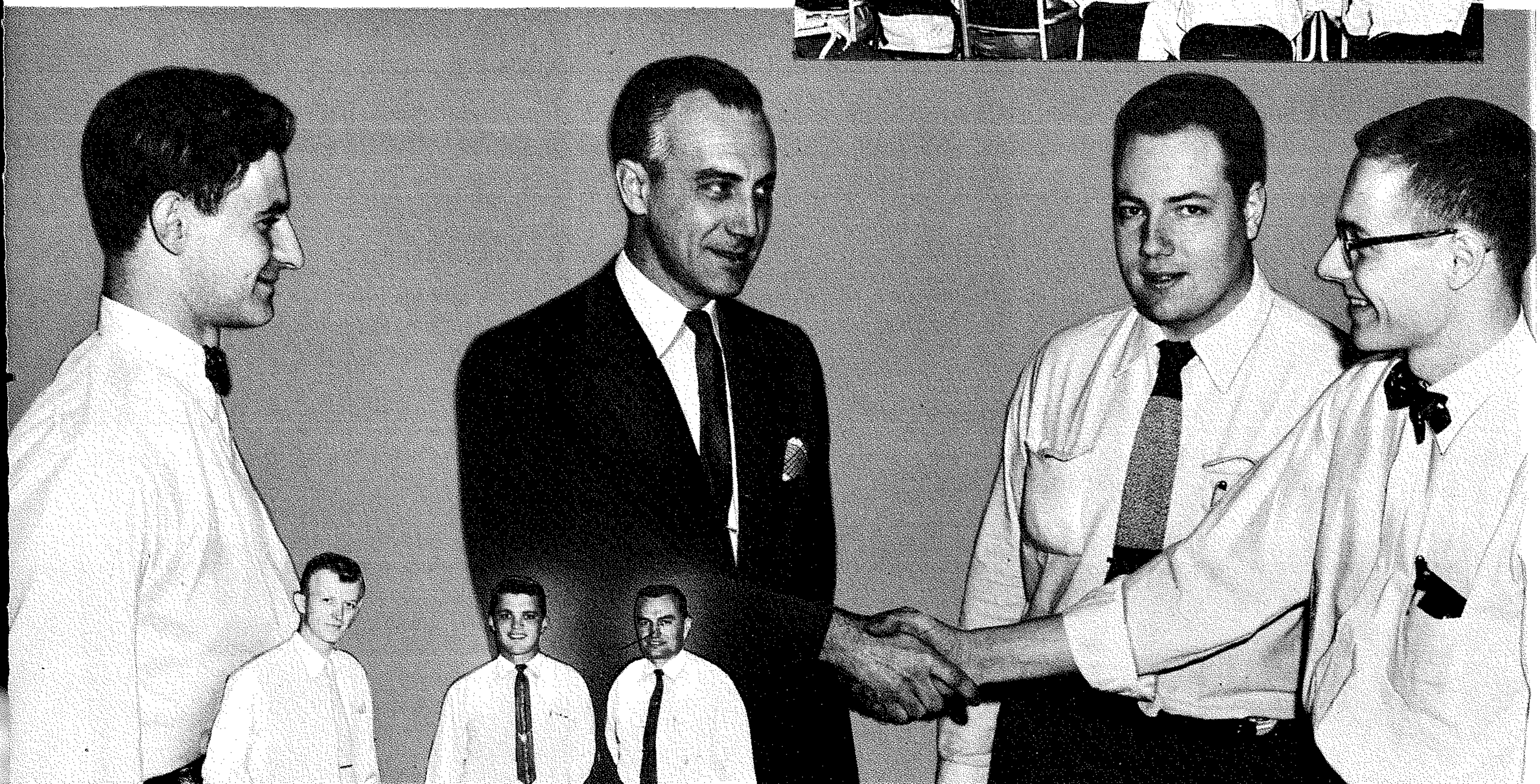


Fig. 1—A session from the Harrison Human Relations Unit. J. B. Lovecchio, Training Instructor Specialist, is conducting the session.



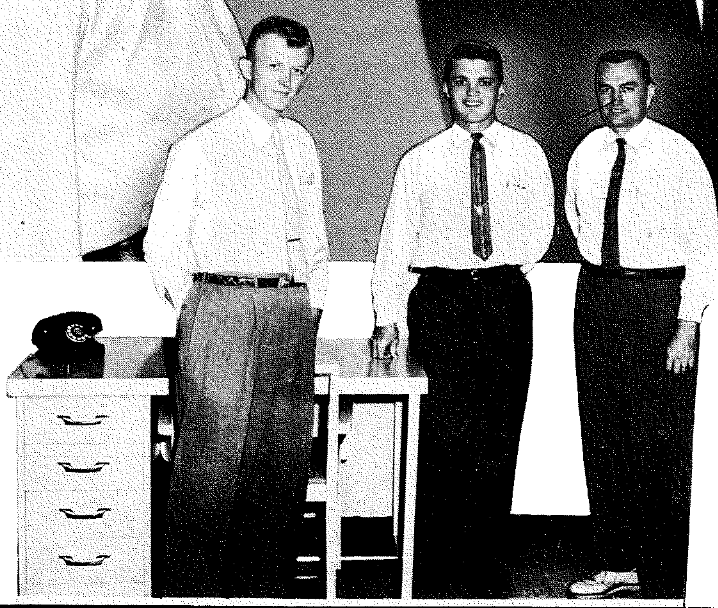


Fig. 2—Dr. D. H. Ewing, Vice President, RCA Laboratories, meets several RCA Lancaster engineers before speaking to the group on "The Place of RCA Laboratories in RCA."

Fig. 3—Engineers participating in the Woodbridge program (left to right): W. Schlegelmilch, M. R. Carbone and L. R. Gormay.

Unit I (Job Introduction) and thirty-seven have completed Unit II (Human Relations). Additional groups will begin Unit II in September so that by October approximately one hundred engineers will have completed this unit. Unit III (Orientation) will be offered for the first time beginning September 25.

Harrison—Ninety-one new engineers have participated in Unit II (Human Relations) and Unit III (Orientation) in the first year of training. Unit I (Job Introduction) is to be introduced following a short familiarization course for engineering managers since this phase is handled by the supervisor. Plans are now in progress for implementation of the second year in 1957.

Lancaster—Sixty-eight new engineers have participated in one or more units of the first-year schedule during the first six months of 1956. Plans are being made for introducing the technical course, Unit IV, at the end of this year.

Marion—Five new engineers have been participating in Unit I. The program was implemented on an individual basis with each supervisor. Unit II is scheduled to start early this fall.

Woodbridge—The three new engineers who started with Woodbridge in July are the first new engineers to receive their training entirely at the Woodbridge location. Plans have been made so that this group will cover the material in Units I and III in an eighty-hour course.

RESULTS

The program is too new to evaluate effectively, but comments from engineers and their supervisors indicate that initial reactions have been favorable. Typical comments are:

"By the nature of their profession engineers are so preoccupied with inanimate things and concepts that often they lack a sufficient understanding of people. For this reason I believe that our discussions on basic human psychology were especially valuable. Of course, the smug individual with nothing new to learn cannot benefit from any program, but I believe that the majority were receptive and will agree that a deeper insight into human behavior was revealed. Beyond question this enlightened program will enhance company operations, once the spirit of understanding the psychology of the other person is instilled in enough people."

Mark Flomenhoft
Participant in the Program
General Engineering Development Activity
Defense Electronic Products
Camden

"Unit I of the *Training Program for New Engineers* is without doubt of great help in making the new engineer feel at home among a group of fellow engineers. It helps shorten the period during which he feels like a 'new man' by making him acquainted with the little things of everyday 'engineering living at RCA' as well as with the ways and means of 'corporation living.' The training program has an equally important effect on the supervisor. The formality of a schedule of discussions is necessary and sufficient to actually bring about the discussion that is all too often postponed to a quiet afternoon that never comes."

Norman C. Colby
Leader in Communications Engineering
Commercial Electronic Products
Camden

"I have been favorably impressed by the training program. Human Relations training was particularly interesting because most of my previous training was in a technical area. This helped me get a broader perspective."

Paul B. Boivin
Participant in the Program
Entertainment Tube Application Lab
Customer Service Unit
Harrison

"This program helps to familiarize new engineers with techniques, organization and basic Company policies. Our new engineers are becoming part of the team sooner."

Timothy M. Cunningham
Engineering Leader
Entertainment Tube Design
Product Development
Harrison

"It was superior! Very helpful in getting acquainted with the organization and learning to know the personnel."

C. A. DeFrees
Participant in the Program
Facilities Control Section
Lancaster

"The program provides new engineers with the *broader* view. They know better what is going on. In my estimation the greatest contribution of the program is through the help it gives

Fig. 4—*RCA Program for New Engineers*. Conducting the group, Richard C. Gies; 1st row, left to right; R. F. Bigwood, E. C. Grogan, B. D. Smith, A. W. Penfield. 2nd row: J. J. Wynne, M. Slobins, M. I. Radis, R. F. Heffelfinger, H. Rubenstein. 3rd row: S. R. Shapiro, D. A. Lesser, R. A. Buck, R. R. Oswald, J. T. Heizer, 4th row. J. A. Ferron, P. G. Van Osten, D. S. Hall.

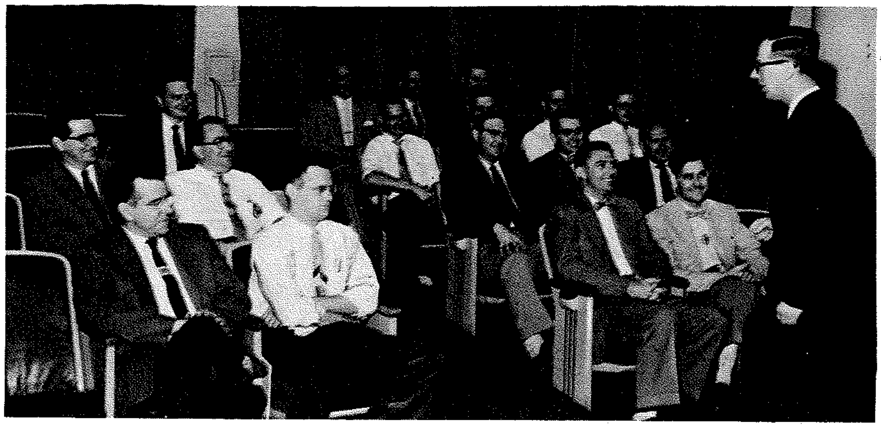


Fig. 5—J. T. Cimorelli is shown with several RCA Lancaster engineers at meeting of 1956 Engineering Orientation Series. Mr. Cimorelli spoke on "The Engineering Profession." Seated to Mr. Cimorelli's left is Dr. Headrick, chairman of the Lancaster Committee.

Fig. 6—RCA Engineering Training Committee (left to right): J. T. Bolden, L. H. Good, R. C. Gies, W. H. Parry, C. M. Sinnett, D. J. Gardam, J. Deckert, G. R. Knowles, J. F. Hirlinger, D. H. Wamsley, W. G. Fahnestock, F. A. Jordano, B. A. Duval.

MISS BETTY A. DUVAL is nationally known in the field of industrial training. A graduate of DePauw University at Greencastle, Indiana, Miss Duval received a bachelor of science degree in psychology. Joining RCA at Bloomington, Indiana, in 1943, she was a training specialist before her present assignment as training manager of RCA Staff at Camden.

In 1951 she was selected as one of RCA's outstanding salaried employes, and was presented with the firm's Annual Award of Merit. She has written several articles for personnel training publications and has appeared on American Management panels on training.

to the new engineer in getting to know the people from whom they can obtain help."

Max Petrisek
Manager
Production Engineering
Power Tube
Lancaster

THE RCA ENGINEERING TRAINING COMMITTEE

The RCA Engineering Training Committee was responsible for the development of this program. This committee was established in November, 1953, to study present engineering training practices and discover methods of preparing the engineer to do a more efficient job of designing a high-quality, yet economical, product. To accomplish this meant analyzing the working habits and goals of engineers as individuals and members of a working group, to improve engineers' technical and managerial skills, and to recommend minimum standards for engineering training throughout RCA.

Since the committee was charged with the planning of a suitable training activity throughout the company, engineering and training representatives were appointed from the Television Division, Radio and "Victrola" Division, Defense Electronic Products, Commercial Electronic Products, Components Division, Semiconductor Division and Tube Division. Original membership of the committee has changed since 1953. Present members are:

R. W. Baumann ...... Somerville
J. T. Bolden .... Camden
J. T. Cimorelli .... Camden
J. Deckert .... Woodbridge
B. A. Duval .... Camden
W. G. Fahnestock ...... Lancaster
D. J. Gardam .... Harrison
D. Garvin .... Lancaster
R. C. Gies .... Camden
L. H. Good .... Camden
J. M. Gregory ...... Moorestown
L. Headrick .... Lancaster
J. F. Hirlinger .... Harrison
F. A. Jordano .... Lancaster
R. L. Klem .... Harrison
G. R. Knowles .... Cherry Hill
E. F. McDonough .... Moorestown
E. Moore .... Camden
W. H. Parry .... Camden
M. O. Pyle .... Cherry Hill
C. M. Sinnett .... Cherry Hill
P. R. Wakefield .... Harrison
D. H. Wamsley .... Somerville

The work of this committee was constantly supplemented and strengthened by the assistance of local training committees in reviewing material and making recommendations for the program. The completed "product" is just one more step in the process of supporting all stages of professional development of our engineers by adequate training. Meeting the training needs of engineers new to RCA hastens the day that their individual talents are recognized and used effectively.

N. C. COLBY

P. B. BOIVIN

T. M. CUNNINGHAM

C. A. DeFREES

M. PETRISEK

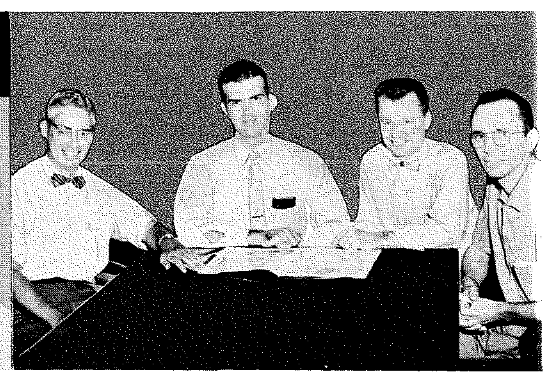


Fig. 7—Engineers participating in the Marion program (left to right): J. Swope, J. Burton, J. Spangler and A. Davis. (R. Delauter not present at time of picture.)

by

DR. JAN A. RAJCHMAN

RCA Laboratories,
Princeton, N. J.

THE TRANSFLUXOR

ONE OF THE latest products of research in magnetics at RCA Laboratories, is the Transfluxor. This simple and reliable new solid state device promises to have many applications because it has a useful and unique property not shared by any other electronic device. It can control electrical signals or power according to any desired level in a continuous range. This level can be established by a single setting pulse and remains stored in the device, whether the device is energized or not, for as long as desired until another pulse establishes a new level.

EARLY DEVELOPMENTS

The story of the transfluxor begins with computers and ferrites. During World War II control of gun fire against targets with ever-increasing speeds required complex computation at speeds with which no existing or imaginable mechanical calculators could cope. Consequently intense research into the feasibility of electronic computers was initiated. Much of that pioneer work was done by RCA Laboratories. Two basic approaches were taken: one in which the variable of computation has a direct analog in a continuously variable quantity such as a voltage and the other in which it is considered as a pure number in digital form, the digit of the number being coded by sets of "on-off" or "yes-no" signals, each signal representing a "bit" of information.

At the end of the war, only the relatively simpler analog computers had any extensive field use. But the digital techniques were greatly advanced. It was possible to add, subtract, multiply, divide and look up tabulated values with an accuracy as high as desired and in times measured in micro or milliseconds. This was exploited for the calculations of ballistic tables for which the first large electronic computer, the Eniac, was built by the University of Pennsylvania. These early successes had far-reaching consequences due mostly to the imagination of mathematicians who conceived the possibility of solving almost any problem capable of a numerical solution with the help of two essential additions to the arithmetic calculator proper: (1) an internal storage device and (2) a system of coding and storing a program of instructions. The storage device for remembering numbers is needed to allow logical chains of calculations in which the result of one is the basis for the next. The program is the specification of the precise chain of calculation required to solve any specific problem. In the universal machine the program is coded by a shorthand, itself exprĕssed by the same on-off signals used to code the numbers. The numbers and instructions are inserted from the input of the machine into its memory. The machine recognizes the instructions and executes them by extracting the right numbers from the memory and disposing of the results back into the memory. Only the final results are brought to the output. Very long chains of numerical computations required to solve complex problems can thus be executed automatically and thereby take full advantage of the speed of electronic computing to obtain a result in minutes or hours which would otherwise take years.

The broad concept of a mathematical universal machine soon became the model of machines for accounting, for handling large amounts of data in inventory control, life insurance, railroad ticket reservation, etc. Extrapolating present trends, many have visualized that man's routine thinking tasks will be taken over by computers in a second industrial revolution, following the first in which man's muscles were supplanted by machines.

At the end of the war, the key to these potentialities was the finding of a device for the internal storage of information. Various approaches were taken, such as storing bits of information in terms of acoustic waves in a delay line or in terms of the magnetization of a coating on a rotating drum or moving tapes. While these solutions provided the first operating machines, there was the fundamental difficulty that access to all bits was in time series so that the greater the number of bits stored the longer the average access time to the desired one. This difficulty could be alleviated only partially by clever programming. What was needed was a memory with direct access to any desired bit and involving no mechanical motion. In such a "random access memory", the storing location within the memory is specified by an address. The address is coded by a number of bits and access for write-in or read-out is only through that code. The method of access in the memory can be compared to the method of access to a person in a city. Random access is used when the person is reached by his coded telephone number. Serial access would be involved if all persons were visited one after another in a given geographical order until the desired one is reached.

RANDOM ACCESS MEMORIES

The first random access memories were based on electrostatic storage tubes. Bits are stored in terms of electric charges on an insulating target. Addressing is by directing a stream of electrons to the selected element which charges it to the desired polarity for writing and later produces a signal indicative of its polarity for reading.

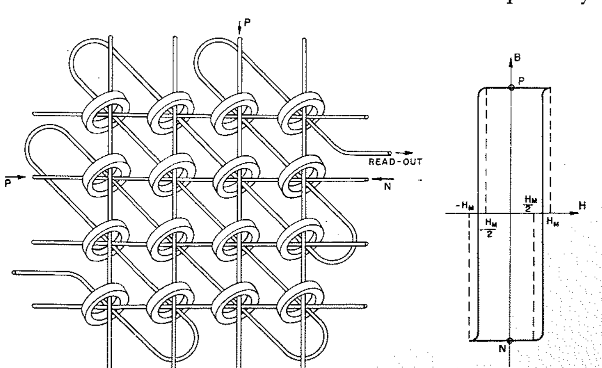


Fig. 1—Random access core memory and idealized hysteresis loop.

The stream of electrons can be the familiar beam of a cathode ray tube, as in the case in a system originally proposed by Williams and in the barrier-grid Radechon tube developed at RCA. In another RCA tube, the Selective Electrostatic Storage Tube, the addressing of the storing element is by truly digital techniques. There is a fixed matrix formed by two sets of parallel wires at right angles to each other which is bombarded uniformly by electrons. The electrons are stopped in all windows except the particular one chosen by applying address selecting voltages to certain ones of the wires. These electrostatic tubes were the basis of the earlier modern computers. Many are still in use, particularly the Williams type. However, the storage capacity is limited to the order of thousands of bits per tube, the operation is not sufficiently reliable and the cost is very high. In the late 40's and early 50's this was the state of the art. An entirely new approach was in order.

This was provided by the advent of magnetic materials which were being developed for magnetic amplifiers. Special metal alloys, cold-rolled into very thin tapes of only a fraction of a thousandth of an inch, proved to have a square hysteresis loop. Moreover the eddy currents were small enough to permit magnetization of the core in microseconds. It was realized that this is an ideal element for the random access memory. A current can magnetize the core in one or the other sense, and when it is removed, a portion of the magnetization remains. The core "remembers" in which direction it was magnetized. While any hysteresis properties provide memory, the sharp threshold of square loops permits the core to be its own address-selecting means. This is illustrated by the typical arrangement of cores in an array which is addressed by windings linking the cores by rows and columns (Fig. 1). To address a given core, currents are sent to the corresponding row and column. The intensity of the current is chosen so that a row or column excitation by itself has no effect on the magnetization of any core because it is below the knee of the hysteresis loop, but the sum of the effects of these two currents is sufficient to reverse the magnetization of the selected core. By sending the currents in one direction or the other the selected core is magnetized in one or the other direction. To read the stored information from the array, the address-selecting rows and columns are energized by currents of a given direction. If the core had previously been subjected to that direction no change of magnetization will occur. If, however, the core was left in the opposite state it will reverse its magnetization and thereby induce a voltage on a winding linking it. The voltage induced on a readout winding linking all cores, when exciting a particuar one, is an indication of the state of magnetization that was stored in that core. The readout is "destructive" in that the state of a core is ascertained by changing it, however the information can be restored by simply rewriting immediately after sensing. The success of the magnetic core memory was immediate. It proved to be extremely reliable. The associated circuits, although extensive, do not require close operating tolerances. The main limitations were due to the metal wound cores themselves which require over five microseconds for switching, and whose high cost prohibits large storage capacities.

INTRODUCTION OF FERRITES

Fortunately the ferrites removed these limitations. Shortly after the War, Snoek in Holland, showed that some compounds of iron oxide with oxide of various metals such as zinc, magnesium, manganese, etc., technically known as ferrospinels, have strong ferromagnetic properties and yet have practically no electrical conductivity. Consequently eddy currents are negligible and operation at frequencies much higher than possible even with the thinest metal laminations became practical. Moreover, the fabrication, consisting chiefly in molding powdery constituents, is adaptable to the production of varied shapes and is very inexpensive. Original work on ferrite materials was initiated at RCA Laboratories as soon as the ferrite discovery was announced. Shortly thereafter RCA went into the production of tons of deflection yokes and fly-back transformer cores for television. It was natural to inquire whether the new fast-operating and inexpensive material could be made to have also the square hysteresis loop required for memory arrays. This question resulted in a research program at RCA Laboratories which had a very rapid success: good square loop materials were synthesized. These turned out to be manganese magnesium ferrites. With these a memory array with ten thousand cores, the myriabit, was built at RCA Laboratories. Today, RCA Bizmac and almost all computers have core memories of comparable size. Square loop ferrites made possible also magnetic switches which greatly simplify the addressing of core memories and which have many other applications. Practical random access memories with storage capacities undreamed of only a decade ago are an operating reality today. We are in the stage of active research for memories with millions of bits—megabits. But still larger capacities and simpler solutions are required to fulfill the requirements of the much heralded second industrial revolution.

Among possible means to increase the storage capacity to millions considered at RCA Labs, cores with several apertures, instead of a single aperture were studied. In the course of the investigation of these cores with

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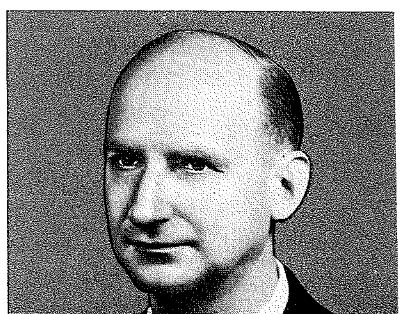
Mr. Rajchman is a fellow of the IRE. He is a member of the American Physical Society, the Council of the Association for Computing Machinery and Sigma Xi. He holds more than 50 patents and is the author of many technical papers.



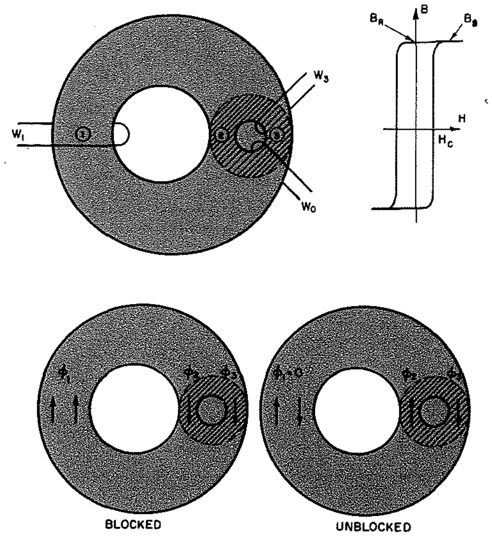


Fig. 2—Principle of the transfluxor.

two or more apertures an entirely new device, the transfluxor, was conceived. It has much broader applications than the memory arrays from which it originated. The device operates by the control of the transfer of flux between the legs of the magnetic circuit formed by the apertures—hence the name "transfluxor".

THE TRANSFLUXOR

To understand the principle of the transfluxor let us consider a core with two apertures of unequal diameter which form three legs, numbered 1, 2, 3 in the Fig. 2. It operates as follows. Assume that at first a current pulse is sent through winding W_1 which is intense enough to saturate legs 2 and 3, but not necessarily leg 1 made deliberately of larger cross-section area. The two legs will remain saturated after the termination of the pulse since remanent and saturated inductions are almost equal in square loop materials. Consider now the effect of an alternating current in winding W_3 producing an alternating magnetomotive force along a path surrounding the smaller aperture as shown by the shaded area in Fig. 2. When this magnetomotive force has a clockwise sense it tends to produce an increase of flux in leg 3 and a decrease in leg 2. But no increase of flux is possible in leg 3 because it is saturated. Consequently there can be no flux flow at all, since magnetic flux flow is necessarily in closed paths. Similarly during the opposite sense of the a-c, the magnetomotive force is in counter clockwise sense and tends to produce an increase in flux in leg 2, which is again impossible since that leg is saturated. Consequently there is no flux flow at all and no voltage induced on the output winding W_0. The transfluxor is "blocked".

Assume now that a "setting" pulse of opposite polarity from that of the first "blocking" pulse and of smaller but prescribed amplitude is applied through winding W_1. The resulting magnetizing force around the larger aperture diminishes gradually with radial distance. Because a critical value of this force is required in square loop materials to produce flux reversal, such reversal is possible up to a critical radius only. The amplitude of the setting pulse determines this radius and can be prescribed so that any desired portion of the width of leg 2 reverses its direction of saturation while the other portion, as well as the more distant leg 3, remain saturated in the original direction. After such a setting, the alternating current on winding W_3, at its first proper phase, will bring back the whole of leg 2 to its original direction of saturation and cause thereby flux in leg 3 to decrease by the amount that flux in leg 2 is increasing, which is precisely equal to that initially "set" by the setting pulse. At the next phase, leg 3 will be saturated to its original direction and the amount of set flux will be transferred back to leg 2. On successive phases the amount of flux set-in will be transferred back and forth between legs 2 and 3. This will cause voltages to be induced in the output winding W_0 which are thus seen to be determined by the amplitude of a single setting pulse. Even though the transfluxor utilizes material which is always saturated completely in one or the other direction, continuous or "analog" control is possible because the position of the limit between the regions of opposite saturations can vary continuously. By saturating the whole width of leg 2 "on-off" or "digital" operation can be obtained also.

The operation of the transfluxor can be compared to the action of a circus juggler who is ready to throw back-and-forth between his hands a ball of any particular size once it is set into one of his hands. His monotonous motions are in vain with a zero size ball (no ball) and remain imperturbable whatever the size (below some maximum) of the ball given to him.

A more technical description considers the amount of flux which can be reversed back-and-forth around the small aperture, or "exchanged" between legs 2 and 3. This is best characterized by a conventional hysteresis loop relating the instantaneous flux to the instantaneous magnetizing force (on leg 3) producing it. For every setting, there is a different amount of exchangeable flux and a different loop. A typical family of loops, as observed on an oscilloscope, is shown in the photograph of Fig. 3. The loops vary in size from the nearly horizontal line obtained in the blocked condition to the largest loop obtained at maximum setting. It is apparent that the transfluxor operates as if the output magnetic circuit consisted of a conventional one-apertured core with the essential property that the effective cross-sectional area of the core can be adjusted by a single set pulse to any desired value from practically zero to a maximum value equal to the physical cross-sectional area of the core.

The amount of flux set by the single setting current pulse depends on the radius of the circle within which the magnetizing force is greater than the critical value required for flux reversal and outside of which it is smaller. The radius of this imaginary circle is proportional to the amplitude of the setting pulse. Therefore below a definite threshold of current setting there is no flux set because the circle is within the large aperture. The amount of flux set increases almost linearly as the circle sweeps the width of the intermediary leg 2. For larger values, flux is set in leg 3 as well as leg 2, so that the amount of interchangeable flux between legs 2 and 3 decreases as the device begins to be

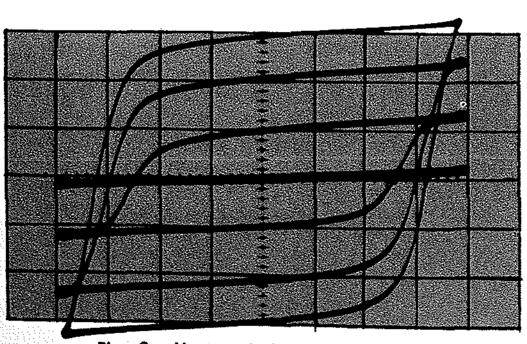


Fig. 3—Hysteresis loop of transfluxor output for different settings.

blocked in the opposite direction. This explains the typical shape of the plot of the useful reversible output flux versus the amplitude of the single setting pulse, Fig. 4. This setting characteristic is for a laboratory model which was the prototype for the first transfluxor made by the Components Division, developmental No. XF1501. It was obtained for setting pulses long enough to allow complete reversal of all settable flux for every setting. For the particular manganese magnesium ferrite and the particular size of the core, this minimum time is about 1.5 microseconds, but can be as short as a few tenths of a microsecond for smaller cores made of slightly differently processed ferrite. The ampere turns required for full setting naturally depend on the size of the transfluxor. For the XF1501 which is about 3/8″ O.D., 1.6 A.T. are required. Experimental transfluxors of .080″ O. D. require only 700 mAT for full setting.

The output magnetic circuit of the transfluxor is similar to a conventional transformer. It is to be expected therefore that power can be transmitted with high efficiency from the primary to the secondary wasting only a small part for magnetizing the core. This is possible, but requires an artifice to prevent malfunction. A transfluxor originally blocked could be spuriously unblocked by flux reversing around the outer legs 1 and 3 in a sense opposite to original blocking thereby bypassing the blocking effect of the intermediary leg 2. Therefore the energizing magnetomotive force in this sense must be kept below a value capable of such reversal but large enough to produce flux reversal around the small aperture via legs 2 and 3 required when the transfluxor is properly set. In the opposite sense the magnetomotive force cannot spuriously unblock, since it tends to bring the blocking leg 3 further into saturation. It can therefore be arbitrarily large and provide not only the required reversing magnetizing force around the small aperture, but also substantial power to a load in the secondary. With such unsymmetric energization conveniently obtained with pulses rather than sine waves, efficiencies of 80% are typical. The energizing pulse can be very short, e.g. a tenth of a microsecond, and produce by rapid flux reversal reasonably high voltages from small cores. Of course, sine wave energization biased or unbiased can be used also. The pulse repetition rate or frequency of the sine wave is limited by power dissipation in the core to about a megacycle for typical transfluxors.

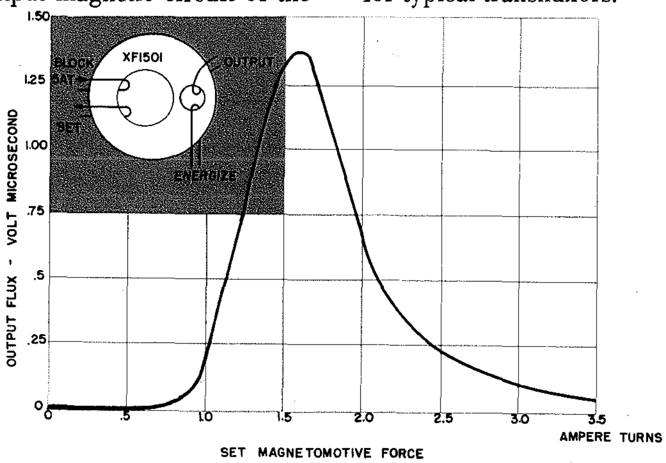


Fig. 4—Setting characteristic of the transfluxor.

APPLICATION OF THE TRANSFLUXOR

The first applications of the transfluxor exploited the "non-destructive" read-out properties of the new device. Read-out from any magnetic storage device must necessarily be dynamic, since induced voltages result from change of flux. In a conventional memory core the stored information is ascertained by changing it, i.e. by destroying it. But in the transfluxor this need not be the case because the flux in the larger leg 1 is not altered by the "interrogation" pulses, retains at all time the stored information, and yet its value determines whether or not flux in legs 2 and 3 will be interchanged as a result of interrogation. A random access memory system using an array of transfluxors (Fig. 5), is the outstanding example of the use of the non-destructive read-out capability of the transfluxor. The two stored states are the blocked and unblocked states. Current coincidence can be utilized for addressing the selected transfluxor both for write-in and read-out. For writing, pulses are applied simultaneously to one row and one column winding linking leg 1. The additive effect of these pulses on the selected transfluxor produces a setting. Because these pulses are kept below the threshold of setting, they have no effect on any other transfluxor. The direction of the writing pulses determines whether the transfluxor is set to the blocked or unblocked condition. Read-out is obtained by applying pulses of the proper amplitude to the selected row and column windings linking leg 3. A read-out is obtained by a pair of oppositely directed pulses on each selecting line. As a result, fluxes in legs 2 and 3 reverse back-and-forth and return to their initial state if the transfluxor is unblocked. If the transfluxor is blocked there are no such reversals. The flux reversal, if any, is detected as an induced voltage on a common winding linking leg 3 of all transfluxors. The non-destructive read-out eliminates the rewrite circuits required in conventional core memories. Further, it makes possible the simultaneous write-in and read-out in different addresses.

The transfluxor can be compared to a latching relay: a pulse will set it to either close or open a circuit until a new pulse sets it differently. A crossbar electromechanical switch is an example of an array of latching relays so arranged that any ones of number of row channels can be connected to any ones of number of column channels depending on which of the relays in the array are closed. The array of transfluxors of Fig. 5 can be utilized for the same purpose. Pulse or amplitude modulated signals applied to the column windings linking leg 3 will be transmitted to those row windings linking leg 3 which are coupled through unblocked transfluxors, but not those coupled through a blocked transfluxor. The setting of the transfluxors can be obtained by using the column and row windings linking leg 1. Transfluxors permit much faster operation than latching relays and are much more reliable, as there are no contacts to wear out. This application of the transfluxor typifies its general use as an on-off device: to transmit on-off or continuously modulated signals. The on and off settings are established by a single pulse and require no holding power to be maintained.

The art of switching by means of square loop magnetic ringed-shaped cores came to existence in recent years, as mentioned previously. Many of the core techniques can be applied to transfluxors and thereby greatly broaden the range of usefulness of the new art. A typical example is the magnetic shift register conceived almost a decade ago at Harvard University. A row of cores are magnetized to one or the other state and thereby register a certain pattern. By means of appropriate couplings between cores the pattern can be shifted along the row by shifting the state of each core to its neighbor in response to so-called advance pulses. A channel commutator can be made using a row of transfluxors instead of cores. All transfluxors are blocked except one. Modulated signals energizing all transfluxors are transmitted only through the unblocked one and therefore the selected channel can be commutated among the outputs by shifting the position of the unblocked transfluxor. This is useful in multiplexing for telegraphy, telephony and telemetering.

The analog storage property of the transfluxor, or the capability to control according to a stored level in a continuous range, can be used to control a resonant circuit. For example the inductance of the circuit can be connected in series with a winding on leg 3 of the transfluxor. For small signals the control is obtained by virtue of the facts that the effective permeability is different for different remanent states, and any desired remanent state can be obtained with proper setting. For large signals, the inductive component, depending on the flux excursion, and the resistive component, depending on the resulting hysteresis losses, have different values for different settings and thereby exercise control of the resonant circuit.

MULTIPLE APERTURES

Transfluxors were made with more than two apertures. The many possible modes of flux transfer between the various legs of the magnetic circuit were exploited to produce interesting storing and switching functions beyond the capabilities of the simplest two-hole transfluxor. For example a device was made to respond to a sequence of pulses, ABC, but not to the occurrance of these pulses in any other order such as BAC or BCA. Another example is a straight "and" gate, in which all of a number of signals must have occurred for the device to be set. A particularly useful transfluxor is one with three apertures. It eliminates the possibility of oversetting, present in the two-apertured transfluxor. It can be set by a pulse of a given polarity so as to be immune to upsetting by any subsequent pulse of the opposite polarity. A good field of research is offered by the study and exploration of the different flux distributions in cores made of square loop material and having complex geometrical configurations.

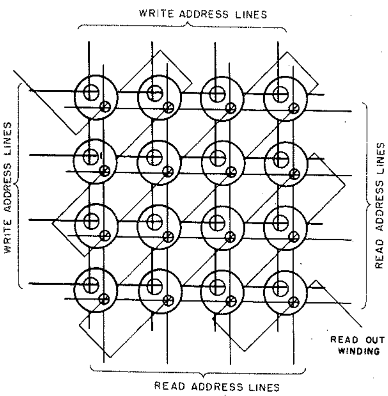


Fig. 5—Array of transfluxors for random access memory with non-destructive read-out.

The few examples of applications of the transfluxor cited here are ones on which active work was or is being done at RCA. Many others have been considered, some in great detail. It is believed that still many more will become important in various fields of electronics, such as radio communication, television, bandwidth compression, automation, information handling systems, etc. For these reasons the Components Division is undertaking an extensive program in manufacturing transfluxors and making available development types adaptable to various needs.

The transfluxor, as other magnetic elements, needs to be driven by tubes or transistors. In many circuits, coupling between transfluxors must include diodes. There is a reasonably good match between some of the present day types of transfluxors and semi-conductor devices. But a better match is needed. It is expected to be possible in the near future with new transfluxors requiring less driving current and new semi-conductors capable of handling more current.

CONCLUSION

The transfluxor has the unique property of being able to control the transmission of electrical power according to a stored level established by a setting pulse. In contrast to the magnetic amplifier in which the input command is not stored and must be present at all times, the transfluxor requires only a single setting. In contrast to the conventional memory core, the transfluxor is not only capable of storing a given amount of set-in flux, but also is capable of furnishing on demand, and for an indefinite length of time an output according to the stored setting without affecting that setting in the least. In a sense, the transfluxor combines the functions of a magnetic amplifier and a memory core.

The transfluxor is relatively simple to manufacture. Like other magnetic devices it is a solid state passive element which is rugged and stable in operation.

Because the transfluxor has these unique properties, it promises to be a significant addition to the list of basic circuit components presently employed in electronics.

ACKNOWLEDGEMENT

A. W. Lo is co-inventor of the transfluxor with the author. G. R. Briggs contributed to the understanding of the device. Ferrite material for transfluxors was developed by I. J. Hegyi, R. S. Weisz, R. L. Harvey and C. W. Wentworth.

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AUTOMATIC EQUIPMENT FOR SINTERING POWDERED METAL INGOTS

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Among the various parts used in the manufacture of electron tubes are wire and ribbon made from several different alloys of tungsten and molybdenum. Tungsten-molybdenum wire is drawn from sintered powdered metal ingots which have previously been swaged or hammered into the necessary shape for the drawing operation. When desired, the wire is also processed into ribbon form by means of rolling. The sintering of the powdered metal has been developed from a manual operation into a completely automatic process. Briefly, the process involves the heating of a powdered metal ingot by passage of an electric current through it in a controlled atmosphere until the diffusion temperature of the metal is reached.

Experience has shown that the best method for developing the necessary heat for sintering is passage of an electric current through the metal ingot. Because the heating is a function of the current, the temperature of the metal can be controlled by means of a current regulator. In an early design of the heat-treating unit, an inductance regulator controlled by a manually operated crank was used to vary the current. This method required several adjustments to be made by an operator during the heating schedule. During the first part of the heating period, the current must be gradually increased as the resistance of the ingot increases with the heat. When diffusion begins to take place, however, the resistance of the ingot decreases and the current must be reduced to prevent melting of the ingot.

The main disadvantage of the early design was the non-uniformity of heating which resulted from the inability of an operator to repeat the procedure in exactly the same way for each unit. In the final design, however, an ignitron contactor is used as a current source, with a combination of a heat-control unit, a current-regulator unit, and a current transformer as the controlling devices. These units consist of standard, commercially available equipment modified slightly to fit this application. A program timer has also been added to make the sintering unit fully automatic.

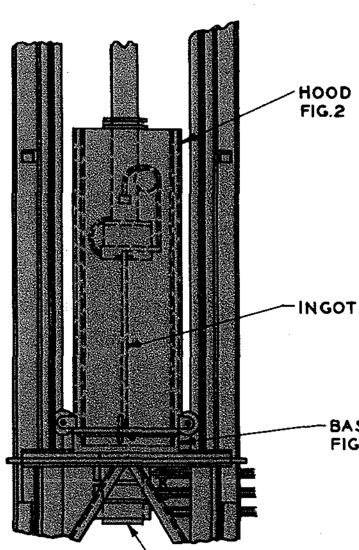


Fig. 1—Overall assembly of sintering equipment.

PHYSICAL DESCRIPTION

An assembly drawing of the sintering unit is shown in Fig. 1. The basic sintering furnace consists of a water-cooled hood and base. The stainless-steel hood is made in the form of a cylindrical shell as shown in Fig. 2, and is approximately 40 inches high and 14 inches in diameter. It is mounted on two small wheels between a pair of iron rails, and can be raised about three feet above the base. The hood is raised or lowered by means of a small one-quarter horsepower motor mounted near the top of the unit. The motor is controlled by push buttons located on the main control panel. The up-or-down motion of the hood is limited by a pair of limit switches.

A water-cooled copper pipe having a diameter of 3½ inches is brought through the top of the hood and is fastened to the water-cooled upper electrode. This pipe, which is the electrical connection to the upper electrode, is insulated from the hood. The metal ingot is clamped to the upper electrode by means of a foot-operated pneumatic control. When the hood is raised to its highest position, the upper electrode is exposed and the ingot can be clamped in easily.

Because the ingots must be sintered in a hydrogen atmosphere to prevent oxidation, an air-tight seal must be made when the hood is down, or in the operating position. The base, which is a Monel casting about 14½ inches square and 3 inches deep, contains a circular groove ¾ inches wide and 2 inches deep, as shown in Fig. 3. This groove is filled with mercury which envelops the bottom edge of the hood when the hood is down, thus making the desired air-tight seal. Hydrogen is introduced through the top of the hood, escapes through an outlet in the base, and is piped to the outside of the building to be dissipated.

An additional feature incorporated in the unit is a means of controlling the dew point of the hydrogen. The hydrogen is passed through a deoxidizing unit, an electric dryer, and a solution of magnesium perchlorate. The hydrogen entering the hood has a controlled dew point of —70° C. Control of the dew point is necessary

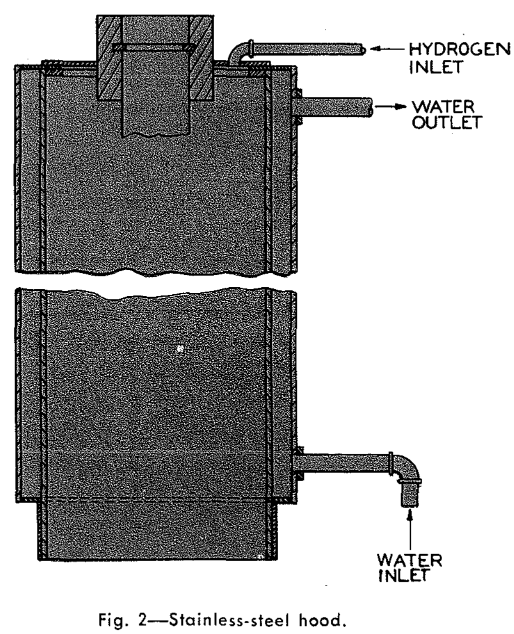
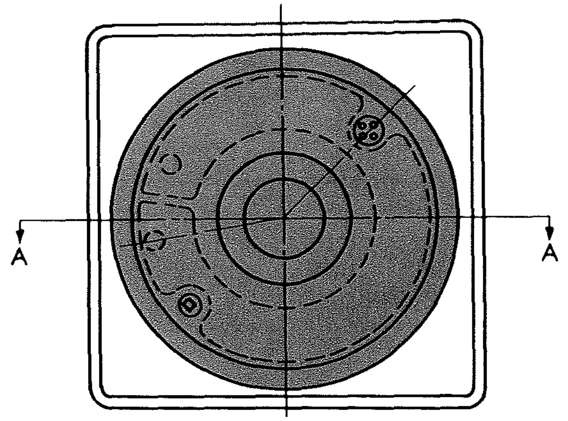


Fig. 2—Stainless-steel hood.



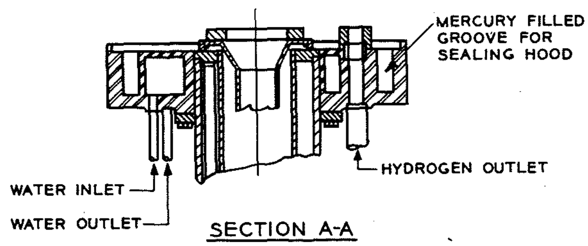


Fig. 3—The base, which receives the lower edge of the hood.

to prevent moisture inside the hood which might cause the formation of large grains in the ingot and resulting breakage during subsequent operations.

The base of the sintering furnace is also water-cooled. As shown in Fig. 4, a mercury-filled Monel pot in the form of a cylindrical shell is fastened in the center opening of the base. During the electrical sintering process, one secondary lead of the transformer is fastened to this mercury pot, which becomes the lower electrode. The other secondary lead of the transformer is fastened to the copper pipe on the upper electrode, as previously described. The mercury pot or lower electrode is not insulated from the base.

The metal ingot, which is approximately 16 inches long, ½ inch wide, and 7/16 inches deep, is prepared for sintering as follows: The metal powder is accurately weighed and measured, and is then placed in a mold and inserted in a hydraulic press. The pressure applied to the ingot is 35 tons per square inch. The ingot is then pre-sintered in a conventional electric furnace for ½ hour at a temperature of 1350°C. This pre-sintering strengthens the ingot so that it may be clamped in the electrodes without breakage and may be handled with more facility.

After being formed, the ingot is clamped vertically to the upper electrode, and a spring-clip type of clamp is fastened to its lower end. When the hood is lowered into place, the bottom clamp is immersed in the mercury pot and becomes part of the lower electrode. The use of the lower ingot clamp serves two purposes: (1) it allows the ingot to shrink during processing without any undue stress or strain, and (2) it keeps the waste from becoming excessive. An ingot may shrink as much as two inches during sintering. If no lower end clamp were used the ingot would have to be immersed in the mercury to a depth of at least 2½ inches so that contact would be maintained during the shrinking period. Because the heating current passes through the contact points on the ingot, the part of the material lying below the surface of the mercury would remain unsintered and would have to be cut off before the ingot could be used. By means of the lower ingot clamp, it is possible to reduce the amount of unsintered waste material to a minimum.

ELECTRICAL DESCRIPTION

The main electrical control panel, situated at one side of the heat-treating unit, houses the meters, switches, and timing devices which start, time, and stop the sintering cycle. When the "start" button is depressed, a small timer starts the treating cycle by actuating a solenoid valve which permits hydrogen to flow into the hood for purging purposes. After two minutes of purging, this timer actuates the main program timer to start the actual heating cycle. The heating cycle consists of five steps, each having a predetermined current valve set by a potentiometer in the current-regulator unit. The current-regulator which normally has only one potentiometer, was modified to include four additional potentiometers to provide the desired five-step current control. The five potentiometers are connected so that one side is common and the other side is connected to the timer contacts. As each set of contacts closes the potentiometers are connected in parallel to provide the highest current value.

One of the two remaining sets of contacts in the main program timer

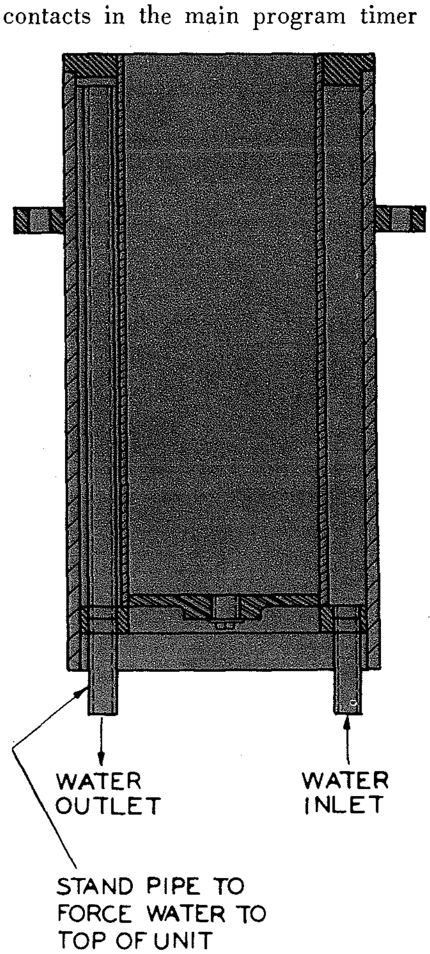


Fig. 4—The mercury-filled Monel-metal pot.

acts as a holding circuit for the timer motor and coil. The other set of contacts is wired in series with the main line magnetic contactor and serves to shut the unit off when the cycle has been completed. A third timer, which is actuated when the heating cycle has been completed, causes a buzzer to sound for several seconds. This timer is a small thermal type which shuts itself off after a specified time.

A block diagram of the sintering unit is shown in Fig. 5. The power transformer, rated at 150 KVA with forced-air cooling, is fed by the ignitron contactor. The primary of the current transformer is connected in the secondary leg of the power transformer. The secondary of the current transformer feeds a signal back to the regulator for control purposes. The current regulator is an auxiliary control used to maintain the current through the ingot substantially constant despite line-voltage variations, changes in the power-transformer impedance or power factor, or any combination of these effects.

This auxiliary control device must always be used in conjunction with a heat-control panel. The heat-control panel acts as an electronic switch controlling the point on the supply-voltage cycle at which the ignitron contactor fires. The ignitron contactor is also an electronic switch having a current capacity much greater than that of the heat-control unit. Its purpose is to supply current to the power transformer when the control circuit is closed, and to cut off the current when the control circuit is open. Both the voltage and current in the output-transformer circuit are metered. The voltage is measured on a double-scale voltmeter having ranges from 0 to 16 and from 0 to 40 volts, and the current on a double-scale ammeter having ranges from 0 to 2500 and from 0 to 5000 amperes.

A series of small indicating lights are also used to provide a visual indication of various phases of the unit's operation. Seven indicating lamps mounted on the control panel are marked as follows: "Time Delay," "Shell Temperature," "Upper-Electrode Temperature," "Lower-Electrode Temperature," "Main Contactor On," "Main Contactor Off," and "Bottle Elevator." The "Time Delay" indicator lights up after the master switch has been closed, indicating that the ignitron contactor, heat control, and current-regulator units have been preheated and are ready for use. The three temperature indicators are operated from Aquastats located in the water-drain lines from the hood, the upper electrode, and the lower electrode. The Aquastats are single-pole, double-throw switches, which cause the temperature indicator lamps to light whenever the temperature of the cooling water in any of the locations exceeds 66° C. The next two indicator lamps show whether or not the main magnetic contactor is on. The last indicator lamp lights when the switch in the hood elevator circuit is closed, indicating that the hood may be raised or lowered.

OPERATION

In actual practice, the amount of current necessary for sintering is determined experimentally. An ingot is placed in the treating unit, and the current is increased in large increments to approximately 3350 amperes during the first five minutes. The current is then increased in 50-ampere steps every 30 seconds until the ingot melts and separates into two parts. At this point, the current falls to zero because the secondary circuit is open and there is no load on the power transformer. A value of 90 per cent of this melting current is then established as the proper fusion current.

The unit is then set for the desired heating schedule by adjustment of the program timer and the potentiometers in the current regulator. A typical schedule consists of the following steps: (1) The hood is purged. (2) The current is increased in four steps from zero to fusion current within a period of four minutes. (3) The current is maintained at the fusion value for 36½ minutes. (4) The unit is shut off and the ingot is allowed to cool for four minutes. (5) The buzzer indicates the end of the cycle.

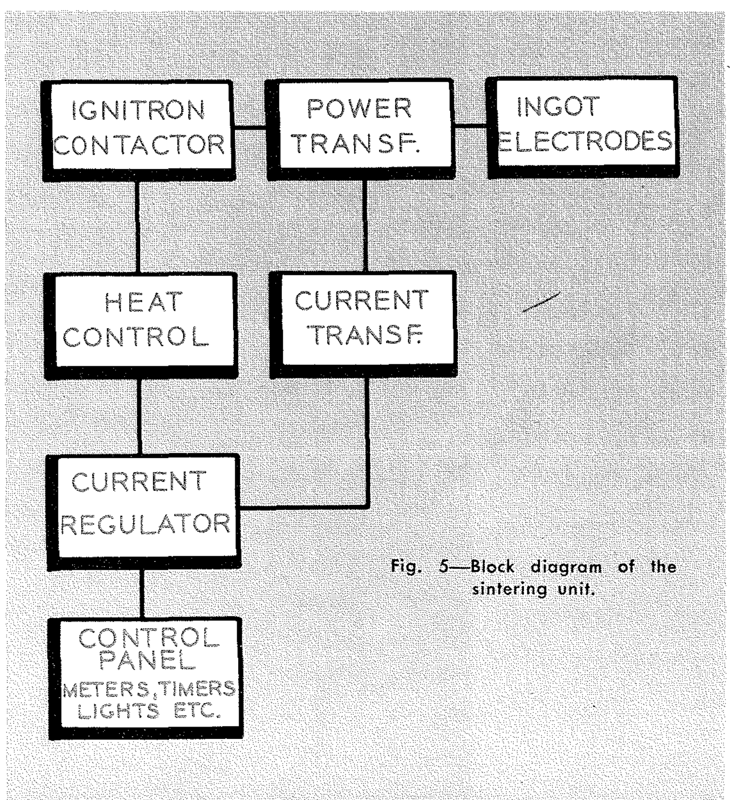


Fig. 5—Block diagram of the sintering unit.

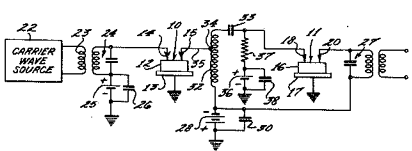
STANLEY I. REED received the B.S. degree in Electrical Engineering from the University of Miami in Florida in 1950. From 1950 to 1951, he was employed in the Measurements Laboratory of the National Union Radio Corporation. In 1951, he joined the Equipment Development activity of the RCA Tube Division in Harrison, N. J. Since that time, Mr. Reed has worked on a variety of tube-processing and tube-testing equipments. At the present time, he is a member of the Electrical Advanced Equipment Development activity working on automatic testing and processing devices. Mr. Reed is a member of the Institute of Radio Engineers.

Patents Granted

TO RCA ENGINEERS

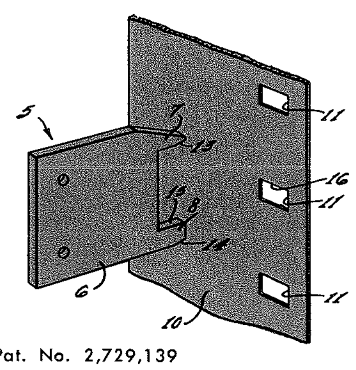
Based on Summaries Received over a period of about two months

BAND-PASS AMPLIFIER SYSTEMS (Patent No. 2,729,708)—granted January 3, 1956 to Hunter C. Goodrich, RCA Victor Television Division, Cherry Hill, N. J. A coupling network between a first and a second transistor amplifier stage including the series combination of an inductor and a capacitor connected between the base and emitter of the second stage, with a connection from the collector of the first stage to a tap of one of the reactive elements, thereby to provide impedance matching.



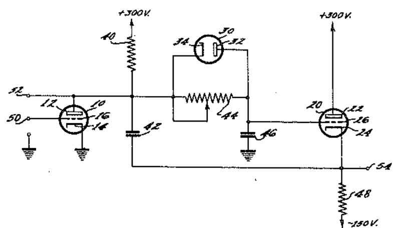
Pat. No. 2,729,708

FILM PULL-DOWN CLAW (Patent No. 2,729,139)—granted January 3, 1956 to Warren R. Isom, Defense Electronic Products, Camden, N. J. An intermittent claw 5 has teeth 7 and 8, tooth 8 having a height in the direction of film motion equal to the height of a sprocket hole 11 minus the film 10 frame shrinkage, minus the sprocket hole 11 shrinkage, and minus the tolerance of good workmanship. The lower edges 13 and 14 of the teeth 7 and 8 are beveled to nudge the film 10 down as the teeth 7 and 8 enter the sprocket holes 11.



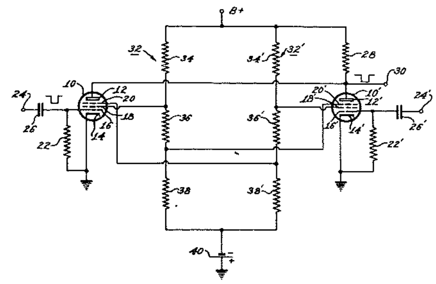
Pat. No. 2,729,139

TIME-BASE GENERATOR (Patent No. 2,735,007)—granted February 14, 1956 to R. J. McCurdy, Defense Electronic Products, Moorestown, N. J. A first capacitor 42 is charged through a first resistor 40. The voltage across the capacitor 42 is integrated by an RC circuit 44, 46. The integrated voltage is applied to the grid of a triode 20. An output, proportional to the integral of the first capacitor 42 voltage, is derived from the cathode of the tube and added to the first capacitor voltage. A linear output may be derived from the junction 52 of the first capacitor and resistor. A square-law output may be derived from the cathode of the tube.



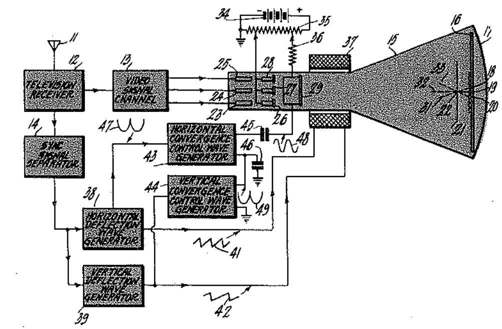
Pat. No. 2,735,007

SIGNAL RESPONSIVE CIRCUIT (Patent No. 2,737,583)—granted March 6, 1956 to Horatio N. Crooks, Defense Electronic Products, Camden, N. J. and Linder C. Hobbs (formerly with RCA). A circuit employing pentodes provides an alternative method of obtaining a logical output in the presence of either one of two input signals, but no output upon the simultaneous occurrence of both input signals. Both pentodes are operated in the absence of input signals with the control grid biased for conduction and the suppressor grid biased to cutoff, thereby permitting screen current flow but no plate current. If a negative input pulse is applied to the control grid of either tube, the screen current of that tube is cutoff. Screen current cut-off, in turn, causes the voltage on a screen grid voltage divider to rise. This rise in screen voltage is transmitted through a coupling network to the suppressor grid of the other tube, thereby allowing plate current flow therein and a resulting output pulse. However, if negative pulses are applied simultaneously to the control grids of both tubes, the negative voltage on the control grid maintains the plate current in both tubes cut-off despite the resulting rise in voltage at the respective suppressor grids. No output pulse results.



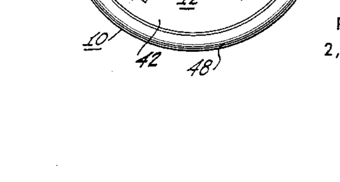
Pat. No. 2,737,583

ELECTRON BEAM CONVERGENCE SYSTEMS (Patent No. 2,737,609)—granted March 6, 1956 to Gordon E. Kelly and Robert D. Flood, RCA Victor Television Division, Cherry Hill, N. J. To dynamically converge a plurality of electron beams in a multicolor kinescope, the convergence field-producing apparatus is energized by at least one wave varying as a sinusoidal function of the beam deflection angle.



Pat. No. 2,737,609

PRONG CONNECTOR FOR PRINTED CIRCUITS (Patent No. 2,742,627) — granted April 17, 1956 to Angelo G. Lazzery, RCA Victor Television Division, Cherry Hill, N. J. and Donald Mackey, Electronic Components Division, Camden, N. J. A tube socket for insertion in and connection to a printed circuit board comprises a plurality of parallel spaced pin receptacles or jacks within the body of the socket. A lip on the socket contacts the unprinted side of the printed circuit board, and bent extensions connected to the pin receptacles and springing radially from the socket contact the printed circuit conductors on the other side of the board to make the required electrical connections and lock the socket in the aperture. The connections may be further secured by dip soldering.

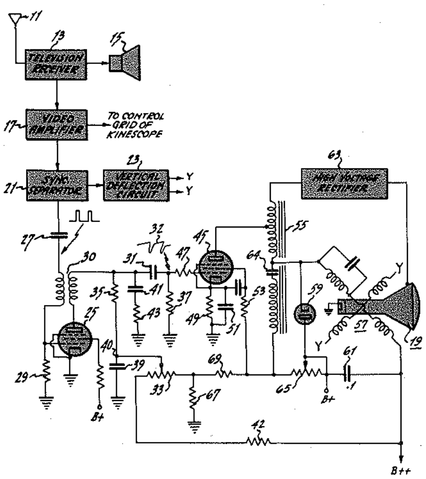


Pat. No. 2,742,627

PATENTS GRANTED

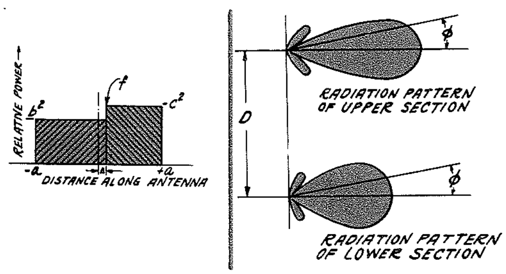
—continued

DEFLECTION CIRCUITS (Patent No. 2,743,382)—granted April 24, 1956 to PAUL M. LUFKIN, TUBE DIVISION, Findlay, Ohio. The width of the scanned raster is controlled by a variable resistor coupled in series with the deflection winding and coupled also to the screen grid of the horizontal output tube and further coupled to the input circuit of this tube. The width control functions simultaneously (1) to adjust the "Q" of the deflection winding circuit, (2) to adjust the power input to the screen of the horizontal output tube, and (3) to adjust the grid drive voltage to the control grid of the output tube.



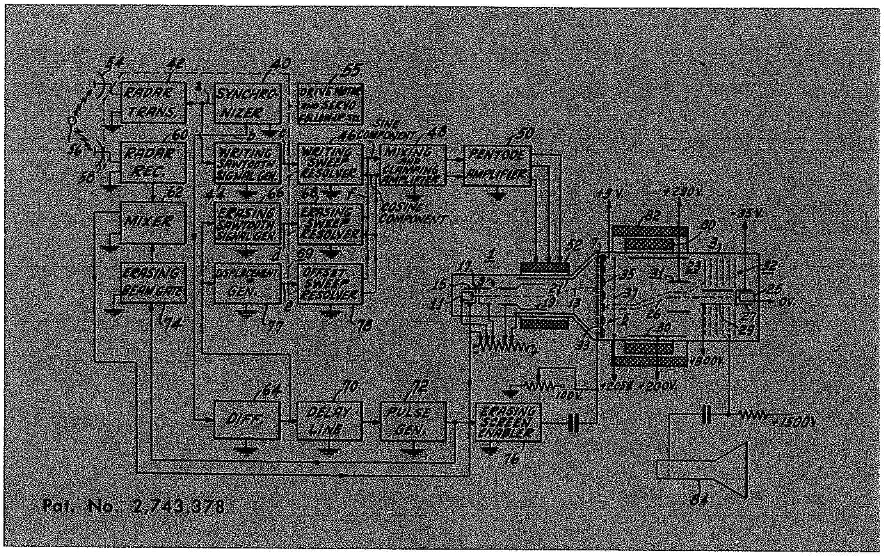
Pat. No. 2,743,382

ANTENNA FEED SYSTEMS (Patent No. 2,744,249)—granted May 1, 1956 to WILLIAM S. BRANDBERG, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. and EDWARD SHIVELY (formerly of RCA). An antenna array, particularly useful for UHF television broadcasting, wherein the feedpoint for the antenna array is displaced from the center of the array, and equal powers are supplied to the antenna elements on both sides of the feedpoint. By this arrangement, good null fill-in is accomplished, and the pattern closely approximates the desired cosecant field distribution necessary for good reception within the circular service area of the antenna.



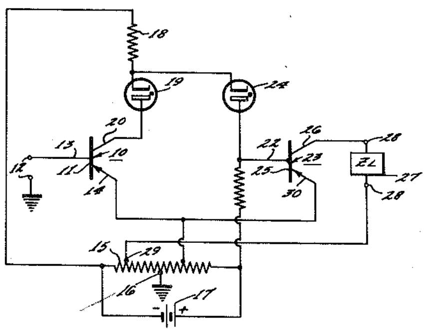
Pat. No. 2,744,249

SCAN CONVERSION SYSTEM UTILIZING RESOLVED WRITING (Patent No. 2,743,378)—granted April 24, 1956 to FRANK D. COVELY, 3rd and LOUIS M. SEEBERGER, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. The reading out of data stored in the Metrechon (half-tone) storage tube does not erase. Scan conversion of radar PPI data may be effected during the radar deflection "flyback time". Writing deflections are produced in a conventional manner by circuitry which includes a resolver 46. During the flyback time, the Metrechon writing beam is gated on by a pulse generator 74 and its suppressor screen 33 enabled for erasure. A second resolver 68 then produces deflection signals for erasing old data immediately in advance of writing new data. A third resolver 78 may also be employed to provide an off-center type erasing sweep.



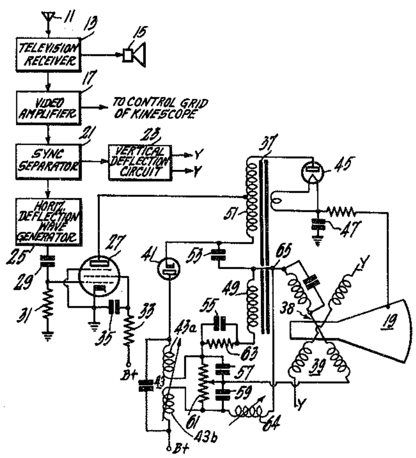
Pat. No. 2,743,378

COUPLING CIRCUIT FOR SEMICONDUCTOR DEVICES (Patent No. 2,747,111) — granted May 22, 1956 to WINFIELD R. KOCH, RCA VICTOR TELEVISION DIVISION, Camden, N. J. A signal translating circuit has a pair of signal terminals with two electrodes of one transistor connected between them. To provide efficient signal coupling through the circuit and biasing potentials for the transistor, a coupling network is connected between the terminals that comprises a pair of unilateral conducting devices connected in opposition. In a point contact transistor bi-stable circuit this pair of devices may be replaced by a single semiconductor diode.



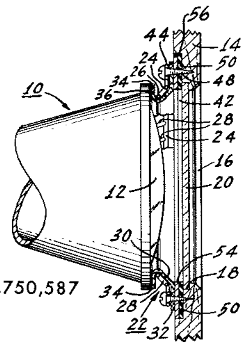
Pat. No. 2,747,111

RASTER CENTERING CONTROL (Patent No. 2,743,381)—granted April 24, 1956 to LEONARD DIETCH, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. A portion of the output transformer, an inductive choke, a potential dividing resistor and a balancing resistor are mutually connected into a closed loop, thereby forming a direct current bridge circuit. Direct current is applied across the potential dividing resistor forming one side of the bridge, and across the balancing resistor, the transformer winding and the choke forming the other side of the bridge. The deflection yoke windings are connected across the bridge from the point between the transformer and the choke to the variable contact of the potential dividing resistor. Centering current through the yoke is permitted to flow in either direction, but through the output transformer it is limited to a single direction which is so chosen that its saturation effect upon the transformer core tends to cancel, or "buck out", the saturation resulting from the flow of anode current from the output tube, through a portion of this transformer to the damper tube.

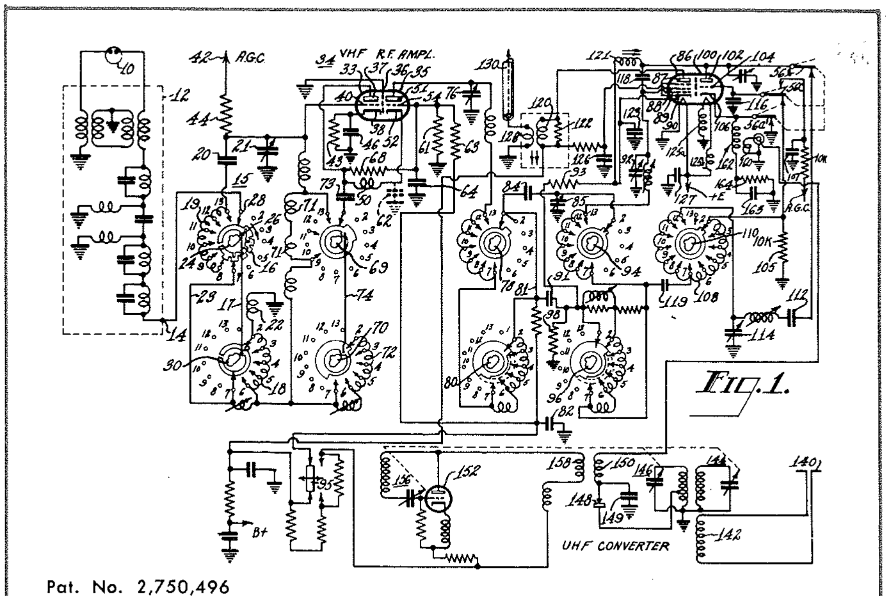


Pat. No. 2,743,381

KINESCOPE MASK & DUST SEAL (Patent No. 2,750,587)—granted June 12, 1956 to JAMES F. NICHOLSON and DONALD J. RANSOM, TUBE DIVISION, Lancaster, Pa. Kinescope mask and dust seal is frangible, being formed of a wire framework covered by paper. In the event of implosion of the kinescope, the pressure acting upon the outer surface of paper, in opposition to the vacuum produced by the implosion, will rupture the paper. Thus, air is permitted to rush into the region between the kinescope and the safety glass, thereby preventing the vacuum from "pulling" the glass out of its seat. Rebounding glass fragments from the kinescope face are thus effectively prevented by the safety glass from flying out of the cabinet opening.

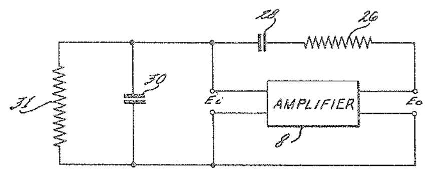


Pat. No. 2,750,587



Pat. No. 2,750,496

SEMICONDUCTOR SIGNAL GENERATOR (Patent No. 2,745,960)—granted May 15, 1956 to BROOKS D. GRIFFITH, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. The signals on the collector and emitter of a point-contact transistor are in phase. Accordingly, an oscillator is provided, in accordance with the invention, by connecting a network comprising a simple Weinbridge between the collector and emitter of such a transistor. The network provides feedback between the collector and emitter of proper phase and magnitude to sustain oscillations.

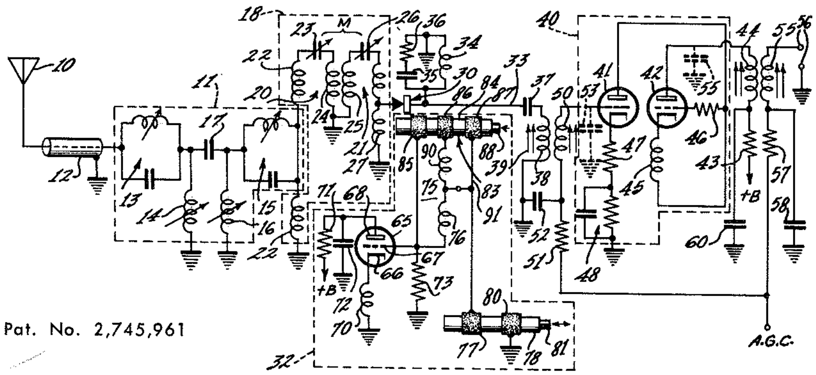


Pat. No. 2,745,960

VHF UHF RECEIVER HAVING LOCAL OSCILLATOR CONVERTIBLE TO AN I.F. STAGE (Patent No. 2,750,496)—granted June 12, 1956 to LEOPOLD A. HOROWITZ and GILBERT C. HERMELING, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The VHF tuner has an r.f. amplifier, a mixer and an oscillator which operate in the usual manner for the reception of VHF television signals. For UHF reception, the mixer and oscillator stages are switched to operate as i.f. amplifiers, and the i.f. signals from the UHF converter are fed to the input circuit of what was formerly the VHF oscillator.

MULTIBAND U.H.F. OSCILLATORS . . . (Patent No. 2,745,961)—granted May 15, 1956 to WEN YUAN PAN, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The frequency determining circuit of the invention includes a first band selecting inductor connected in series with a variable tuning capacitor. A plurality of other band selecting inductors are provided for successive connection in parallel with said first inductor through a capacitive switch to tune the frequency determining circuit to other frequency bands. The successive inductors which are connected in parallel with the first inductor have an inductance value selected to tune the frequency determining circuit to successively high frequency bands.

APPARATUS FOR POSITIONING AND WELDING SUPPORTS IN A CYLINDRICAL STRUCTURE (Patent No. 2,749,418)—granted June 5, 1956, to CLARENCE H. MATTSON, TUBE DIVISION, Lancaster, Pa. For fixing shadow mask supports (24) to a top cap assembly, a disk-shaped apparatus has radially extending and movable carriers (54, 55, 56) for carrying the mask supports into suitable relation to the inner wall of cylinder 21 of the top cap assembly. The positions of the carriers are controlled by locating members (38, 39, 40) also radially extending from the disk body (36) of the apparatus.



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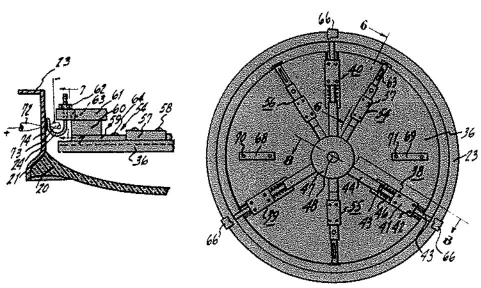
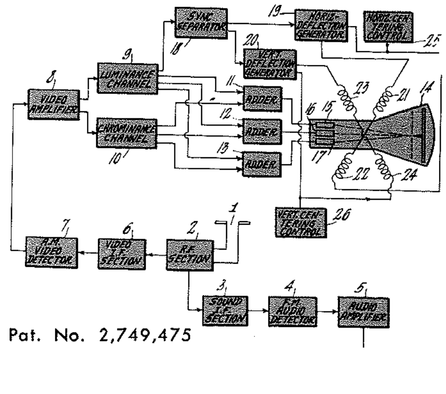


Pat. No. 2,749,418

TV VERTICAL DEFLECTION CIRCUIT (Patent No. 2,749,475)—granted June 5, 1956 to BERNARD V. VONDERSCHMITT, ELECTRONIC COMPONENTS DIVISION, Camden, N. J. To prevent currents of horizontal deflection frequency from adversely affecting vertical deflection, a low capacity-high inductance choke, which may be bifilar wound, is interposed in the d-c centering supply leads to isolate the vertical deflection winding from horizontal deflection currents.



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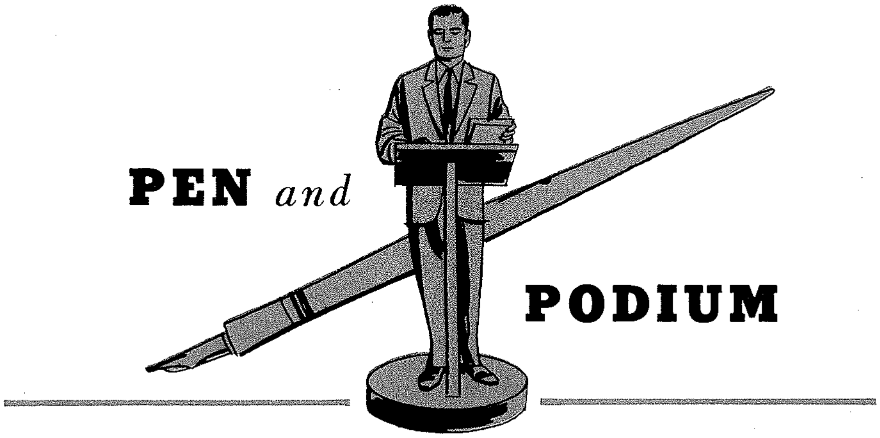
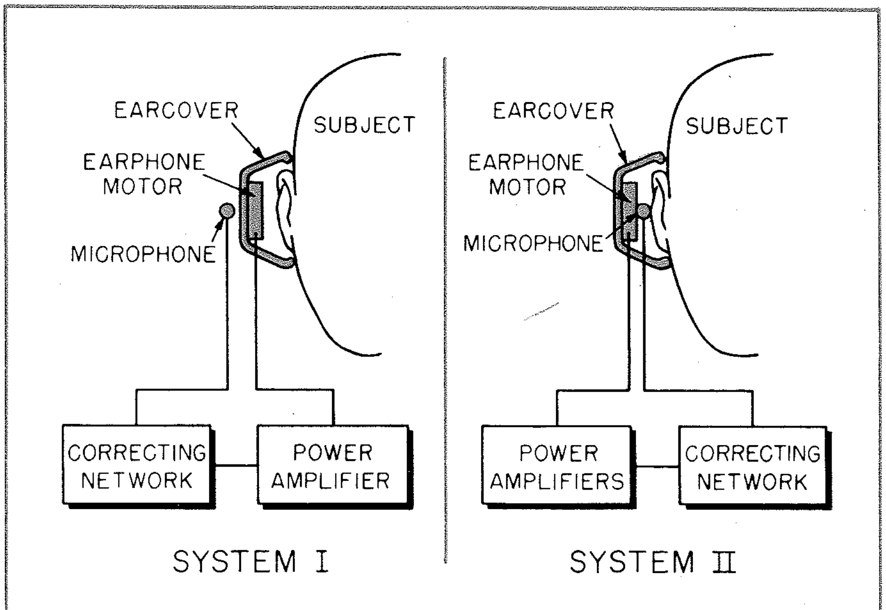


BASED ON REPORTS RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

EXTENDED RANGE TIMING TECHNIQUES . . . By A. I. MINTZER, DEFENSE ELECTRONIC PRODUCTS, Moorestown, N. J. Presented on August 24, at the 1956 WESCON Convention. Most precision tracking radar and navigational systems using crystal oscillators as reference time bases face extremely stringent stability problems if their range capabilities are extended while maintaining the same resolution. This paper discusses timing circuit techniques, including recycling multiscale mechanical range systems, precision peaking circuits, time base circuits with quasi-range tracking, locked phase frequency dividers with recycling and other techniques, which provide reliable precision timing and ranging limited in range basically by the P. R. F. and the crystal oscillator stability. These techniques are not affected by discrete P.R.F. changes or modulation, provided the constraint imposed by the one time around P.R.F. duty cycle limitation is not exceeded.

THE NOISE CANCELLING HEADSET—AN ACTIVE EAR DEFENDER . . . By E. D. SIMSHAUSER, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented at the joint meeting of the Second International Congress on Acoustics and the 51st meeting of the Acoustical Society of America at Harvard on June 21, 1956. Some of the more noisy devices of our modern age (jet aircraft for example) make communication difficult and endanger the hearing of persons near them. The object of the Active Ear Defender is to lower the noise (at the ears of the user) by means of acoustic interference. One configuration, system I, has a microphone mounted outside an earcover. After correction in phase and amplitude, the microphone output is amplified and drives the earphone motor which produces a sound equal but opposite to the noise inside the earcover. System II uses an internally mounted microphone and is a negative feedback system, the noise reduction being nearly equal to the feedback.



Noise cancelling headset.

PRINCIPLES OF COLOR TV FOR THE LAYMAN . . . by D. G. GARVIN, TUBE DIVISION, Lancaster, Pa. Presented at Wheatland Lions Club, Lancaster, Pa. on June 12, 1956 and at the No. Lancaster Kiwanis Club on August 15. This paper outlines the development of compatible color television by RCA, and compares compatible color with mechanical non-compatible systems of reproduction. A brief description of the operation of color television is given, including the use of the image orthicon in the studio camera and the use of the color kinescope in the receiver in the home. The Lancaster plant where these tubes are manufactured is described, and the major products of the plant are listed. Present development work on color-television tubes and plans for future are outlined.

FORMULATION OF RCA BIZMAC COMPUTER TO ACCOMMODATE APPLICATION REQUIREMENTS . . . By L. S. BENSKY, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented on May 10, 1956 at the Massachusetts Institute of Technology, Operations Research Seminar. In general, the remarks described some of the problems encountered in the early system design of the BIZMAC computer. The problems highlighted the effects of application requirements on formulating the computer as a unit of the RCA BIZMAC System. The studies which led to to the solution of these problems were discussed and quantitative approaches were indicated whenever possible. The application requirements and the resulting computer problems were drawn primarily from the inventory control functions of the Detroit Army Ordnance Tank and Automotive Center. These requirements involve consideration of accounting procedures, programming, and operation-maintenance procedures.

RCA BIZMAC ELECTROFAX PRINTER, A CONTINUOUS DIRECT DRY PROCESS ENLARGER . . . By H. G. REUTER, JR., and G. C. SIH, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented on August 24, at the 1956 WESCON Convention. The Electrofax Printer is a companion piece to the Ultratype Camera for the high-volume Production of output documents from a digital computing system. The printer works with 35 mm film as input and produces output documents on which the information appears at a density of 10 characters per inch, 6 lines per inch. Paper moves through the printer at the rate of 6 inches per second. Printing is fully automatic and is accomplished through utilization of the RCA Electrofax direct dry electro-photographic process. Provision is made to shear the paper automatically according to document size.

EXPONENTIAL TRANSMISSION LINES AS RESONATORS AND TRANSFORMERS . . . By RABINDRA N. GHOSE, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Presented at the 1956 WESCON Convention on August 23. In this paper attempts have been made to analyze the theory of exponential transmission line from its complex reflection coefficient's standpoint and to indicate how the characteristics of an exponential line can be completely represented for any frequency with the help of a Smith Chart. It is shown that the optimum design parameters of an exponential transmission line which may be used as a transformer with a frequency sensitive load at one end can be readily determined with the help of Smith Chart and some derived equations. The paper also includes a study of the coaxial type exponential line which can be used as a series or parallel resonator. Theoretical expressions for the attenuation constant, stored energy and Q for such type of resonators have been derived to indicate how they can replace the uniform line co-axial type resonators in many microwave and VHF wave filters particularly when a large power handling capacity is warranted.

SITUATIONS THAT EFFECT THE PRODUCTIVITY OF ENGINEERS . . . By M. C. BATSEL, *Chief Technical Administrator,* DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented at the 1956 WESCON Convention, San Francisco, on August 21. The performance of engineers is closely related to their motivation. Some techniques of administration that encourage individual engineers to identify themselves with their jobs and to feel a responsibility for accomplishing the objectives of management were discussed.

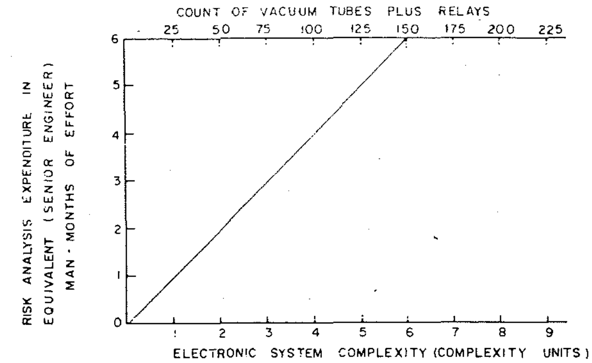
CALCULATIONS OF THE RISK OF COMPONENT APPLICATIONS IN ELECTRONIC SYSTEMS . . . By JOHN A. CONNOR, COMPONENTS DIVISION, Camden, N. J. Presented on August 22, at the 1956 WESCON Convention. A panoramic insight into the prediction of Electronic-System Reliability from component characteristics was given by demonstrating the means whereby simple and economically-practical computations can be made to determine the "risk" factors. A range of specific circuitry and environmental conditions were chosen as test cases. The statistical adequacy of certain computational procedures were asserted along with the promotion of a scheme for appraising complete complex systems. The criteria for determining acceptable costs for such Reliability evaluations were described and shown to be compatible with the bounds of practical Reliability economics.

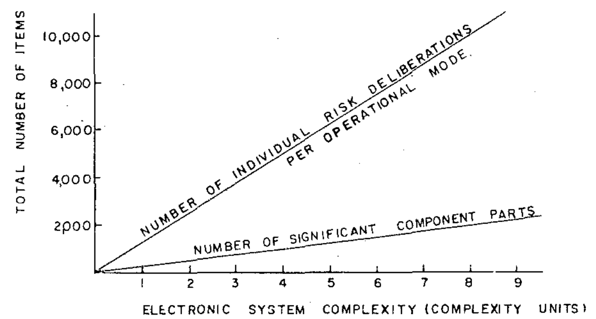
MAGNETS FOR FUN AND UTILITY . . . By RHYS SAMUEL, TUBE DIVISION, Harrison, N. J. Published in POPULAR ELECTRONICS, August 1956. This paper describes a simple, inexpensive magnetizer unit which can be used to magnetize hand tools, toys, cabinet latches, and other devices. The magnetizer is built around an RCA-202D1 focus coil from an RCA Model 630TS television receiver, although any focus coil designed to handle a direct current of 120 milliamperes or more can be used. A schematic diagram and construction details for the unit are given, and operating considerations are discussed.

NEW TECHNIQUES USED IN THE DEVELOPMENT OF A 40-WATT CERAMIC UHF POWER TETRODE . . . By M. B. SHRADER, TUBE DIVISION, Lancaster, Pa. Presented at WESCON, Los Angeles, Calif., August 21-24, 1956. The design goals for the development of a new ceramic tetrode capable of providing a carrier power output of 40 watts under plate-modulated conditions in the 200-to-400-Mc band are described. Various initial approaches in the design of a tube to meet the proposed requirements are discussed, together with a review of the construction techniques available at the beginning of the development program. Construction problems encountered in the development of these tubes are reviewed, as well as the steps leading to the development of an entirely new approach to control-grid and screen-grid fabrication. Techniques developed for mechanizing the ceramic-metallizing process are also discussed.

A detailed description is presented of the electrical discharge process for simultaneous machining of two coaxial grids in exact alignment. Advantages of the resulting structure and problems solved which are peculiar to this process are reviewed.

Definition of complexity unit for electronic systems.





Electronic system complexity (complexity units).

Electrical performance data for the tube as a plate-modulated amplifier over the 200-to-400-Mc region are presented, together with the results of tests at frequencies above 400 Mc. Typical circuits used for evaluation of the tube in the uhf region are given. The results of shock and vibration tests on this type are discussed, as well as plans for meeting increased demands in this direction.

VERY-LOW-NOISE TRAVELING-WAVE TUBE . . . by E. W. KINAMAN and M. MAGID, TUBE DIVISION, Harrison, N. J. Presented by Dr. B. B. Brown on May 29 at the International Congress on Microwave Tubes, Paris, France. This paper describes recent modification of a traveling wave tube which has substantially reduced the noise figure and culminated in the commercially available RCA 6861 S band low noise traveling-wave tube. Earlier developmental models of this tube had an average noise figure of 8.5 db. This average noise figure has been reduced to 6 db, and values as low as 4.7 db have been achieved on individual tubes. The effect on noise figure of variations in helix and gun parameters, focusing, and beam-current level is discussed. Tube characteristics are presented, together with discussions on phase distortion, linearity, and variation of noise figure with operation conditions.

COLOR TV LIGHTING SURVEY AND REPORT . . . By G. F. RESTER, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. Published in the JULY issue of the SMPTE Journal. Also presented on May 2, 1956 at the Society's Convention at New York City. A survey of current lighting practices of TV stations engaged in live color origination was requested by the Television Studio Lighting Committee of the SMPTE. Seven major categories were covered: General Studios, Lighting Materials, Personnel, Instrumentation, Make-up, and Miscellaneous. The main purpose of the survey was to determine the areas where independent and affiliated stations could benefit from assistance and advice. It was planned that after these areas were defined, SMPTE Lighting Subcommittees would be assigned specific areas for investigation.

MAGNETRON TESTER DETECTS LOST PULSES . . . By P. KOUSTAS and D. D. MAWHINNEY, TUBE DIVISION, Harrison, N. J. Published in ELECTRONICS, August 1956. This paper describes a new type of missing-pulse detector for use in production testing of magnetrons by tube manufacturers or by manufacturers of equipment utilizing magnetrons. The "direct-cancellation" type and "coincidence" type of missing-pulse detectors presently used are described, and the advantages of the new unit are evaluated. The new detector is similar in principle to the coincidence-type detector, but it avoids the difficulties associated with crystal demodulators by the use of a thermal detector (a bolometer or barretter). This type of demodulator de-

PEN AND PODIUM

—continued

livers an integrated output signal having a peak amplitude directly proportional to the rf energy content of each magnetron output pulse, and thus makes it unnecessary to use either a separate integrator or video circuitry. The new unit requires no complex setup procedure, and has only one operating adjustment. Circuit diagrams and operating considerations are included.

PREMIUM TUBE TYPES AT RCA . . . By H. E. Stumman, Tube Division, Harrison, N. J. Presented at Lincoln Laboratories, M.I.T., Cambridge, Mass., on May 17, 1956, and at Remington-Rand and Minneapolis-Honeywell, Minneapolis, Minn., on June 19, 1956. This paper outlines the evolution of premium tubes, and describes the RCA Special Red tubes designed for long life and severe environmental conditions, the ARINC program for improvement of miniature tubes for aircraft equipment, and the Military sponsorship of development contracts for premium tubes. Special features of design, construction, choice of materials, and specifications for premium tubes are discussed. Curves are presented showing performance of premium miniature tubes over 1000 hours of life and of premium subminiatures over 5000 hours of life. The paper stresses the importance of operating tubes within ratings. Future requirements of tubes for military applications are outlined.

THE PART QUALITY CONTROL PLAYS TO PROVIDE IMPROVED RELIABILITY ON COMPUTER AND PREMIUM TUBE TYPES . . . By W. H. Chalmers, Jr., Tube Division, Harrison, N. J. Presented at Lincoln Laboratories, M.I.T., Cambridge, Mass., on May 17, 1956, and at Remington-Rand and Minneapolis-Honeywell, Minneapolis, Minn., on June 19, 1956. This paper points out that the main function of quality control is to establish the necessary controls to build into each tube the quality desired, and its secondary function is to test and evaluate the finished tube properly to determine whether the final product meets the demands of the application and the applicable tube-type specification. A brief description is given of the requirements which tubes must meet and the methods by which tubes are made. Process-control charts on various manufacturing processes are displayed and briefly explained. The microscopic inspection used on computer and premium tube types, is evaluated, and typical rejects detected by this inspection are shown. The paper emphasizes that quality cannot be achieved solely by testing and selection, but must first be built into the tubes.

PROPOSED NUMERICAL EVALUATION SYSTEM FOR SOFT SOLDERS, SOLDER FLUXES AND SOLDERABILITY . . . By L. Pessel, Electronic Components Division, Camden, N. J. Presented on June 19, 1956 at the 59th Annual Meeting of the American Society for Testing Materials held in Atlantic City, N. J. Standard solder specimens in form of one-turn loops are prepared by tightly wrapping solder wire of 0.062" diameter around a straight portion of the same wire serving as mandrel and cutting off excess wire. Without weighing or other form of measurement, adequate uniformity in weight and dimensions is obtained. Examples given include changes in solderability of copper due to heat-formed oxide, of tin-zinc alloy plating due to exposure to high humidity, of nickel plating due to exposure to elevated temperature, and of electrodeposited silver, gold, palladium, and rhodium due to exposure to hydrogen sulfide fumes. Advantages cited for this evaluation system are speed, simplicity, and ready coordination of a significant numerical expression with visual appearance of the spreading phenomenon.

UNUSUAL ELECTRON-TUBE EFFECTS OF CONCERN TO CIRCUIT DESIGNERS . . . By W. E. Babcock, Tube Division, Harrison, N. J. Presented to IRE Section Meeting, Akron, Ohio, May 22, 1956 and the IRE Section Meeting, Emporium, Pa. on Aug. 25. In many applications the circuit designer may be completely unaware of the existence of certain electron tube phenomena and thus be at a loss to explain the peculiar effects noted with certain circuits or with certain tubes. The phenomena of cathode interface, Whippany effect, and dc shift in electron tubes and their effect on circuit performance were discussed. Other electron tube phenomena, such as stray emissions, leakages, snivets and Miller effect were also described. Various methods of minimizing difficulties arising from these effects were pointed out.

ULTRATYPE CAMERA. A HIGH-SPEED ELECTRON-OPTICAL PRINTER FOR DIGITAL COMPUTING SYSTEMS . . . By A. M. Spielberg, S. R. Parker, and K. G. Kaufmann, Commercial Electronic Products, Camden, N. J. Presented on August 24, at the 1956 WESCON Convention. The RCA Electronic Printer accepts binary coded RCA BIZMAC characters and translates them into readable symbols organized as a document on the face of the RCA Image Selection Display Tube to be photographed on 35 mm film. The arrangement of characters is determined by coded editing symbols included with the incoming data and by certain self-editing features. Items may be arranged or deleted from their incoming sequence and form outlines can be projected onto the film simultaneously with character information. Printing speed of 10,000 characters per second is possible, although the present model has been conservatively designed to operate at 4,000 characters per second. Film frames may be advanced at the maximum rate of 20 per second.

RECENT IMPROVEMENTS IN THE RCA-21AXP22 COLOR KINESCOPE . . . By R. B. Janes, L. B. Headrick, and J. Evans, Tube Division, Lancaster, Pa. Published RCA REVIEW, June 1956. The 21AXP22 has proven to be a high-quality color kinescope which is readily adaptable to quantity production. As a result of manufacturing experience obtained during the production of thousands of tubes and changes made in the construction and processing, nearly perfect color purity and white uniformity have been achieved. A good deal of the processing improvements are due to changes made in the "lighthouse" on which the phosphor screens are exposed. After a brief review of the principles of the tube and data on its operation, both the tube and lighthouse changes are explained.

IMAGE ORTHICON FOR PICKUP AT LOW LIGHT LEVELS . . . By A. A. Rotow, Tube Division, Lancaster, Pa. Presented to the Radio-Newsreel-TV Working Press Association, New York City on June 20, 1956. This paper describes a new image orthicon developed by RCA to extend the range of useful sensitivity to extremely low light levels. The new design substantially reduces the time lag and noise level at low light levels. The primary difference between the new tube and the standard image orthicon is an increased spacing between the glass target and the mesh screen. Theoretical considerations involved in the design of the new tube are explained. The tube characteristics and examples of applications are discussed.

CRYSTAL QUALITY AS A FACTOR IN CONTROLLING THE ALLOYING OF INDIUM ONTO GERMANIUM SURFACES . . . By H. V. Kettering, Semiconductor Division, Somerville, N. J. and J. Pankove, RCA Labora-

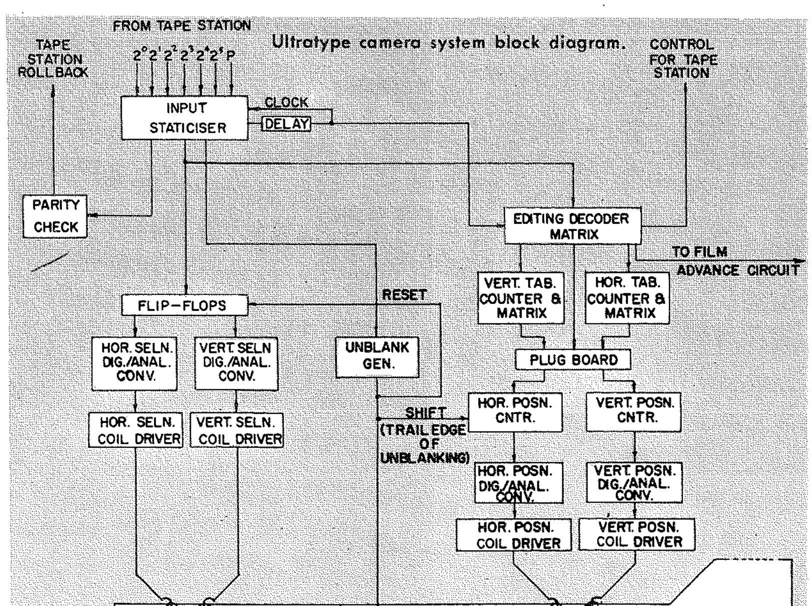


Figure 3 Ultratype Camera System Block Diagram

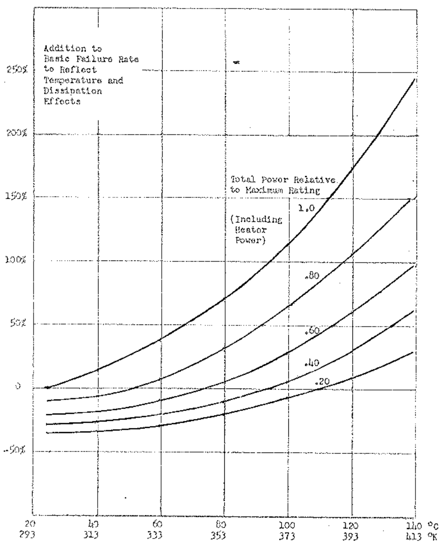
TORIES DIVISION, Princeton, N. J. Presented at AIEE/IRE Semiconductor Devices Conference, Purdue University, Lafayette, Indiana, June 26, 1956. This paper discusses the role of edge dislocations in controlling the geometry of indium-germanium alloy transistors. Recent experimental work has shown that crystal quality influences the spreading of indium on (111) germanium surfaces during the alloy process. If indium is alloyed onto a (111) surface which is substantially devoid of edge dislocation sites, the final spread area is not reproducible. If, however, a high density of such sites is present, the spread diameter can be controlled within close limits. Under the latter conditions, the spread-diameter magnitude is dependent on the mass of indium and the alloying conditions.

AVAILABLE COMMERCIAL SEMICONDUCTOR DEVICES AND FUTURE DEVELOPMENTAL PROGRAMS . . . By R. D. LOHMAN, SEMICONDUCTOR DIVISION, Somerville, N. J. Presented at Remington-Rand and Minneapolis-Honeywell, Minneapolis, Minn., June 19, 1956. This paper describes the general characteristics and applications of the semiconductor devices presently available in the RCA line. The commercial transistors decribed include the 2N77 and 2N105 hearing-aid types, the 2N104 and 2N215 general-purpose types, the 2N109 and 2N217 class B audio-output types, the 2N175 low-noise type, and the 2N139 and 2N140 types for AM broadcast-receiver applications. Semiconductor devices presently in development are also discussed, including a closely controlled general-purpose transistor, two switching transistors, a high-frequency amplifier transistor, and a semiconductor diode. Plans for future developmental programs on semiconductor devices are reviewed briefly.

INCREASING THE SENSITIVITY OF A COMMERCIAL SPECTRORADIOMETER . . . By A. E. HARDY and G. P. KIRKPATRICK, TUBE DIVISION, Lancaster, Pa. Published in the June issue of REVIEW OF SCIENTIFIC INSTRUMENTS. This paper describes a method by which the basic sensitivity of a commercial spectroradiometer can be increased by a factor of 200. In this method, a simple cathode-follower bridge circuit is used between the multiplier phototube and the recorder amplifier. The use of the cathode-follower circuit permits the value of the load resistor in series with the anode of the multiplier phototube to be increased to approximately 5000 times its original value without affecting the low-input-resistance requirement of the recorder amplifier.

SERIES-STRING APPLICATIONS OF ELECTRON TUBES (Commercial and Military) . . . By R. G. RAUTH, TUBE DIVISION, Harrison, N. J. Presented at RETMA Symposium on RELIABLE Tubes, University of Pennsylvania, Phila., Pa., on May 21, 1956. This paper presents experimental data and universal curves for the prediction of the probable magnitude of surge voltages in series-string applications. Methods of minimizing heater-cathode leakage are described, and the significance and importance of heater-cathode-voltage ratings are discussed with respect to life-test data and circuitry. The reliability of series-string and parallel heater operation is analyzed on the basis of equipment life tests.

PREDICTION OF TUBE FAILURE RATE VARIATIONS . . . By M. P. FEYERHERM, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Presented on August 22, at the 1956 WESCON Convention. The prediction of a reliability figure for an electronic equipment requires that due consideration be given to the various stresses and environments associated with the electron tubes. In order to handle large numbers of tubes, it is necessary to derive certain broad rules and formulas which when applied to "basic" failure rates will give rates representative of the assumed special conditions. In spite of the fragmentary and varied nature of available data, it has been possible to formulate rules and equations which have been demonstrated by experience to yield satisfactory results.



Effective ambient temperature.

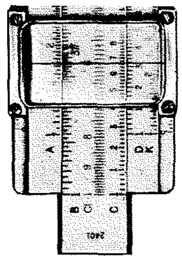
GUIDANCE—THE BRAINS OF MISSILES . . . By N. I. KORMAN, DEFENSE ELECTRONIC PRODUCTS, Moorestown, D. T. Sigley, American Pipeline & Foundry Co. and G. Woreley, Applied Physics Lab, Johns Hopkins University. Published in the July, 1956 issue of the AERO DIGEST. The Automatic Guidance System of the present-day guided missile is an intelligent machine. The intelligence system, with its associated launching site equipment, is a complex of integrated electrical and electro-mechanical equipment designed to give the missile the ability to make its own decisions automatically. What is the nature of the techniques used in guiding missiles? To help answer the question, this article attempts to present explanations of some of the standard types of guidance systems. Details on the designs, present status, and tactical use have been intentionally avoided to conform with the present security regulations imposed by the government on this field of activity.

MANAGEMENT OF RESEARCH AND DEVELOPMENT . . . By PAUL H. CLARK, DEFENSE ELECTRONIC PRODUCTS, Dayton, Ohio. Presented on May 14, 1956 at the National Conference on Aeronautical and Navigational Electronics, Dayton, Ohio. This paper has stressed that management of research and development with few exceptions is as necessary as is management of any corporation, division or group. It stressed the fact that research and development is the backbone of competitive industry as well as the victor in the military. It covered the skills and tools of management generally and pointed out the variations specifically necessary in research and development, such as selection of programs, transferring the results of research, types of research establishments and the selection and characteristics of personnel in research.

"Q" CALCULATIONS FOR HIGH-FREQUENCY INDUCTORS . . . By R. J. SCHULTE, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Published in the TELE-TECH and ELECTRONIC INDUSTRIES magazine, July 1956 issue. Equations have been developed for calculating the merit factor of h-f iron-core or air-core inductors of known dimensions and materials. Derivation of the equations was presented with data and examples covering all practical designs in the 5 to 60 MC range.

ANALYTICAL APPROACHES TO LOCAL OSCILLATOR STABILIZATION . . . By W. Y. PAN, and D. J. CARLSON, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. Presented on August 21, at the 1956 WESCON Convention. The behavior of local oscillator tubes and associated circuit elements under the complex conditions of heat flow can be treated analytically. By means of such an analytical treatment, local oscillators at frequencies up to and beyond 1000 Mc can be stabilized methodically with conventional temperature-sensitive elements. The resultant frequency stability is generally satisfactory for most practical purposes. Special considerations are, however, often required to stabilize uhf local oscillators, primarily due to the fact that the physical dimensions of the circuit elements may correspond to substantial fractions of wave lengths at such frequencies. The analytical approaches to local oscillator stabilization in general and the special considerations at uhf are fully illustrated with two types of commercial television tuners. The vhf television tuner exhibited a maximum residual frequency deviation of ±50 kc, while that of the uhf television tuner was ±100 kc after either tuner has been energized for a period of two minutes.

MATHEMATICS FOR ELECTRONICS WITH APPLICATIONS . . . By HENRY M. NODELMAN, HEAD, DEPARTMENT OF MATHEMATICS AND PHYSICS, RCA Institutes; Mathematics Instructor, Polytechnic Institute of Brooklyn; and Frederick W. Smith, Jr., Television Engineer, National Broadcasting Co., published by McGraw-Hill Book Co., August, 1956. A unique mathematics book for electronics and television engineering students and practicing engineers . . . This book is designed to correlate engineering practice and mathematical topics which the authors consider of prime importance to the electronics and communications field. Mathematical topics presented in this text have been thoroughly integrated with electronic engineering problems taken directly from the technical literature. All of the leading American and foreign technical periodicals devoted to communications and electronics were carefully researched to determine (1) which mathematical topics are of maximum importance for a text of this kind, and (2) to obtain more than 300 specific applications which have been incorporated into the text.

Engineering  NEWS *and* HIGHLIGHTS

RADIOMARINE MERGES WITH RCA

August 31, 1956 marked the merger of the Radiomarine Corporation of America with the Radio Corporation of America. A previously wholly owned subsidiary, the various Radiomarine responsibilities have been assumed by CEP, DEP, RCA Communications and RCA Service Company. Delegation of former Radiomarine functions is as follows:

(a) Marketing, Production and Engineering activities are assigned to Commercial Electronic Products and Defense Electronic Products. Defense Electronic Products now operates the New York plant on a Landlord basis, providing such space and supporting facilities as are required by the Sales and Engineering functions of the Communications Products Department.

(b) Maintenance contracts with shipping companies operating vessels of the Merchant Fleet have been taken over by the RCA Service Company.

(c) Licenses for Company owned shipboard installations and the operation of Radiomarine Coastal Stations are now responsibilities of RCA Communications, as are the domestic and inter-national accounting for ship-to-shore message traffic.

Communications Products Department activities in the New York plant consists of Radiomarine Sales, Radiomarine Product Planning and Radiomarine Engineering. The engineering product lines are Radar Equipment and Communications Equipment. The Radiomarine Radar Engineering activity develops and designs a comprehensive line of commercial radar, loran and sonic depth-finding equipment for world-wide installation in merchant vessels of many flags, and for a growing market of trawler and small-craft applications. The Radiomarine Communications Engineering activity develops and designs radiotelephone, radiotelegraph and direction-finding equipment for commercial ships and small craft of all classes. For descriptions of Radiomarine Designs, see RCA ENGINEER VOL. I—NO. 6, Articles by I. F. Byrnes and Niles L. Barlow. The product line includes transmitters and receivers in many frequency bands for AM, FM and SSB (single side-band) operation. Transmitter power ratings range from a few watts in small-craft "ship-to-shore" telephone sets to many kilowatts in some of the high power shipboard and coastal station installations.

The high quality of Radiomarine products has made their trademark emblem known and respected throughout the maritime world. The management, design and supporting personnel of the Radiomarine engineering activity include highly qualified experts who have been leaders in their field for many years.—J. C. Walter

WYNKOOP ELECTED VICE-PRESIDENT OF RCA. Election of Rear Admiral Thomas P. Wynkoop, Jr., U.S.N. (ret.) as Vice-President, Commercial Marine Distribution, Radio Corporation of America was announced recently by Brig. General David Sarnoff, Chairman of the Board of RCA.

Since 1949 Admiral Wynkoop has been President of Radiomarine Corporation of America, a wholly owned subsidiary which was recently merged into RCA. Radiomarine's communications, manufacturing, marketing and service functions have been transferred to other RCA units. Admiral Wynkoop will be responsible for the coordination of commercial marine distribution activities throughout the corporation.

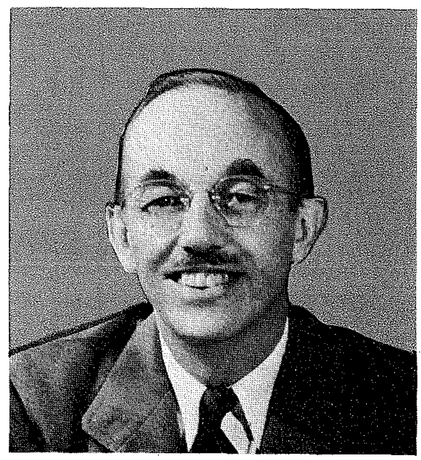
Born in Philadelphia, Admiral Wynkoop attended the United States Naval Academy at Annapolis, Md., and was commissioned an Ensign in 1918. He received an M.S. degree from Massachusetts Institute of Technology in 1922.

O. B. HANSON RECEIVES JOHN H. POTTS MEMORIAL AWARD . . . The Audio Engineering Society presented its John H. Potts Memorial Award of 1956 to O. B. Hanson, Vice-President, Engineering Services, Radio Corporation of America, in "recognition of his contributions to better broadcasting systems and facilities."

Presentation was made by John D. Colvin, Chairman of the Awards Committee, at the annual banquet of the Audio Engineering Society at the New York Trade Show Building, Thirty-Fifth Street and Eighth Avenue, New York, on September 27, 1956.

Mr. Hanson, formerly Vice-President and Chief Engineer of the National Broadcasting Company and a pioneer of nearly thirty-five years in radio and television, said in accepting the Award that he did so "with heartfelt acknowledgement of contributions by the many other engineers" with whom he had worked in the broadcasting field.

Mr. Hanson's early education was acquired in England where he studied electrical engineering at Hillyer Institute. In 1915 he became a student at Marconi School (now RCA Institutes). In 1917, Mr. Hanson transferred to the Engineering Department of the Marconi factory. In 1921, Mr. Hanson entered the broadcasting field and operated and programmed WAAM, Newark, N. J. until 1922 when he joined the engineering staff of WEAF. Mr. Hanson became Plant Manager for WEAF and was active in developing the Red Network. In 1926 WEAF became a part of the newly formed National Broadcasting Co. and Mr. Hanson continued in his capacity of Plant Manager.



In 1934 Mr. Hanson became Chief Engineer and in 1937 was appointed Vice President and Chief Engineer of NBC. In this position he supervises technical developments and technical operations, including development of black and white and color television. In June 1954 Mr. Hanson became Vice President, Operations Engineering, RCA, and in 1955 assumed his present position as Vice President, Engineering Services, RCA.

Mr. Hanson has been a member of IRE since 1918 and a Fellow of IRE since 1941. He is also a Fellow of Acoustical Society of America, and of the Society of Motion Picture and Television Engineers. He is a member of the Radio Pioneers.

I. F. BYRNES APPOINTED MANAGER, RADIOMARINE ENGINEERING, CEP

In the recent organizational move merging Radiomarine activities with those of Commercial and Defense Electronic Product functions of the parent company, Irving F. Byrnes has been appointed Manager, Radiomarine Engineering, New York, reporting to John C. Walter, Chief Engineer, Communications Engineering, CEP.

Mr. Byrnes joined the Radiomarine Corporation in 1930 after twelve years with the General Electric Company. His long experience in marine radio communications is attested to by the excellence of RCA's position in the marine radio field. He has been granted several U. S. patents for radio devices, and in 1940 he received the Modern Pioneers Award from the National Association of Manufacturers for his contributions in the art of marine radio communications. The U. S. Navy Bureau of Ships awarded Mr. Byrnes its certificate of commendation in 1947.

For further biographical information on Mr. Byrnes, see "New Editorial Representatives Appointed," *News and Highlights*, this issue, as well as biographical sketch in Vol. 1, No. 6.

D. P. Heacock, (left) and J. T. Cimorelli discuss their recent moves to new positions.

CIMORELLI AND HEACOCK MOVE TO NEW ENGINEERING POSTS

Joseph T. Cimorelli, Administrative Engineer, Product Engineering, RCA and David P. Heacock, Manager of Entertainment Tube Development, Tube Division, Harrison, have recently moved to new engineering assignments.

In the new move, Mr. Heacock will assume the duties of Administrative Engineer, reporting to D. F. Schmit, Vice President, Product Engineering, RCA. This position was previously held by Mr. Cimorelli, who will assume duties as Manager, Engineering, Receiving Tube Operations, Tube Division at Harrison, New Jersey.

In addition to their widespread experience in the design and proper circuit application of Receiving Tubes—both men have had an interest in the advancement of all fields of electronics engineering.

The entire staff of the *RCA ENGINEER* extends best wishes to Mr. Cimorelli in his new position and at the same time welcomes his successor, Mr. Heacock, as a member of the Editorial Advisory Board.

David P. Heacock received the B.S. degree in Mechanical Engineering from Rutgers University in 1941. He received an M.S. degree in Electrical Engineering from the Stevens Institute of Technology in 1946.

In 1941 he was employed by RCA as an engineer in the Test Engineering Group. Here he worked on tube specifications and the development of tube test equipment. In 1946 he was transferred to the Application Laboratory where he worked on circuit problems involving the proper application of receiving tubes.

In 1953 he became Manager of the Application Laboratory, and in 1955 was promoted to the position of Manager of Entertainment Tube Development. In 1956 he assumed his present duties as Administrative Engineer, Product Engineering.

Mr. Heacock is a member of Tau Beta Pi and Phi Beta Kappa. He is a senior member of the Institute of Radio Engineers.

Joseph T. Cimorelli graduated from the Massachusetts Institute of Technology with the B.S. degree in 1932, and in 1933 received the M.S. degree in Electrical Engineering.

In 1935 Mr. Cimorelli joined RCA in Harrison, N. J. where he worked on tube-application problems. In 1940, he was transferred to the company's Chicago office. Here he worked as the field engineer of the tube application section, assisting local receiver manufacturers in their design problems. In 1942 Mr. Cimorelli returned to the Harrison laboratories to continue field engineering work with government agencies, and laboratories.

In 1944 he was appointed Manager, Receiving Tube Application Engineering Laboratory of the Tube Department at Harrison. Mr. Cimorelli transferred to Camden in 1953 as Assistant to the Vice President and Director of Engineering, RCA-Victor Division and later became Administrative Engineer on the Staff of the Vice President, Product Engineering.

On September 1, 1956, he returned to Harrison to assume his present position as Manager, Engineering, Receiving Tube Operation, Tube Division.

Mr. Cimorelli, who has served on several committees of I.R.E., was Sec-Treas. of New York Section in 1945, and Chairman in 1946. He became a Senior Member in 1945, and a member of the Professional Group on Engineering Management in 1952. He is also a member of the Radio Club of America.

CEP APPOINTS FOUR CHIEF ENGINEERS

In a recent organizational announcement, the following appointments have been made in Commercial Electronic Products:

J. Wesley Leas, Chief Engineer, BIZMAC Engineering.

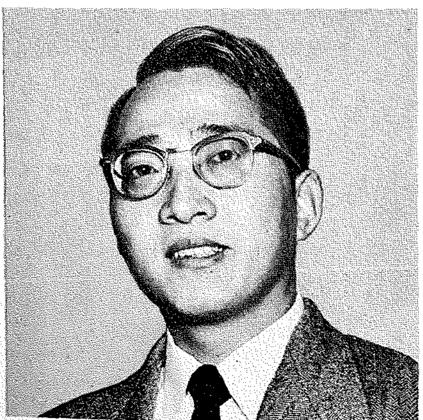
John C. Walter, Chief Engineer, Communications Engineering.

V. Elmer Trouant, Chief Engineer, Broadcast and Television Equipment Engineering.

Norman M. Brooks, Chief Engineer, Theatre and Sound Engineering.

These men were formerly Chief Product Engineers in their respective activities. For biographies, See *Engineering News and Highlights*, Vol. 1, No. 6.

DR. LI RECEIVES AWARD



During July 1956 Dr. C. H. Li received the Nomography Award for 1955-56, set up by the Engineering Drawing Division of the American Society for Engineering Education.

The award includes a citation for excellence in the Science of Nomography and also a $100-cash prize, awarded by the David Gessner Company.

The award referred to Dr. Li's article titled "A Nomograph for Determining Significant Differences," which was published in the RCA ENGINEER, Vol. 1, No. 4, and in *Metal Progress* of November 1955, p. 104-B.

The Nomograph allows rapid calculation of the significance of test results from the number of defectives encountered.

—*R. L. Klem*

THREE RCA ENGINEERS ELECTED SMPTE FELLOWS . . . Sixteen members of the Society of Motion Picture and Television Engineers have been approved as Fellows by the Board of Governors, it was announced by John G. Frayne, President of the Society.

Three of these members are RCA Engineers.

The 16 members were elevated to the Fellow grade "by their proficiency and contributions they have attained to an outstanding rank among engineers or executives of the motion picture or television industries." The three honored RCA engineers are:

Herman M. Gurin, Engineer, NBC

Warren R. Isom, Development Engineer, DEP General Engineering Development

Michael Rettinger, Acoustic Engineer, Hollywood Engineering, CEP

T. J. McCudden

McCUDDEN AS MGR., PRODUCTION ENGINEERING, INDIANAPOLIS TUBE PLANT . . . Thomas J. McCudden has been promoted to Manager, Production Engineering at the Indianapolis Tube Plant. Mr. McCudden received his B.S. degree in Physics from Siena College in 1948 and his M.S. degree from Stevens Institute of Technology in 1952. He joined the RCA Tube Division, Harrison, N. J. as a manufacturing engineer in 1948. In 1955 he was transferred to the Receiving Tube Design activity where he served as liaison engineer for the Marion and Indianapolis Tube Plants. From 1944 to 1946 Mr. McCudden served in the U. S. Infantry and attended the Signal Corps Radio School.

—*F. H. Ricks*

COMMITTEE APPOINTMENTS

COMMERCIAL ELECTRONIC PRODUCTS

RICHARD M. JACOBS, BIZMAC Engineering CEP, was elected by IRE-PGRQC as Publicity Chairman—3rd National Reliability and Quality Control Symposium—to be held in Washington, D. C. on Jan. 14, 15, 16, 1957. Sponsors include IRE, PGRQC, ASQC, AIEE, RETMA, and IAI. He has also been appointed as General Chairman for a Symposium on "Quality Control Methods and Management" jointly sponsored by Drexel Institute of Technology and A.S.Q.C. Philadelphia Section—to be held September 21, 1956 at Drexel. Richard M. Jacobs has been selected as Philadelphia Chapter AIEE—Salary Survey Chairman.

—*T. T. Patterson*

N. C. COLBY has been elected chairman of the Philadelphia IRE Section PGMTT and PGAP joint Professional Groups on Microwave Theory and Techniques and on Antennas and Propagation. —*B. F. Wheeler*

J. R. NEUBAUER has been appointed Chairman of the Program Committee of the Communications Technical Division, AIEE.

—*B. F. Wheeler*

LOWELL H. GOOD, Manager, Optical, Mechanical and Circuit Development, was elected Chairman of the Philadelphia Section IRE Professional Group on Audio for the year 1956-1957. —*L. M. Seeberger*

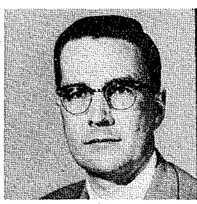
Surface Communications Engineering

At the annual meeting of AIEE Philadelphia Section, held April 9, 1956, T. H. STORY was elected Chairman of the Communications Technical Division and a member of the Board of Managers of the Philadelphia Section. —*M. Bocciarelli*

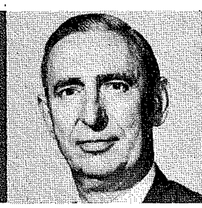
TUBE DIVISION

MARKUS NOWOGRODZKI has been appointed new Chairman of JTC 13.4 Sub-Committee on Traveling-Wave Tubes. Mr. Nowogrodzki is in charge of Traveling-Wave Tube Engineering in the microwave tube activity in Harrison. —*F. R. Arams*

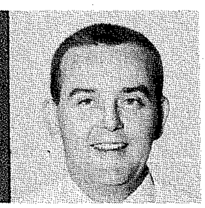
R. S. BURNAP, Mgr., Commercial Engineering, has been re-elected to serve on the AIEE Standards Committee.—*C. A. Meyer*



J. R. Neubauer



T. H. Storey



J. V. Dunn

Bizmac Engineering

J. WESLEY LEAS, Chief Product Engineer, has been elected Chairman of the Professional Group on Engineering Management of the Philadelphia section of IRE.

—*T. T. Patterson*

Broadcast and TV Equipment Engineering

J. B. BULLOCK, with E. E. GLOYSTEIN alternate, has been appointed to the Committee on Television Microwave Relays, TR4.2 of RETMA. —*J. H. Roe*

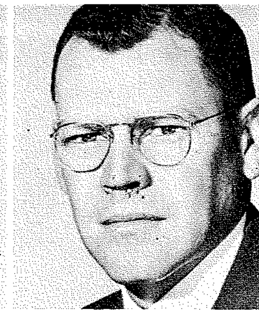
DEP Engineering Standards and Services

L. S. BENSKY of General Engineering Development was elected Vice-chairman of the Philadelphia Chapter of the IRE Professional Group on Electronic Computers.

—*L. M. Seeberger*

JAMES V. DUNN, Manufacturing Engineer at the Indianapolis Tube Plant, has been elected Secretary-Treasurer of the Indianapolis Section of the I.R.E. —*F. H. Ricks*

I. F. Byrnes



T. T. Patterson

NEW EDITORIAL REPRESENTATIVES

Irving F. Byrnes has been appointed Editorial Representative, RCA ENGINEER, for the Radiomarine Engineering activity of CEP, New York.

Mr. Byrnes' 26 years of experience with the Radiomarine Corporation and his active interest in engineers and engineering have been an inspiration to the people with whom he has worked. Over the years he has maintained a high degree of interest in editorial work. Not only has Mr. Byrnes encouraged younger engineers, but he has written many professional technical papers on radio communication equipment. He is a member of the *RCA REVIEW* Board of Editors and the RCA Institutes Board of Technical Advisors. See "The Radiomarine Engineer at the National Motor Boat Show," by I. F. Byrnes, *RCA ENGINEER*, Vol. 1, No. 6.

Theodore T. Patterson has been appointed to represent BIZMAC Engineering on the DEP-CEP Editorial Board. He will supersede Walter K. Halstead.

Mr. Patterson recently joined RCA as Leader of BIZMAC Publications. He holds the degree of B.E.E. from the University of Virginia. In addition to engineering work, he has spent several years in technical writing and editing, most recently at the Burroughs Corporation Research Center, Paoli.

J. M. SPOONER NAMED MANAGER OF FINDLAY PLANT . . . Appointment of John M. Spooner as manager of the Findlay, Ohio, plant was announced by William T. Warrender, General Manager, RCA Components Division. Prior to this appointment, Mr. Spooner was manager of the kinescope servicing plant at Sellersville, Pa., an activity of the RCA Service Company, Inc.

A native of San Francisco, Mr. Spooner was graduated from the University of Toledo in 1936 with a B.S. degree in Engineering. The same year, he joined RCA at the Harrison, N. J., plant where he was assigned to engineering and manufacturing functions. In 1943 he was in charge of glass fabrication operations at the Lancaster, Pa., plant, where he later became a manager in the power tube manufacturing and engineering operations.

REGISTERED PROFESSIONAL ENGINEERS

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

Record Division, Indianapolis

Name	*State*	*Licensed As*	*License No.*
Stephen W. Liddle	Indiana	Prof. Eng.	7671
David H. O'Herren	Indiana	Prof. Eng.	7704

DEP WCEPD, Dayton

James DeLuna	Ohio	Prof. Eng.	19635

ENGINEERING DEGREES AWARDED

DEFENSE ELECTRONIC PRODUCTS

Harold S. Altamuro, Designer, Airborne Fire Control Engineering; Diploma, Drexel Institute of Technology.

A. V. Balchaitis, Standards Engineering; B.S.E.E., Drexel Institute of Technology.

Lyle W. Barney, Airborne Fire Control Engineering; Diploma in E.E., Drexel Institute of Technology.

John S. Baugh, Designer, Airborne Fire Control Engineering; Diploma, Drexel Institute of Technology.

Mrs. Shirley Beller, General Engineering Development; M.A. in Mathematics, Temple University.

Nicholas C. Brandimarte, Airborne Fire Control Engineering; B.S., Drexel Institute of Technology.

Ruland A. Feldman, Draftsman-Designer, Missile and Surface Radar Engineering; M.E. in Machine Design; Drexel Institute of Technology.

Eli Gevirtz, Airborne Fire Control Engineering; M.S. in E.E., Drexel Institute of Technology.

Lawrence H. Gilligan, General Engineering; B.S. in Physics, St. Joseph's College, 1955.

Robert F. Haworth, Airborne Fire Control Engineering; B.S. in E.E., Drexel Institute of Technology.

Sheppard A. Levine, Airborne Fire Control Engineering; B.S. majoring in E.E., Drexel Institute of Technology.

R. S. Lawton, Surface Communications Engineering; M.S. in E.E., Drexel Institute of Technology.

A. A. Litwak, Missile and Surface Radar Engineering; Diploma in E.E., Drexel Institute of Technology.

Walter S. MacPherson, Airborne Fire Control Drafting; B.S., Drexel Institute of Technology.

Edward J. McQuillen, Airborne Fire Control Engineering; M.S. in M.E., Drexel Institute of Technology.

John P. Mayberry, Airborne Systems; Ph.D. in Mathematics, Princeton University, Oct. 1955.

Chester J. Mroz, Airborne Fire Control; B.S., Drexel Institute of Technology.

I. K. Munson, Standards Engineering; M.S.E.E., Drexel Institute of Technology.

T. W. Nachtrieb, Missile and Surface Radar Engineering; B.S. in M.E., Drexel Institute of Technology.

Edward J. Nossen, Airborne Systems; Moorestown; M.S. in E.E.

Daniel Page, Airborne Systems Laboratory, Waltham; D.B.A. in Engineering and Management, North Eastern University, Boston, 1955.

Edward F. Poole, 3rd, Airborne Systems, Moorestown; M.S. in Physics, Drexel Institute of Technology.

Robert H. Ray, Airborne Fire Control Engineering; M.S. in E.E., Drexel Institute of Technology.

John S. Rydz, General Engineering Development; M.S. in Physics, University of Pennsylvania.

Robert F. Schmicker, Airborne Fire Control Engineering; B.S., Drexel Institute of Technology.

Sidney Sternick, Missile and Surface Radar Engineering; M.S. in M.E., Drexel Institute of Technology.

Louis C. Tomaine, Missile and Surface Radar Engineering; B.S.M.E., Indiana Technical College.

Samuel Walstein, Airborne Systems Laboratory, Waltham; M.S. in M.E., North Eastern University, Boston.

Earl T. Wojciechowski, Airborne Fire Control Engineering; B.S. from Drexel Institute of Technology. —*J. B. Davis*

COMMERCIAL ELECTRONIC PRODUCTS

Don Cancelli, Senior Designer, BIZMAC Engineering; Diploma in E.E., Drexel Institute of Technology.

R. N. Clark, Broadcast Transmitter Engineering; M.S. in E.E., Drexel Institute of Technology.

Joseph W. Crist, Missile and Surface Radar Engineering; B.S.M.E., Drexel Institute of Technology.

H. Newton Garber, CEP Management Assistant; ScD, Massachusetts Institute of Technology.

Gustave R. Gaschnig, BIZMAC Engineering; B.S. in E.E., Drexel Institute of Technology.

Joe Griffonetti, Senior Designer, BIZMAC Engineering; Diploma in M.E., Drexel Institute of Technology.

Daniel Hochman, Communications Engineering, presently on loan to Surface Communications Systems at Tucson, Arizona; M.S. in E.E., University of Pennsylvania.

Anthony B. Litwak, Broadcast and TV Equipment Engineering; Diploma in E.E., Drexel Institute of Technology.

D. L. Lundgren, Frequency Control, Theatre and Sound Products Engineering; M.S. in E.E., Drexel Institute of Technology. —*J. B. Davis*

TUBE DIVISION

R. F. Walton, Receiving Tube Parts Mfg. Engineering; M.S. in Chemical Engineering, Brooklyn Polytechnic Institute.

H. Foster, Commercial Engineering, Tube Division; B.S.E.E., Newark College of Engineering.

E. Byrum, Receiving Tube Parts Mfg. Engineering; M.S. in Ind. Eng., Stevens Institute.

R. E. Brooks, Receiving Tube Engineering; M.S.I.E., Stevens Institute.

R. N. Peterson, Receiving Tube Engineering; M.S.I.E., Stevens Institute.

Miss Ann Hathaway, Receiving Tube Engineering; B.A., Upsala College.

A. G. Dingwall, Receiving Tube Engineering; M.S., Applied Math., Brooklyn Polytechnic.

F. Scott, Receiving Tube Engineering; M.S., Management Eng., Newark College Eng. —*J. F. Hirlinger*

TEN $3,500 DAVID SARNOFF FELLOWSHIPS AWARDED TO COMPANY EMPLOYEES BY RCA . . . Ten employees of the Radio Corporation of America have been named to receive David Sarnoff Fellowships for graduate study during the 1956-1957 academic year, it was announced by Dr. C. B. Jolliffe, Vice-President and Technical Director of RCA.

"These fellowships were established in honor of the Chairman of the Board of RCA who will commemorate his fiftieth year of service with RCA and its predecessor company on September 30, 1956. Each fellowship is valued at approximately $3,500 and includes full tuition fees, $2,100 for living expenses and $750 as an unrestricted gift to the university. Although appointments are for one academic year, each fellow is eligible for reappointment," said Dr. Jolliffe, who is Chairman of the RCA Education Committee.

The David Sarnoff Fellows were selected on the basis of academic aptitude, promise of professional achievement, and character. They will pursue graduate studies in electrical and mechanical engineering, physics, applied mathematics, business administration and dramatic arts.

RCA product engineers who will be on a leave of absence and enjoying the privilege of a David Sarnoff Fellowship during the current academic year are:

John W. Caffry, Lancaster, Pa., who will study toward a Master's degree in Business Administration at Harvard University. In 1952, Mr. Caffry received his Bachelor of Science degree in Electrical Engineering from Cornell University where he was President of the Engineering Student Council. He joined RCA in 1952 and is employed in the Color Kinescope Operations Department of the RCA Tube Division at Lancaster, Pa.

John W. Douglas, will continue studies leading to a Master's degree in Electrical Engineering at the University of Michigan. In 1953, Mr. Douglas received his Bachelor's degree in Physics from Albion College, Albion, Michigan. He also received a Bachelor's degree in Electrical Engineering from the University of Michigan in 1954. He is employed as an engineer in Airborne Systems Equipment Engineering, Defense Electronic Products, at the RCA plant in Moorestown, N. J.

Gardner C. Hendrie, Morton, Pa., will study toward a Master's degree in Physics at the University of Pennsylvania. Mr. Hendrie received his Bachelor's degree in Physics from Harvard University in 1954. He is employed in General Engineering Development, RCA Defense Electronic Products at Camden, N. J.

Leon S. Levy, Collingswood, N. J. will work toward his Doctorate in Applied Mathematics at Harvard University. In 1952, Mr. Levy received his Bachelor's degree from Yeshiva University where he majored in Physics and Mathematics. He is employed in "Bizmac" Engineering, RCA Commercial Electronic Products at Camden, N. J.

Other RCA employees selected are:

ALVIN S. HERLICH, General Accounting Department, Camden, N. J.
CHARLES A. PASSAVANT, RCA International Division, Clark, N. J.
GEORGE L. KASYK, David Sarnoff Research Center, Princeton, N. J.
ROBERT J. PRESSLEY, David Sarnoff Research Center, Princeton, N. J.
ROBERT STAFFIN, David Sarnoff Research Center, Princeton, N. J.
FRANKLIN M. NASH, National Broadcasting Company, New York City.

MEETINGS, COURSES, AND SEMINARS

THERMAL DESIGN

Approximately 75 DEP and CEP engineers attended a recent two-part Symposium on Thermal Design in Electronic Equipment (Aug. 23 and 30). The Symposium, sponsored by the Reliability Committee on Environment, presented a series of 12 papers by DEP/CEP engineers. Individual papers in the first session dealt with the quantitative relationships between thermal environment and component and system reliability, with basic cooling techniques, and with techniques of thermal evaluation. The second (classified) session was devoted exclusively to case studies of thermal design in recent airborne and surface radars, high power transmitters, surface communications equipment, and miniaturized equipments. Mr. T. C. Reeves of Components Application Review was program chairman of the Symposium. —*T. T. Patterson*

SCATTER

The first meeting of the Communications Technical Division of the American Institute of Electrical Engineers, joint with the Franklin Institute, will be held October 31, 1956. The speaker will be Dr. Harold A. Staras, David Sarnoff Research Center, Princeton, New Jersey. His topic will be "Scatter—A New Breakthrough in the Communications Bottleneck."

The talk concerns itself with the physical ideas underlying this new mode of communication. By means of scatter propagation it is now possible to establish highly reliable communication links across barren wastes, rugged terrain and water barriers. Some of the major considerations in determining systems parameters on a scatter circuit will be discussed.

Dinner at 6:30, preceded by cocktails, will be served at the Franklin Institute. The meeting will be held at 8:15.

VALUE ENGINEERING PROGRAM

On August 22, Captain W. I. Bull, Assistant Chief of the Bureau of Ships for Electronics, Captain J. M. Waters, Director of Value Engineering, and Messrs. R. B. Bussler and M. L. Roylance, Value Engineers, gave a presentation to RCA on the BuShips Value Engineering Program.

Mr. T. A. Smith made the welcoming address for the session.

Subsequent to the BuShips presentation, R. H. Baker and S. N. Lev gave a presentation on the RCA approach to Value Engineering. Supplementing this presentation was a display of items showing the results of cost reduction programs and showing the organizational planning to achieve the Value Engineering approach.—*H. E. Coston*

RCA ENGINEERS ACTIVE IN THE TUCSON SECTION OF IRE

On May 25, 1956, the members of the IRE Section in Tucson, Arizona, elected three RCA engineers to serve as Section officers for the 1955-56 season. Shown in the picture are the members of the executive committee, from left to right:

W. V. Record.........J. B. Miller, Inc.
A. J. Bersbach.....Hughes Aircraft Co.
R. C. Bundy.......Hughes Aircraft Co.
G. A. Walker......Hughes Aircraft Co.
R. C. Eddy.........Hughes Aircraft Co.
F. J. Janza
Surf. Comm. Sys., RCA, DEP
D. Hochman
Surf. Comm. Sys., RCA, DEP
C. L. Becker (absent when picture was taken)....RCA Service Company, Inc.

D. Hochman serves as Section Secretary; C. L. Becker is Section Treasurer, and F. J. Janza is Chairman of the Technical Program and Paper Committee.
—*T. T. N. Bucher*

PROFESSIONAL GROUP ON MILITARY ELECTRONICS (PGMIL) . . . In recognition of the impact of military electronics on the electronics industry, the Institute of Radio Engineers has added to its professional groups a Professional Group on Military Electronics. The Philadelphia Chapter of this Professional Group has recently been organized. The organizer and Temporary Chairman is R. H. Baker, DEP Engineering Standards and Services. —*H. E. Coston*

M. M. Tall—Reliability Administrator for the Talos project Moorestown Engineering joined the company recently from Vitro Corporation. He is the General Chairman for the 3rd National Symposium on Reliability and Quality Control in Electronics. C. M. Ryerson, Component and Reliability Administrator, DEP, is Program Chairman, M. C. Batsel is on the Advisory Board, R. M. Jacobs Publicity Chairman and A. L. Goldsmith, DEP, Quality Control is on the Publicity Committee—This is truly an RCA affair even though it didn't start out that way.
—*T. T. Patterson*

DON McLAUGHLIN TALKS TO AUTOMATING COMMITTEE... Dr. L. McLaughlin, of General Engineering Development, DEP, appeared before the Automation Committee on August 14th to explain the "electronic inspector" he had developed. This device, which saves putting obviously defective parts through the complete testing procedure, is expected to be a significant advance in the development of the automatic factory.

Don realized that automatic assembly machines, lacking the judgement of a human worker, would continue to make any mistake that once got started. He believed that television could be used to permit inspecting subassemblies in large quantities without requiring the presence of a live inspector at each point. His equipment is based on the industrial television camera, and it can give a picture of the part undergoing inspection or can set off an automatic alarm if the part is visibly defective.

Realizing the possibilities of this equipment, Dr. J. Hillier, Chief Engineer of Commercial Electronic Products, called it to the attention of the committee on automation. Having heard Mr. McLaughlin describe the device, the members of the committee will recommend the best way to realize its advantages. —*L. M. Seeberger*

TELEVISION ROBOT DEMONSTRATED ... On June 26, 27, and 28, RCA and the Kaman Aircraft Company jointly demonstrated a television robot aircraft to the military and the public. The system includes a pilotless helicopter and a television camera. The craft, developed by the Kaman Co. for the Navy, is a standard HTK model to which has been added an auto-pilot and a radio control link. It is believed to be the first helicopter auto-pilot to be successfully flown. The vehicle carried the mobile television equipment developed by DEP Surface Communications Engineering for the Signal Corps.

Arrangements for RCA's part in the show were made by Mr. R. C. Bitting of DEP General Engineering Development. A. F. Flacco, W. W. Mras, B. F. Walker, and A. C. Stocker took care of the equipment.
—*L. M. Seeberger*

RCA EXHIBIT AT TESMA CONVENTION FEATURES 'EVERYTHING FOR THEATRES,' INDOOR AND OUT . . . "Everything for Theatres" was the theme and composition of the exhibit of RCA at the annual Convention of the Theatre Equipment Supply Manufacturers Association, September 20-24, in the New York City Coliseum.

The RCA exhibit featured equipment for both indoor motion picture theatres and drive-ins. RCA products displayed ranged from carpets, chairs, loudspeakers, and amplifier racks, to sound systems, motion picture projectors, and screen-lighting systems. Equipment designed specifically for drive-in theatres will include arc-lamp systems, in-car speakers, and in-car heaters.

RCA ACTIVE AT WESCON

The Western Electric Show and Convention (WESCON), sponsored by the Seventh Region of IRE, was held August 21-24, 1956, at the Ambassador Hotel, Los Angeles, California. This internationally recognized event brought together in forty-eight sessions outstanding people from research laboratories and manufacturing organizations throughout the U. S., it provided the latest information on new technical developments as well as the new concepts of human relations in engineering management.

The following papers were presented by RCA personnel: (See "Pen and Podium" this issue for summaries.)

Ultratype Camera. A High-Speed Electron-Optical Printer for Digital Computing Systems . . . By A. M. Spielberg, S. R. Parker, and K. G. Kaufmann, Commercial Electronic Products, Camden, N. J.

RCA BIZMAC Electrofax Printer, a Continuous Direct Dry Process Enlarger . . . By H. G. Reuter, Jr., and G. C. Sih, Commercial Electronic Products, Camden, N. J.

Extended Range Timing Techniques . . . By A. I. Mintzer, Defense Electronic Products, Moorestown, N. J.

Tube Failure Rate Variations . . . By M. P. Feyerherm, Defense Electronic Products, Camden, N. J.

Calculations of the Risk of Component Applications in Electronic Systems . . . By John A. Connor, Components Division, Camden, N. J.

Analytical Approaches to Local Oscillator Stabilization . . . By W. Y. Pan and D. J. Carlson, RCA Victor Television Division, Cherry Hill, N. J.

New Techniques Used in the Development of a 40-Watt Ceramic UHF Power Tetrode . . . By M. B. Shrader, Tube Division, Lancaster.

Situations that Affect the Productivity of Engineers . . . By M. C. Batsel, Defense Electronic Products, Camden, N. J.

Exponential Transmission Lines as Transformers and Cavities . . . By R. N. Ghose, Commercial Electronic Products, Camden, N. J.

NEW TUBE DATA FOR RCA ENGINEERS

RCA-6903 is a head-on type of multiplier phototube intended especially for the detection and measurement of ultraviolet radiation, and in other applications involving low-level radiation sources.

RCA-6893 is a small, sturdy, beam power tube for use as an r-f power amplifier and oscillator as well as an a-f power amplifier and modulator in mobile equipment operating from a 12-volt storage battery. Except for its heater which is rated at 12.6 volts/ 0.4 ampere, the 6893 is identical with the 2E26 and has the same technical data exclusive of IMS conditions.

RCA-6326-A is a small camera tube intended primarily for use in compact color television cameras utilizing the method of simultaneous pickup of the film or live subjects to be televised. This method employs three 6326-A's—one for each channel—to produce the information necessary for the formation of a color-television image.

RCA-6201 is a "premium" high-mu twin triode of the 9-pin miniature type. Constructed to give dependable performance under conditions of shock and vibration, this "premium" version of the popular 12AT7 is especially suited for use in a wide variety of applications in mobile and aircraft equipment and numerous critical industrial control devices.

RCA-5725 is a "premium" sharp-cutoff pentode of the 7-pin miniature type intended particularly for use in gated amplifier circuits, delay circuits, gain-controlled amplifiers, and mixer circuits.

RCA-12AD6, 12AE6, 12AF6, 12AJ6, 12BL6, 12F8, and **12K5-7** are receiving tubes designed for use in automobile receivers in which transistors are used in the output stage and in which the tube and transistor electrode voltages are obtained directly from a 12-volt storage battery. Each of these types has a 12.6-volt/0.15-ampere heater except the 12K5 which has a 12.6-volt/0.4 ampere heater.

RCA-12AD6 is a pentagrid converter for use as a combined mixer and oscillator tube.

RCA-12AE6 and 12AJ6 are 7-pin miniature multiunit tubes. Each contains two diodes and a medium-mu triode in one envellope and is intended to perform the combined functions of AM detection, audio-frequency amplification, and automatic volume control.

RCA-12AF6 and 12BL6 are remote-cutoff 7-pin miniature pentodes intended for use as r-f or i-f amplifiers.

RCA-12F8 is a 9-pin miniature multiunit tube containing two diodes and a remote-cutoff pentode in one envelope. It is intended for use as a combined AM detector and automatic-volume-controlled audio amplifier.

RCA-12K5 is a high-perveance 7-pin miniature power tetrode designed specifically as a driver tube to supply high input power at low distortion to the transistor in the output stage.

RCA-6CD6-GA is a high-perveance beam power tube of the glass-octal type designed especially for use as a horizontal-deflection amplifier tube in television receivers. Utilizing a button-stem construction in a T-12 envelope, the 6CD6-GA is smaller and more compact than the 6CD6-G, but features a modified mount design to maintain the same high perveance and to permit operation at higher ratings.

RCA-5FP14-A is a 5-inch oscillograph tube featuring high resolution capability and a medium-long persistence characteristic. It is intended particularly for pulse-modulated applications, such as radar indicator service. The 5FP14-A is unilaterally interchangeable with the 5FP14.

NEW PREFERRED TUBE TYPES PROGRAM ANNOUNCED TO EQUIPMENT MANUFACTURERS . . . As an answer to the need for greater standardization in television receiving circuitry and tubes, RCA has introduced a new Preferred Tube Types Program encompassing a group of electron tubes having universal application in TV receiver design.

RCA's new listing of Preferred Tubes includes types for television receiver applications—such as r-f tuners, amplifiers, deflection oscillators, rectifiers, damper circuits, and control circuits. Each type noted as "Preferred" has been especially selected by engineering analysis and customer preference.

The program enables electronic equipment manufacturers to concentrate on fewer tube types. Concentration on fewer tube types makes possible lower tube production costs, lower warehousing and stocking expense. All of these factors can contribute to lower prices for the user.

WALTER REED COLOR TELEVISION INSTALLATION . . . Medical television will take a big stride forward with the elaborate color television system, planned and installed under the supervision of the Broadcast Systems Group, which is nearing completion at the Walter Reed Army Medical Center in Washington, D. C.

Control rooms at the Armed Forces Institute of Pathology, the Walter Reed Army Hospital, and the Walter Reed Army Institute of Research are equipped to produce three programs simultaneously. Although the three control rooms are separated from each other by approximately 1000 feet, master control facilities in the AFIP control room permit the combination of pictures from the three locations into a single program by the use of underground audio and video cables.

Included at AFIP are two TK-41 Image Orthicon Color Cameras, two TK-45 Vidicon Color Cameras, a TK-26 Vidicon Color Film System, a 6 x 12 TS-20 Relay Switching System and a three-channel Monitran-Antennaplex RF Distribution System. One of the TK-45 cameras will be installed on the ceiling above the autopsy table and the second one will be used with a microscope.

At the Hospital a third TK-45 camera will be installed on the ceiling above the operating table in the "famous" Operating Room 6. A TK-41 camera is also included at the Hospital and may be used in any of four operating rooms.

Dental surgery as well as veterinary surgery may be demonstrated from WRAIR by the use of the two TK-41 cameras installed there.

The entire system will be installed and tested by the Broadcast Studio Department and delivered to the Signal Corps at Walter Reed ready for immediate usage.—*J. H. Roe*

ENGINEERING DATA AND CATALOGUES

AN-166 "Proper Degaussing of the RCA-21AXP22-A Color Kinescope"

This note discusses the importance of degaussing the 21AXP22-A color kinescope during the initial set-up procedure and whenever a color television receiver is reoriented after initial set-up.

AN-167 "Color-Purity and White-Uniformity Adjustment Procedure for the RCA-21AXP22-A Color Kinescope"

This Application Note describes the correct procedure for color-purity and white-uniformity adjustments in equipment employing the RCA-21AXP22-A color kinescope. Although the specific components involved and methods of control may vary with the design of the equipment, the steps of the procedure should always follow the order indicated. This procedure is also applicable for equipment employing the RCA-21AXP22. —*C. A. Meyer*

SERIES OF BROCHURES INTRODUCED . . . The first in a series of Defense Electronic Products departmental brochures has just been completed. The first, for the West Coast Electronic Products Department, is an attractive sixteen-page booklet in two colors and is designed to display the research and development qualifications of Los Angeles Engineering to the government, to other departments and to other companies.

Similar brochures on Missile and Surface Radar Department, Surface Communications Department, Airborne System Department and Defense Engineering Department will be available within the next few months. —*L. M. Seeberger*

ENGINEERING MEETINGS AND CONVENTIONS
October - November, 1956

OCTOBER 16-18
Conference on Magnetism and Magnetic Materials, AIEE, Hotel Statler, Boston.

OCTOBER 22-23
Fall Meeting of Assembly, Radio Technical Commission for Aeronautics, Hotel Marrott and CAA Technical Development Center, Indianapolis, Ind.

OCTOBER 25-26
2nd Annual Tech. Mtg. of IRE Prof. Gp. on Electron Devices; at Shoreham Hotel, Washington.

OCTOBER 25-26
Annual Display of Aircraft Electrical Equipment, by the Aircraft Electrical Society, at Pan-Pacific Auditorium, Los Angeles.

OCTOBER 29-30
Third Annual East Coast Conference on Aeronautical and Navigational Electronics, Baltimore Section of IRE, Fifth Regiment Armory, Baltimore.

OCTOBER 31-NOVEMBER 2
20th Anniv. Nat'l Time & Motion Study & Management Clinic, sponsored by Industrial Management Society; at the Sherman Hotel, Chicago.

NOVEMBER 8-9
Ann. Tech. Conf., Kansas City, Kansas, IRE Secton; at Town House Hotel, Kansas City, Kans.