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RCA ENGINEER

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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.

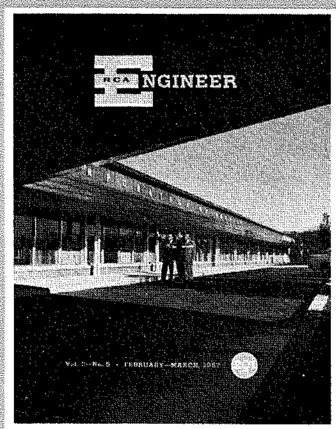
To serve as a medium of interchange of technical information between various engineering groups at RCA.

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

The cover photo is a view of the main entrance and front of the RCA Semiconductor Division's new plant at Somerville, N. J. The facilities at Somerville are devoted to the engineering development and manufacture of semiconductor products. The Division's administrative groups are also located at this plant. A. L. Gorman (front), Plant Engineer, R. E. Rist, Engineer and RCA ENGINEER Editorial Representative, and R. E. Higgs (left), Manager, Planning and Budgets, survey the building just completed. For a complete description of the new plant, see the article by R. E. Higgs and A. L. Gorman.

AN ENGINEERING CHALLENGE

A mere eight years have elapsed since the first announcement of the transistor. It was an end product of a directed effort along very basic lines to achieve a solid-state amplifier. The magnitude of the achievement can be measured by the fact that these eight years have sufficed for its stature to be so evident that it has already merited the acme of scientific recognition—The Nobel Prize.

In the past the transition from basic revelation of a principle to its reduction to practice and extensive application has consumed extended periods of time measured at least in decades. Thus, for example, the basic studies of Ampere and Faraday in the early part of the nineteenth century led to Maxwell's predictions made with regard to electromagnetic radiation after the mid-point of the century. And more than twenty years had still to elapse before Hertz demonstrated the existence of such radiations and nearly another twenty years before Lodge and Marconi achieved their commercial realization.

Even in the twentieth century, nearly four decades elapsed between Einstein's formulation of the equivalence of mass and energy and the "practical" demonstration and utilization of this concept in the first atomic pile at Stagg Field in Chicago.

Our economic system (as well as the world political situation) no longer permits so leisurely a course. Regardless of what we may feel about such a situation, the fact remains that we operate under pressures to compress the period from conception to realization into ever-decreasing spans. These are the challenges of today to the engineer. In the transistor and related semiconductor field, the engineer has met this challenge in a dramatic fashion. In less than eight years a new industry has developed whose output is measured in tens of millions of dollars per year and whose rate of increase of several fold per year holds portent for a future for these devices equalling, if not exceeding, that of any presently existing electron device.

A challenge has already been met. It has been shown that these new devices not only can do some of the old jobs as well or better than earlier devices, but also open up new areas for growth of the electronic art. As great a challenge remains before us who are taking part in this truly exciting experience. The boundaries, if they exist, are beyond our present sight and ken. Where can we go as regards such factors as frequency, power, noise figure, adaptability, cost, and a host of other factors? We do not know! But we do know that the unexplored areas far transcend these already surveyed, albeit in the most sketchy fashion. This is our challenge of the future—to explore the unknown, to chart carefully, to realize in practice. As a reward we see the satisfaction that comes, to many at least, from the realization that one's contributions are affecting — and hopefully, favorably — the course of mankind.

L Malter

Chief Engineer
Semiconductor Division
Radio Corporation of America

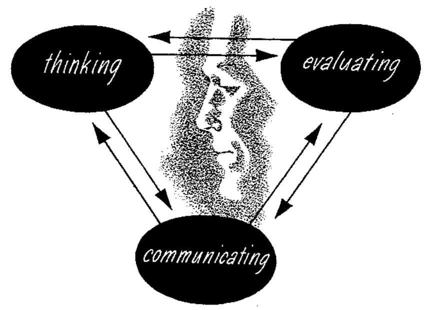
THE ENGINEERING APPROACH

MUCH PUBLICITY HAS been given recently to such expressions as "Creativity," "Brainstorming," "Synergy," "Morphological," etc. These terms are part of the vocabulary used in a relatively new science called Creative Engineering, which deals with fundamental principles and techniques for helping us to become more effective engineers. Although the subject of Creative Engineering is a vast one, even a brief review of some practical factors involved in the Engineering Approach, which is an important phase of this subject, should be of value.

An engineer's activity may be divided into three general categories, namely:

(1) Thinking
(2) Evaluating
(3) Communicating

The application of the Engineering Approach requires continual, two-way interchange among these three categories as indicated in the diagram.



by **W. N. PARKER**
Power Tube Engineering
Tube Division, Lancaster, Pa.

AN ENGINEER THINKS

An engineer is trained in the solution of problems in the applied sciences. This training should enable the engineer to foresee and recognize problems and pitfalls, as well as favorable paths of exploration, during the development or design of a new product. It is thus extremely desirable for him to possess a keen "problem awareness" and a curiosity as to "why" and "how." This same ability also enables him to recognize a need for a new product or invention.

The recognition of a need or a problem does not always require an engineering training. However, the realization that something can be done about the problem is an important aspect of the engineering approach. Along with this realization will follow some possible solutions, the number of which depends largely upon the stimulation provided for the engineer's thinking activity.

This thinking activity is affected by a number of factors other than native intelligence and education. Free discussion of a problem with another engineer or in a small group can be exceedingly stimulating. The "Brainstorming" technique* for producing a large number of ideas makes effective use of this mutual stimulation effect. Regardless of the number of individual engineers in the group it is important that the problem be well analyzed and stated in terms as broadly fundamental as possible to generate the most problem-solution ideas.

New ideas frequently occur to an engineer while he is actively engaged in fabricating, assembling, or testing a model—especially when unexpected results or difficulties arise. It has often been said that the design of parts would be much simpler, and probably less costly, if the designer had to make them himself.

Ideas seem to flow more freely when the engineer has discovered or chosen the problem himself. Furthermore, the enthusiasm, vigor, and chance of success are all greater than if the problem had been "handed down from on high." An amazing number of useful and valuable inventions have resulted when an engineer has been encouraged to work on a project that is entirely his own. This method of idea stimulation is, of course, not always practical, even if quite effective.

Sometimes it is necessary to assign to an engineer a problem which may not at first seem interesting to him or in line with his training. However, it is a rare assignment that lacks an abundance of engineering challenges if one but looks for them. Furthermore, an engineer should welcome the opportunity to widen his field of experience.

Solutions to knotty problems often appear unexpectedly during a period of relaxation, especially if the relaxation is preceded by a period of intense but unsuccessful application to the problem. One well-known engineer fosters this effective idea-getting means by providing at his bedside a pad, pencil, and light so that he may jot down immediately any spontaneous inspirations.

AN ENGINEER EVALUATES

Another important aspect of the engineering approach is the evaluation of the proposed solutions. Of the many possible solutions (or hypotheses) resulting from the thinking activity, some will be better than others. Each should be considered and scientifically evaluated as to feasibility, desirability, cost, etc.

Evaluation may take various forms such as numerical computation, paper designs and layouts, "breadboard" setups, mechanical models, and finally, actual prototype tests. Numerical computations as a means of trial-and-error experimenting can be quite ef-

* See "(Ideas)^N—Is There a Limit?" by C. M. Sinnett, RCA ENGINEER, Vol. 1, No. 6.

WILLIAM N. PARKER, Staff Engineer, Power Tubes, received his BSEE from the University of Illinois in 1928. In 1929 Mr. Parker was employed by Western Television Corp., where he was associated with the development of mechanical television equipment. Following several months as Chief Engineer of broadcast station XENT, Mr. Parker returned to television development at Philco in 1934 where he pioneered in television transmitters. During World War II, Mr. Parker was with the U. S. Government Army-Navy Expediting Production Agency. He joined RCA in 1943 and has been associated with development of super-power and high-power uhf tubes at Lancaster.

Mr. Parker served as Manager of Large Power Tube Development for two years prior to December, 1955, when he was appointed Staff Engineer. He is the holder of 15 U. S. Patents. Mr. Parker belongs to Eta Kappa Nu, Sigma Tau, Sigma Xi, Pi Mu Epsilon, and is a Senior Member, IRE.

fective, especially where digital and analogue computers are available. When the design factors are not all known or are too complex, it is easier to build a preliminary model using smaller or more available components, and then to cut-and-try by varying the parameters. An electrical circuit breadboard is frequently used in this manner. Such a model then becomes its own analogue computer.

Early evaluation or experimentation is quite desirable because it frequently reveals controlling design factors not realized or considered important in the thinking stage. In development work, because it is practically impossible to foresee all the factors, it is important to try something, even if it does not prove to be the final solution. Keen observation and analysis of failures, as well as favorable results, during the early stages of a development help to avoid costly revisions later on.

Part of an engineer's formal training is devoted to the making of tests, measurements, computations, and analyses. However, an effective evaluation also requires a judgment based on experience. Here again the combined experience of a group is much more effective than that of the individual engineer.

AN ENGINEER COMMUNICATES

The advantages of communication with others during the thinking and evaluation phases has already been pointed out. However, communication has other important aspects. When a problem is being presented or a job assignment is being given the engineer should be a good listener. In order to become acquainted with field needs so that he himself may create new and improved products the engineer should be a good reader and conversationalist. Because the compensation, facilities, services, and space necessary to provide an environment favorable to those engaged in engineering work require substantial investment, effective presentation of propositions to management and customers represents another important aspect of communication. A further obvious need is in the specifying of parts and other work required for the evaluation of a proposed solution. This need requires an engineer to be competent in communication by writing and drawing in order that his craftsmen team-mates may clearly understand their parts of the job. Reporting the results of a test or evaluation again calls for clear and effective written or oral presentation. Also, since communication involves dealing with other people, a good working knowledge of human relations, especially a sensitivity to the feelings and reactions of others, is very helpful.

When you as an engineer seek advice on a problem it is helpful for you to have *some* sort of a solution prepared in advance, even if it is obviously unsatisfactory. It is usually much easier for the other person to criticize than to solve *your* problem from scratch. The very act of criticism then stimulates him to come up with an alternate solution, or at least to make constructive suggestions, and the discussion is off to a wholesome and promising start. The above approach is especially important when a problem is discussed with a supervisor; most supervisors appreciate an engineer who enjoys thinking for himself.

An opportunity often overlooked by engineers is an informal discussion with the shop foreman or craftsman early in the design of a part or mechanism. He is familiar with the equipment, materials, and techniques readily available and can often point out valuable short-cuts and simplifications. His years of practical experience can supplement the "book-learning" and experimental knowledge possessed by the engineer. This area of communication is becoming even more important as shop courses are being crowded out of many engineering curricula. Furthermore, the successful achievement of a difficult mechanical job is very much more likely if the foreman or experienced craftsman has been given the opportunity to offer suggestions during the design period.

An engineer is inherently a conscientious individual and should be the first to realize the futility of a project. When he loses his faith in its success the project is probably doomed to failure unless the faith is restored somehow. It might be well in such a case to drop the project or rearrange assignments to get a fresh approach.

The importance of a fresh approach may be illustrated by an actual example. The widely used metal pinch-off exhaust tabulation came about during the early development of some large vhf power tubes. The fragile glass tubing then used for connecting the heavy metal envelope to the metal vacuum pumps was very apt to break and so caused considerable trouble. A metal exhaust tube was desirable but the tipoff posed a problem. One company had devoted considerable time and money in attempting unsuccessfully to solve the problem in connection with the first metal-envelope receiving tubes. Although most of his associates were extremely pessimistic as to the success of another attempt, the power-tube engineer assigned to this project had faith that under the proper conditions of time, temperature, and pressure, a pinch-off weld could be made. Since both long time and high temperature were inconvenient, he suggested a high unit pressure sufficient to cause plastic flow of the metal tubing. Accordingly a test was arranged using extremely simple makeshift equipment, but with considerable attention paid to what were considered to be important details.* The very first experiment gave a successful vacuum-tight cold weld!

It is sincerely hoped that the above observations and suggestions will stimulate further thought by the engineer as to how he can better contribute to the already remarkable technological advantages which mankind enjoys today.

*L. P. Garner and W. K. Bricker, U. S. Patent 2,427,597

SYSTEMS ENGINEERING—A GROWING CONCEPT

By **Dr. ELMER W. ENGSTROM**
Senior Executive Vice President
Radio Corporation of America

THE TASK OF adapting our increasingly complex devices and techniques to the requirements and limitations of the people who must use them has presented modern engineering with its greatest challenge. To meet this challenge, we have come to rely increasingly in recent years upon the comprehensive and logical concept known as systems engineering.

The growth of the systems concept, and its application to solution of complex engineering problems, is a matter of interest to all of us engaged in developing new products, techniques and services. With this growth has developed a close inter-relationship among all functions encompassed by engineering, focusing them upon the basic objective of adapting technology to people and their needs.

SYSTEMS ENGINEERING DEFINED

What do we mean by systems engineering? The many popular definitions boil down to the simple fact that systems engineering is a method of going about our business. This method is best described by stating the two major requirements for its success:

First, a determination of the objective that is to be reached.

Second, a thorough consideration of all factors that bear upon the possibility of reaching the objective, and the relationships among these factors.

There is nothing new about the *practice* of systems engineering. As a method, it has been employed for years without benefit of specific designation. John Ericsson's "Monitor" of the Civil War era is an outstanding example of systems engineering.

What *is* new is not the practice, but our recognition of it by name and our appreciation of its value. Only recently have we come to realize that in systems engineering lies the effective method for solving the most difficult problems raised by today's complexities in engineering.

EVOLUTION OF SYSTEMS ENGINEERING

Our appreciation is not an overnight development. The systems approach has figured prominently for many years in the engineering of our modern telephone systems and the distribution of electric power. In the 1930's, the concept was adopted in the research and development of our modern television service. This latter work is an outstanding example of the method as applied to electronics.

The experience of World War II gave the greatest impetus to the extension of the systems approach over a far broader area, largely because of developments in electronics. The need for many novel types of electronic gear for airborne use gave rise to a wide variety of component devices, popularly known as "black boxes." These included radar equipment, novel bomb sights, fire control systems, and communications equipment. These were ingenious devices, but their application in terms of the entire system of which they were merely parts was a matter of improvisation. The practice, under wartime pressures, was to think largely of the individual component and its use, rather than of the general environment in which it was to operate.

Inevitably, the proliferation of "black boxes" brought problems of establishing proper interaction among them. Thus the systems engineer began to come into his own, performing the essential task of looking ahead to the ultimate objective—the system—and considering the whole of which each "black box" formed a part.

Under the unique pressures of World War II, the old approach succeeded in "grafting" novel electronic devices onto existing planes and vehicles. It would hardly suffice today for such tasks as the design of an earth satellite, an intercontinental missile, or a nuclear reactor.

CHARACTERISTICS OF THE SYSTEMS METHOD

We now recognize systems engineering as a discipline in its own right, having a set of rules affecting its conduct, requiring people with specialized training, and calling for changes in our engineering organizations.

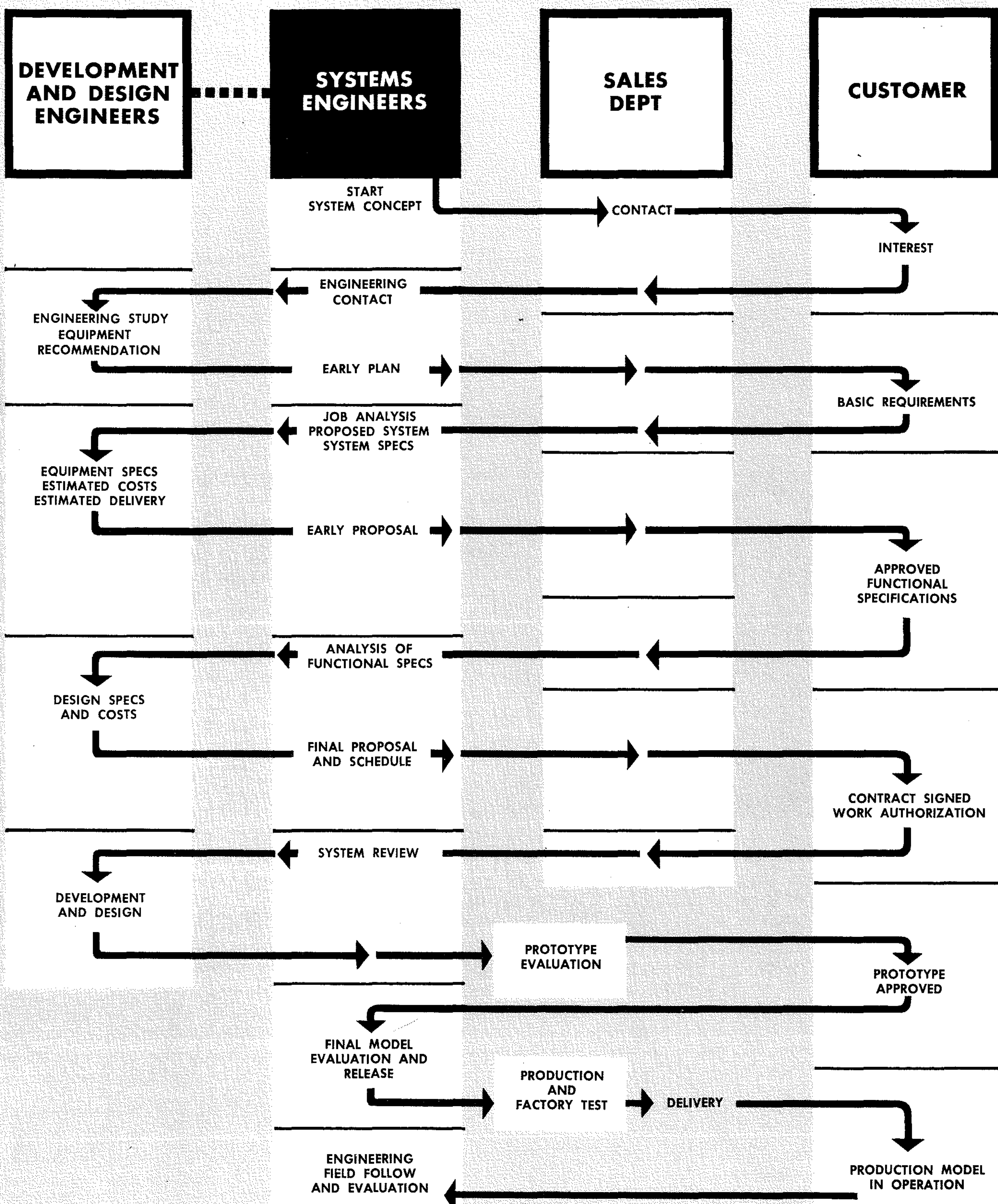
As a discipline, the systems approach has these characteristics in all cases, regardless of the great variety of objectives and detailed methods:

1. *It is broad in scope,* ignoring the boundaries that separate the various academic disciplines, that separate research from engineering, and advanced development from product design and marketing.
2. *It is cooperative,* usually involving large numbers of people and functions that may appear at first glance to have little to do with one another.
3. *It requires compromise,* because success in developing a complex system normally involves a sacrifice at one or more points of detail for the sake of the whole.
4. *It is thorough*—and by the same token a bit skeptical. The systems engineer must examine every detail that bears upon the function of the complete system. At the same time, he must distrust the tempting "easy" first solution.

There is one more highly important point to be emphasized. The principal reason for developing most systems is to surmount the limitations of human perception, physiology, or temperament. This is true whether the system involves the control of a supersonic plane, the solution of a complex mathematical problem, or the operation of a telephone dial.

The all-important question of human limitations is the basis of human engineering, a related discipline

FLOW CHART FOR CREATION OF BIZMAC SYSTEM



Systems Engineering: The steps followed in the design of an RCA BIZMAC Data-Processing System are indicated diagrammatically. The System Engineer has the role of coordinating all aspects of the system to insure compatibility of equipments within the system, and with the customer's requirements. He figures prominently in the determination of how the system will be designed to do its job within the engineering state of the art.

which has now become an integral part of the systems approach. We deal in the field of human engineering with such questions as the amount of detail that will satisfy the human eye in a television system, or the maximum number of controls that an aircraft pilot can safely handle. A lack of proper human engineering can be costly, or even catastrophic. On the other hand, proper consideration of human engineering factors in a design can contribute to success.

The success of a "systems" approach can be judged, then, by its effectiveness in producing a sound physical design, adapted for use by persons of defined skills, and based on concepts resulting from operational research.

THE PEOPLE AND THE ORGANIZATION

The systems approach is a complex matter, increasing in complexity as we move up the scale to larger and more involved units. Because each system must be considered as a unit, inattention to any aspect of the smallest component can jeopardize our success in attaining the final objective. Thus success or failure rests upon the competence and reliability of people to whom we entrust engineering projects.

The engineering team engaged in any systems project will normally include a number of individuals of varied technical skills, having in common the ability to fit their special talents into the achievement of the complete system. This team frequently will call upon specialists who do not have the systems viewpoint to refresh and enlarge their knowledge of the various technical specialties. While it is true that leadership will reside in one man, nevertheless, the essential work of systems engineering on a project of any magnitude is done by the team and not by an individual.

A broad range of scientific and technical specialties is encompassed by such a team. There may be aerodynamicists, ballistics experts, electrical engineers, designers, mathematicians, physicists, chemists, psychologists and many others, in a variety of combinations according to the task at hand. In a fully cooperative team, a wide range of talents is thus brought to bear on each problem. Such a team has both positive and negative virtues. It is able not only to advance directly to a desired objective, but also to prevent a waste of time, effort and expense on impractical projects.

The supervision and team activities of systems engineering demand engineers of superior knowledge, vision and tact. They must be equipped, above all, with the ability to apply standards which will enable them to judge the progress of the detailed work in relation to the final objective. Such engineers are developed through special training and through experience in an environment that encourages the flowering of their talents.

Many companies today maintain special training programs for systems engineers. RCA, for example, has cooperated with the Moore School of Electrical Engineering of the University of Pennsylvania in the establishment of a two-year graduate course in systems engineering at the University. In the words of the prospectus, this course is planned

"(1) to supplement, for use in systems engineering or operations research, the education of persons of suitable experience in industry, graduate work, government service, or an equivalent, and

"(2) by concentrating on systems problems to inculcate a 'systems consciousness'."

RCA engineers selected for their potential effectiveness as systems engineers are given the opportunity to take this course after completing a preliminary lecture course at RCA.

COLOR TV: ACHIEVEMENT OF A SYSTEM

The development of the RCA compatible color television system is an outstanding example of systems engineering on a large scale.

At the outset, the systems engineers concerned with this project were faced with a series of basic conditions and problems. They had to establish first that there was need for color television. Then it was necessary to determine that color tv was technically possible and economically feasible.

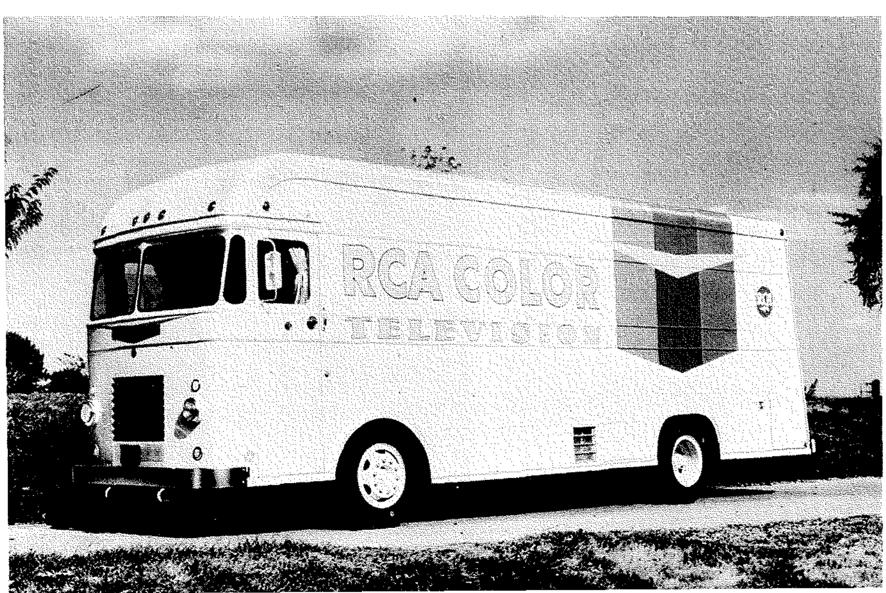
Subsequently, they had to consider the environment in which color television would start, grow and continue. This was a most important consideration, since for practical reasons black-and-white television came first, creating a large and growing public investment in black-and-white television receivers. In this environment, the systems engineers concluded that the new color system must be compatible with the existing black-and-white service. In other words, the color system must be so designed that color broadcasts could be received in monochrome on existing black-and-white receivers, while the new color receivers could also receive black-and-white.

In retrospect, choice of a compatible system seems utterly logical—but it was not so in the development period. In fact, an incompatible system urged by some in industry was approved as standard by the government regulatory body. This move later had to be undone before further progress could be made toward establishment of a practical color tv service.

Another broad problem for the systems engineering team was the definition of technical specifications. Involved in this question were such considerations as balancing the requirements of human vision for picture detail and color characteristics, and balancing the potentials of apparatus performance and availability of channel space for broadcasting stations.

In the latter case, early analysis in-

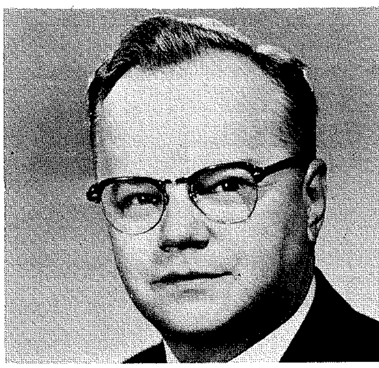
The color tv mobile unit above houses many items of equipment. Each one, including the truck itself, microwave relays, tv receivers, color tv tubes, as well as entire tv stations, are all components which go to make up the compatible color television system discussed in this article.



DR. ELMER W. ENGSTROM, Senior Executive Vice President and a Director of RCA, joined RCA in 1930. He received the B.S. degree in Electrical Engineering at the University of Minnesota in 1923.

In the early thirties, Dr. Engstrom directed RCA's television research toward a practical service. He was responsible for the development and construction of apparatus used in field tests and in the planning and co-ordination which led to the reality of black-and-white television. Since then, he and his associates have conducted research on television in color. Dr. Engstrom was a member of the NTSC at the time TV standards for broadcasting were established and a member of the Radio Technical Planning Board. He was a member of the NTSC which developed technical signal specifications for color television transmissions, adopted by the F.C.C. December 17, 1953.

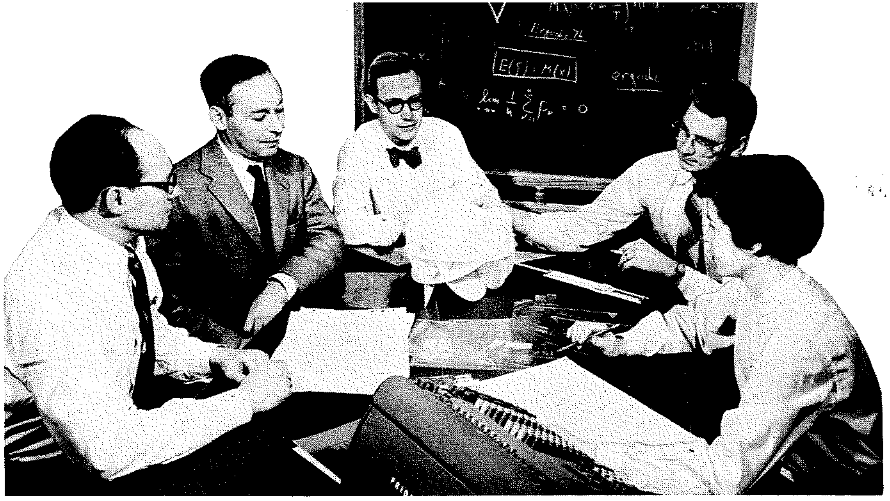
In 1942 when all the research activities of RCA were brought together at Princeton, N. J., Dr. Engstrom became Director of General Research and in 1943, Director of Research of RCA Laboratories. On December 7, 1945, he was elected Vice President in Charge of Research of the RCA Laboratories Division; on September 7, 1951, he was elected Vice President in Charge of RCA Laboratories Division; on January 11, 1954, he was elected Executive Vice President, RCA Laboratories Division; on June 4, 1954, he was elected Vice President, Research and Engineering, and on October 21, 1955, he was appointed to his present position. Under his direction are the RCA Laboratories and RCA's Defense Electronic Products and Commercial Electronic Products. He is responsible as well for the Engineering Services, Manufacturing Services and Product Planning activities of RCA.



The honorary degree of Doctor of Science was conferred on Dr. Engstrom in June, 1949, by New York University. In August, 1949, Dr. Engstrom received a silver plaquette from the Royal Swedish Academy of Engineering Research. In October of 1950 he received the Outstanding Achievement Award gold medal from the University of Minnesota. On October 4, 1955, Dr. Engstrom received the Progress Medal Award from the Society of Motion Picture and Television Engineers.

Dr. Engstrom is a member and past President of the Princeton Chapter of Sigma Xi, science research honor society; a Fellow of the IRE, of which he was a director in 1949, and of the AIEE. He is Chairman of the New Jersey State Commission on Educational Television.

dicated a need for basic advances in technology and invention to fit picture information into a narrower frequency band than could be achieved by earlier straight-forward communication techniques. It was evident, too, that new apparatus would have to be invented — particularly the picture tube for reproducing color images. There was a clear need as well for broad experience in propagating radio signals and transmitting color.



At the Airborne Systems Laboratory in Waltham, Mass.: Staff analysts Maurice Hellman, Harris Safran, Homer Eckhardt and Edward Wallner join computist Marjorie Ray at one of the frequent meetings devoted to mathematical analysis.

As the work moved beyond these initial determinations into the more practical stages, a host of more detailed problems had to be solved. These related to apparatus design, practical operation under broadcast conditions, industry participation in determining signal specifications for transmission, and approval of these specifications as standards by the Federal Communications Commission.

Finally, there came the problems of establishing color television service, expanding studios, interconnecting networks, installing transmitters, and creating program production groups. In the final stage, too, arose the matters of selling color to television advertisers, marketing receivers, and measuring public reaction.

Thus, from concept to fruition, the color television system presents a "textbook" example of the systems concept in action. All of these matters required full consideration by the systems engineering team, working toward the single defined objective.

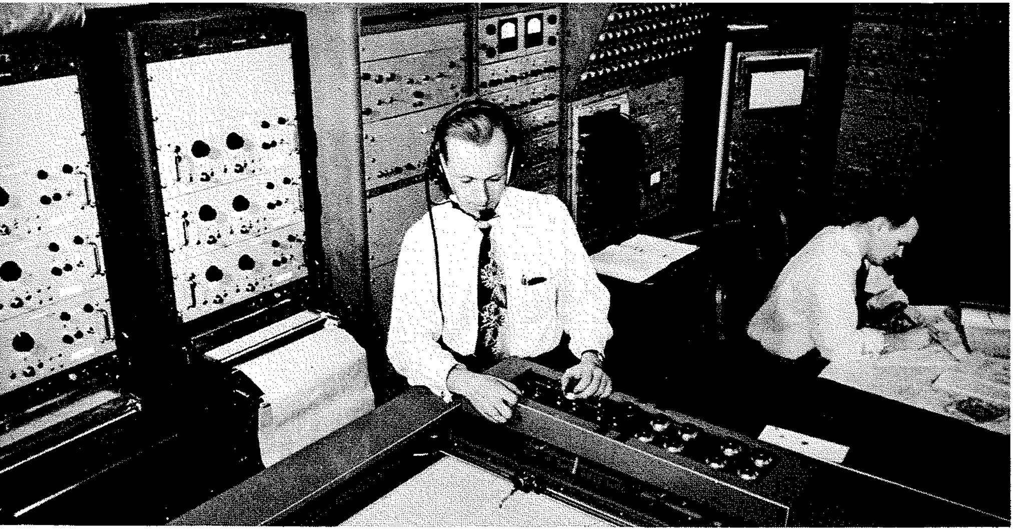
The engineering of the color television system is one of several outstanding examples of the concept in action. Others include RCA's experience in microwave communications, broadcasting and radio networking, missile and radar, airborne systems, and in development of "Bizmac."

A SPECIFIC SYSTEMS PROJECT

Creation of color television represents a systems approach on the broadest scale. Yet the concept is as applicable on a narrower or more specific basis. We can see in the development of a military weapon how the same pattern of systems engineering emerges.

We do not need to be specific as to the exact nature of the weapon: it might be a tactical system such as an aircraft for support of ground troops, or it might be a strategic system such as an intercontinental ballistic missile. In any case, the systems group must begin with a basic study to achieve the following objectives:

1. Determine requirements for the weapon. How does it fit the scheme of military tactics or overall operational plans for the period it will be operational?
2. Determine the technical state of the art, and the prospects for advancement in the technical areas applicable to the problem.
3. Determine the optimum system that can be achieved in terms of the various functions, or sub-objectives, that are involved. This analysis will include establishing a scale of values for the various functions, and determining the penalties incurred through cost, size, weight, or engineering complexity. This step frequently leads to compromise based on the most favorable ratio of value versus penalty, with the aim of achieving more important objectives at the expense of those which are relatively less important.
4. In cases where the ultimate solution of a part of the problem



The Airborne Systems Laboratory analogue simulator and plotting board are operated here by Daniel Page, seated, and William Nicholson who is in charge of the facility.

may still be only a gleam in the engineer's eye, to determine whether interim solutions will permit development of the system as a whole pending development of the lagging parts.

5. Determine whether the system can be developed so that it can be operated by personnel with the training (or lack of it) that will be available.

6. Determine whether the system can be maintained in operation under field conditions. How much degradation is to be expected during use in the field? Should there be compromise between theoretical performance and field performance for the sake of achieving a greater probability of effective use?

7. Determine whether the system can be supported logistically in the planned operating area. For example, should standard components be used extensively to ease field maintenance problems, or would this degrade performance too seriously?

8. Determine whether the equipment will be subject to countermeasures by the enemy, such as jamming. Similarily, a determination should be made as to how far the system should be complicated by including safeguards against such enemy action.

9. Determine the extent to which a systems concept and design are susceptible to control by human operators under the conditions of use. For example, the human operator may be a part of the system, and his probable reactions and level of training must be taken into account in designing the system.

All of these determinations fit into the general problem which the systems engineering team must resolve. Each answer from the resolution must be included in the design concepts and in operation of the system.

These two examples—the engineering of a broad color television system and of a specific weapons system—are far apart in their concept and application. However, a common thread runs through both in the analysis and the prosecution of the work. Both present design problems that submit to the systems engineering concept. Clearly, both a color television system and a new military weapon call for the same kind of careful study and analysis, and the same application of appropriate skills to the variety of problems related to the final overall objective. These requirements apply with equal force in all cases, whether the objective is an electronic business machine for a life insurance company, an inventory control system for a large business firm, or even a system for the complete traffic control of the airways of our country.

THE BROADER SIGNIFICANCE OF SYSTEMS ENGINEERING

Systems engineering is enabling us today to reap maximum benefits from new, expanding, scientific and technical knowledge. At the same time, it is providing us with broader experience of immense value in preparation for the coming era of automation.

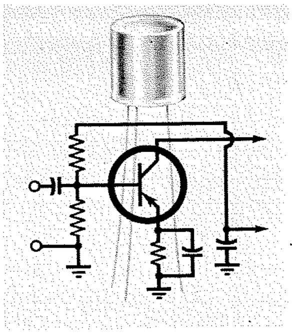
Automation in its ultimate form will encompass all aspects of systems engineering, on the broadest scale. For a generation of engineers trained in the design of comprehensive systems, it will be a relatively short step in the philosophical sense from the electronic data-processing systems of today to the automatic factories of tomorrow. It will be just as short a step from today's largely automatic jet fighter to tomorrow's completely automatic jet airliner operating in an environment of controlled traffic.

The complexity that has overtaken our technology has at the same time overtaken our economy, our social environment, and our relationships with the rest of the world. There is every reason to believe that this complexity, like that in the field of technology, will grow greater rather than less in the future.

Many of these complexities arise from changing or evolving relationships between racial or economic groups, between nations, and between conflicting ideologies. In each case, we must start with the determination of an objective, and with a thorough consideration of all factors bearing upon the possibility of reaching this objective. We must make ourselves aware of the relationships among these factors. We must consider the limitations of perception and tempermanent among people upon whom success of the proposed solution depends. There is a striking parallel here between the steps required to solve many problems in broad areas, and those required by systems engineering in the field of technology.

The systems concept has been designed specifically to fulfill requirements in the engineering of complex systems. Its effectiveness can be measured by our success in developing wonderfully versatile systems of home entertainment, communications, automatic controls, and military weapons. In each case, application of the concept has led to new achievement through imaginative planning, effective and extensive teamwork in a worthy enterprise, and an ability to compromise when necessary to achieve the desired objective.

Surely a philosophy which encourages these traits need not be confined in the future to the field of technology alone.



THE SOMERVILLE SEMICONDUCTOR PLANT

By

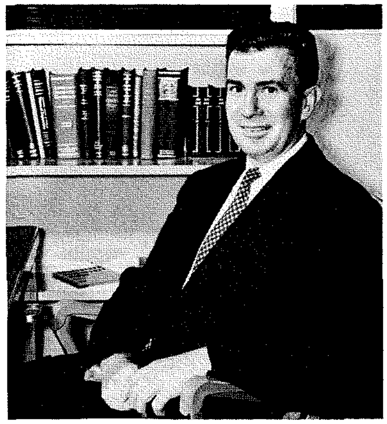
R. E. HIGGS, Mgr., *Planning and Budgets*
and A. L. GORMAN, *Plant Engineer*
Semiconductor Division, Somerville, N. J.

BECAUSE OF THE unique technical requirements and problems which characterize the development, manufacture, and marketing of semiconductor devices, this product line has recently been established as a separate entity, both organizationally and physically. The Semiconductor Division is now moving into its new Somerville Plant, which has been especially designed and built to provide for special needs of this activity.

This new and modern plant, shown on the front cover, is nestled in the rolling countryside of Bridgewater Township, New Jersey, just two miles west of Somerville and about twenty miles north of Princeton. The 175,000-square-foot rectangular plant houses all the functions of the Semiconductor Division. The plant is a testimony to RCA's engineering prowess, its ability to volume-produce a quality product, and its faith in the future of the transistor industry.

Because Engineering plays such an important part in semiconductor operations, the portion of the plant assigned to the Division's engineering headquarters is high, greater than 30 per cent. Engineering areas are carefully planned to provide engineering personnel and functions with the facilities and atmosphere necessary for the continuing development of better and more efficient devices and techniques. Another important requirement satisfied by the new plant together with its comprehensive air-conditioning system is the provision of an unusually high degree of cleanliness.

The Plant Engineering function, which coordinated all phases of plant layout, maintained close contact and consulted with both Manufacturing and Engineering personnel at each stage of the planning. This joint effort resulted in a highly integrated combination of "custom-tailored" functions.



ARTHUR L. GORMAN has attended evening sessions at both Newark College of Engineering and Brooklyn Polytechnical Institute. He joined the General Electric Company in 1929, and was transferred to RCA when the Tube Department was formed in 1930. He has held various positions in the Harrison plant, including Factory Production and Quality Control supervision; General Foreman, Electrical Department; Superintendent, Equipment Production; and Manager, Plant Layout and Construction. He is presently the Plant Engineer at the new Somerville Semiconductor plant. Mr. Gorman has long been involved with plant layout, new construction, and plant rehabilitation, and is a member of the RCA 25-year club.

ROBERT E. HIGGS received the B.S. degree in Electrical Engineering from Worcester Polytechnic Institute in 1940 and the M.S. degree from Stevens Institute of Technology in 1950. After serving with the U.S. Navy from 1943 to 1946, he joined RCA as a receiving-tube design engineer in the Tube Division at Harrison, N.J. He was appointed Assistant to the Chief Engineer of the Tube Division in 1953, and Administrator of Receiving-Tube Planning in 1954. He became Manager of Planning and Scheduling for the Semiconductor Operations Department in 1955, and Manager, Planning and Budgets, Semiconductor Division in 1956.

Mr. Higgs is a member of the Institute of Radio Engineers and has served as Chairman of the JETEC Subcommittee 5.5 on Computer Tubes.

GENERAL LAYOUT

As shown in Fig. 1, the plant is divided into four general areas: Production, Engineering, Administration, and Personnel Services. The basically longitudinal division of the plant provides considerable leeway for expansion within and beyond the present area without functions overlapping and/or "leap frogging." The 85-acre plant site permits expansion of the building to both the north and the west.

Design of the plant took advantage of naturally sloping ground which permitted construction of a half-basement beneath the Production area at minimum additional cost. All of the air-conditioning, heating, and other plant equipment is housed in this basement, as well as dust-producing manufacturing equipment. The parking facilities, driveways, shipping and receiving platforms, sewage- and acid-disposal units, water tower, and power substation are designed and located to be close to the main structure and, at the same time, blend in with the surrounding woods and fields.

The design of the manufacturing area provides 50,000 square feet of clear space. Exposed piping is kept to a minimum to reduce dust accumulation. Construction costs were minimized and maximum operating efficiency of the air conditioner is permitted by the absence of ceiling-high partitions or walls in this area. Wiring and piping are run along the ceiling of the basement, and connections to the manufacturing floor above are made through sleeve openings built into the floor. All services are distributed to the manufacturing floor through a system designed for maximum layout flexibility and convenient access.

The Administration area located at the front of the building contains all of the Division Staff offices, together


MANUFACTURING AREA
ENGINEERING AREA
ADM. OFFICE AREA
SERVICE AREA

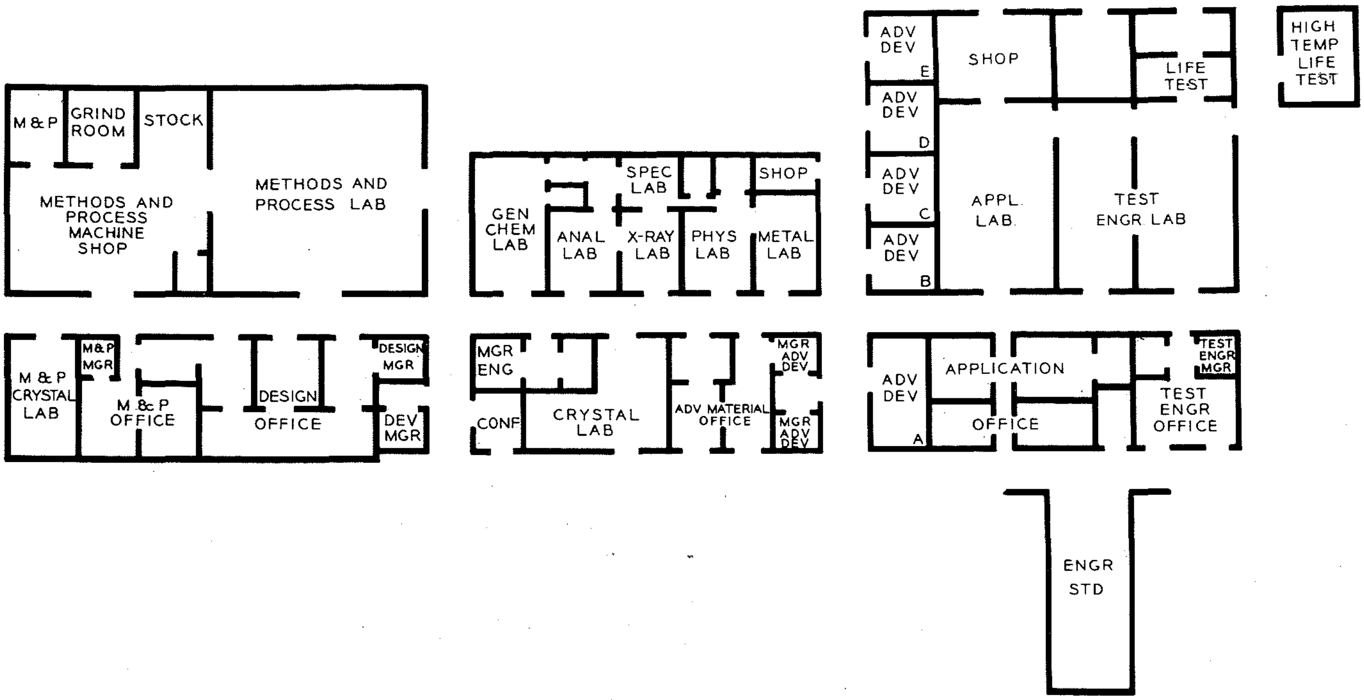


Fig. 2—Floor plan showing the Engineering Areas.

with the Sales, Marketing, Purchasing, Accounting, and Financial activities.

The Personnel services area occupies the remainder of the front section of the building. This area includes the employment office, the dispensary, the employe sales store, and the kitchen, cafeteria, and service dining room. The cafeteria is so located that it offers an outside view, and its panelled walls give the room a warm friendly appearance which is welcome at an important time of day.

ENGINEERING FACILITIES

The Engineering area, shown in Figs. 1 and 2, runs longitudinally across the plant, separating the Administrative from the Manufacturing function. This area has been given special attention to provide a layout built around the specific engineering job to be done. The investment in Engineering facilities is equivalent to one-fourth of the investment in building and grounds. Office-type partitioning is used to separate functions and, in some cases, working groups. The over-all decor of the plant is light and airy.

Space assigned to the individual engineering functions is based chiefly on analysis of their inherent growth probabilities and, secondly, on organizational considerations. Activities such as the Advanced Materials activity, which are likely to have a less rapid rate of expansion, are located in the central areas of the plant. Those having the highest rate of growth potential, such as the Methods and Process Laboratory and the Test Engineering activity, are located closer to the outer extremities, thus providing built-in flexibility.

The erection of ceiling-high masonry wall enclosures was necessary in some cases in the Engineering area to separate certain operations. Some of these walls were required to permit the supply of different atmospheres to relatively small, adjacent areas. Other walls act as light, sound, vibration—or dust barriers. For example, a separate Spectrograph Room was required to satisfy the precise humidity, temperature, dust, and darkness conditions necessary for accurate operation and proper care of the spectrograph. In the case of the Analytical Balance Room, ceiling-high masonry walls were required primarily to exclude dust and vibration. Noise-producing activities such as the Machine Shop and Applications Laboratory are located to provide minimum interference with other activities.

Particular attention was given to the location of the Engineering Library, which extends into the Personnel Services area at the front of the building. It offers an outside view and is a pleasant and, it is hoped, inspiring place for the engineers to conduct their research and general studies in a quiet out-of-the-way atmosphere.

GENERAL PLANT FACILITIES

Electric power is supplied from Somerville to the plant substation by

Fig. 1—View of the front of the new Semiconductor Division's plant in Somerville, N. J. L to R: R. E. Higgs and A. L. Gorman, who were responsible for plant layout and planning, are describing facilities to R. E. Rist, Semiconductor Engineer and Editorial Representative for the *RCA ENGINEER*. The inset shows the distribution of floor area which totals 175,000 square feet (125,000 on main floor and 50,000 in basement). Engineering areas represent about 30% of the total available space.

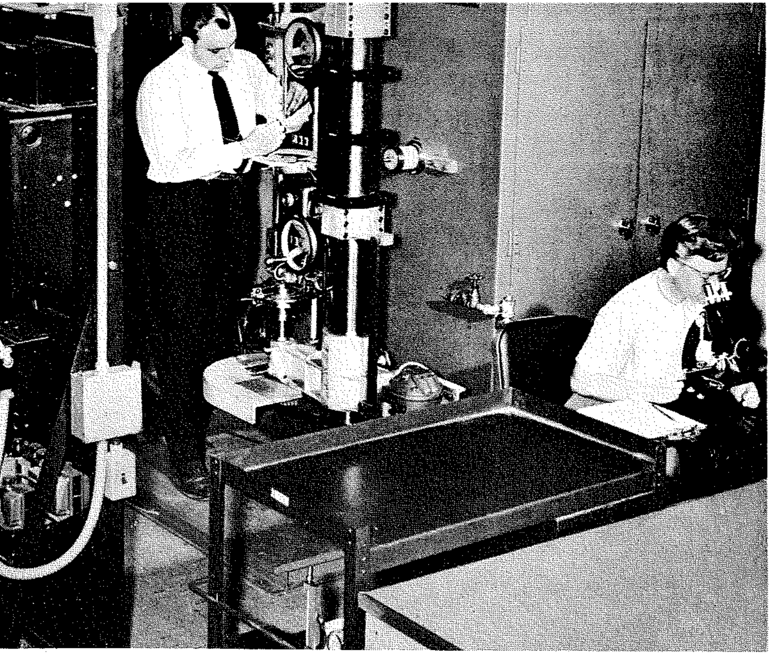


Fig. 3—Single-crystal furnace is being set up by C. L. Carlson in the Crystal Laboratory of the Advanced Materials activity. P. Lintz examines germanium crystal specimen under the microscope to observe crystal imperfections. The techniques of crystal growth are explored with the facilities of this laboratory.

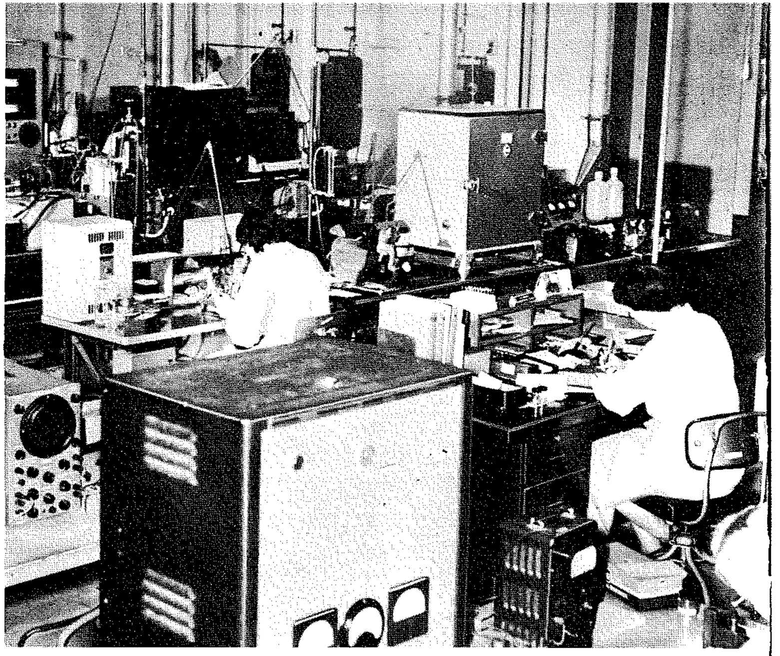


Fig. 4—A general view of the Methods and Process Laboratory transistor assembly area. These facilities are used for development of new devices and processes.

Fig. 5—L. D. Armstrong observes the transistor mounting operation in the manufacturing assembly area.

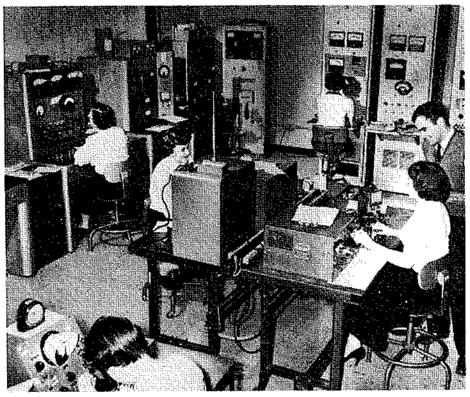


Fig. 6—S. C. Simons of Test Engineering checks testing of transistors in Testing Laboratory. Life tests and design checks on both factory product and engineering samples are made by this group.

Fig. 7—J. Gnall and S. Baran are shown adjusting flow rates through the plant's water deionizer. Deionized water is used in those rinsing operations where a very high degree of cleanliness and purity is essential.

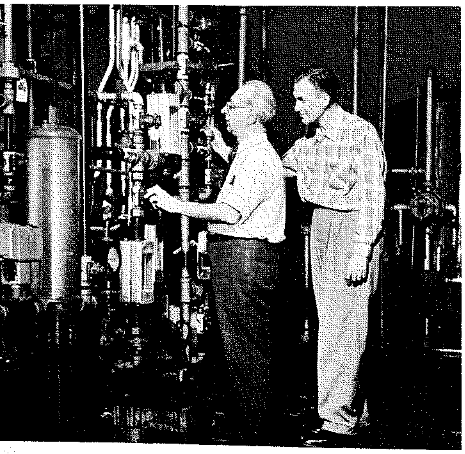
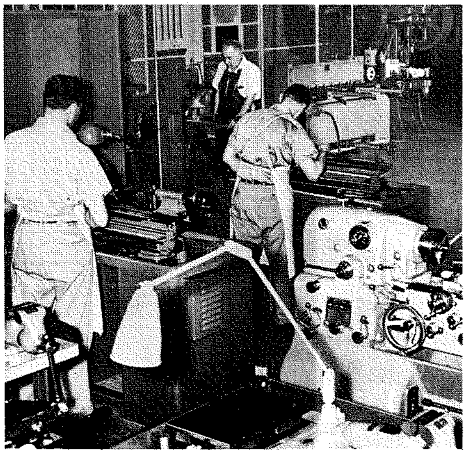


Fig. 8—A general view of the Methods and Process Laboratory machine shop. This shop provides tools, parts, and fixtures for all of Engineering. Some equipment maintenance for Manufacturing is performed here as well.



means of a 26,000-volt line having a capacity of 2000 kilowatts. Power is reduced to 440 volts, 3 phase, to operate the air-conditioning compressors and waste-disposal plants, and to 220 volts, 3 phase, to supply the main building. Further reduction and regulation of line voltage is made where necessary for laboratory and testing work. Wiring has been installed for a centralized television antenna system.

Unusually precise and dependable air-conditioning equipment is required for development and manufacture of semiconductor devices. Successful fabrication is dependent upon tight humidity controls in the atmosphere of the assembly area. Humidity does not exceed 50 per cent at any place in the plant. In special areas, such as the spectrograph room, a controlled atmosphere having a maximum humidity of 10 per cent is provided.

Because some electrical characteristics of semiconductor devices vary with ambient temperature, industry-wide testing specifications have been based upon a specific temperature (77°F.) and a specific tolerance (within 2.7°). Consequently, the temperature of the testing laboratory must be carefully controlled. Although the entire main floor (130,000 sq. ft.) of the plant, with few exceptions, is air-conditioned, each area is supplied according to its own needs. Administrative areas, for example, use only conventional controls.

The various air-conditioning needs are met by two 350-ton chilled-water compressors and nine air-conditioning centers. Seven of the nine centers are used to meet exact humidity or temperature requirements which prevail in 100,000 square feet of the total area. Each center is self-contained and capable of operating independently of the rest of the system. These centers provide cooling, heating, filtering, and humidity control throughout the year. Heat is furnished to the system by one 400-horsepower low-pressure steam boiler.

Water is supplied by three 630-foot-deep wells to a 200,000-gallon-capacity gravity storage tank. One-half of the tank water is always maintained as a reserve for sprinkler and fire-protection purposes. Because process water used in the manufacture of semiconductor devices must be virtually free of impurities, a water deionizer is a basic piece of plant equipment. The deionizer and its associated separate dual plastic piping system are capable of delivering 15,000 gallons of deionized water per day. The deionizer unit occupies more than 400 square feet in the basement.

The plant incorporates its own complete sewage and industrial-waste disposal systems. Industrial wastes are handled through a plastic piping system that is not affected by acids and solvents. The wastes are collected in four 9,000-gallon reservoirs, individually analyzed, and given proper chemical disposal treatment. It is interesting to note that the sanitary part of the system is capable of handling the waste-disposal requirements of a 2,000-home community.

A highly efficient central vacuum-cleaning system, capable of trapping and removing even the most minute dust particles, is used to satisfy the cleanliness requirements of semiconductor device fabrication. Cleaners can be plugged into any of 70 outlets to collect dust and liquids from any corner of the plant and carry them to a central disposal drum located in the basement.

The five-million-dollar Somerville Plant was designed to provide efficient and flexible facilities for the rapidly growing Semiconductor Division. In these new facilities, the Division looks forward to continued growth and success in the semiconductor field.

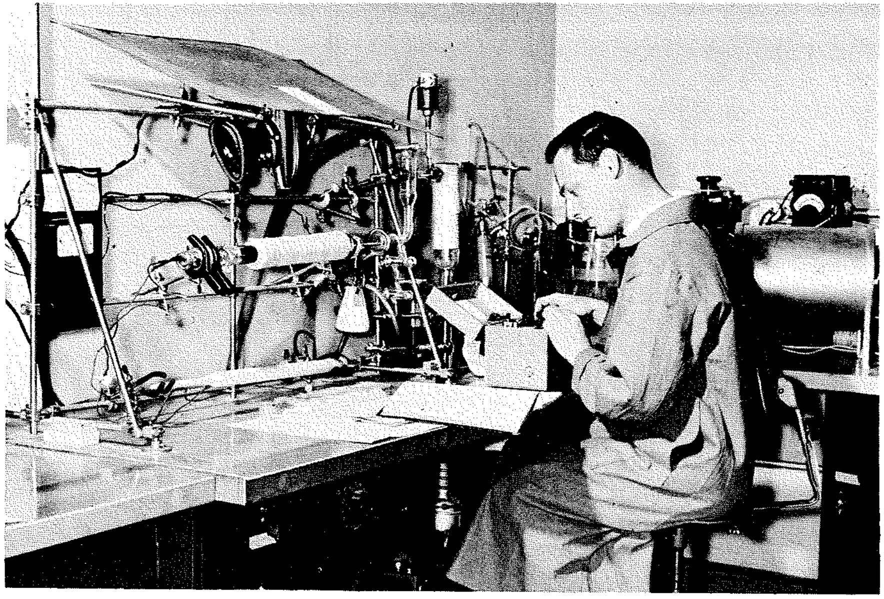
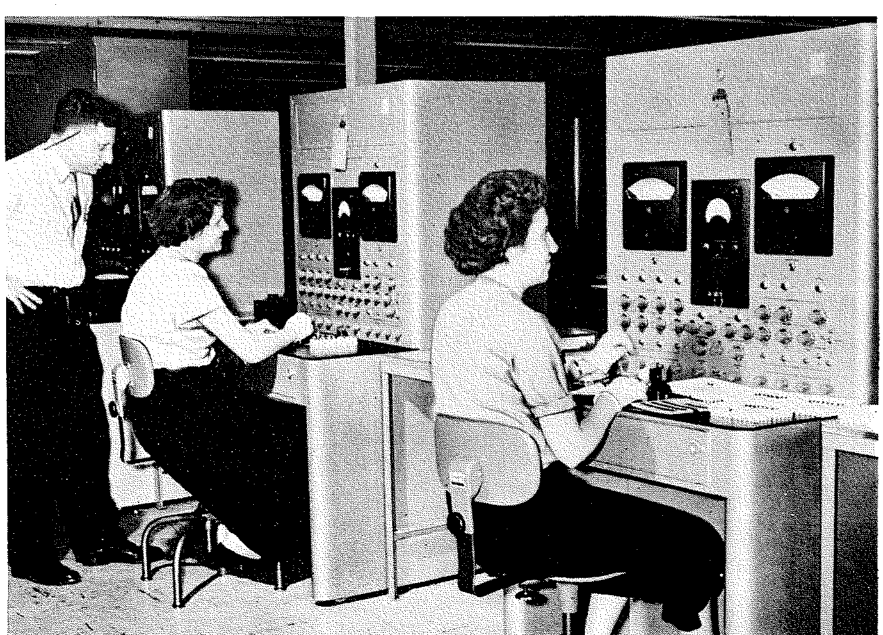
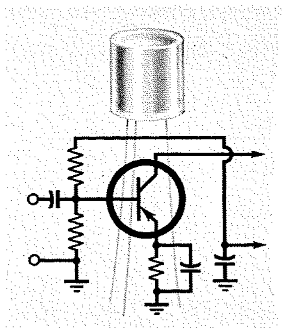


Fig. 9—D. Des Jardin is shown preparing for a silicon diffusion experiment in the Advanced Devices Laboratory.

Fig. 10—E. Sailer and J. Sarace are shown examining a cross-sectioned transistor with the metallograph in the Metallurgical Laboratory of the Advanced Materials activity.

Fig. 11—J. Ollendorf observes production testing of junction transistors on universal test sets.





SURVEY OF RCA TRANSISTORS

by

Dr. R. B. JANES, Mgr.

Semiconductor Design
Semiconductor Division
Somerville, N. J.

EDITOR'S NOTE: The editors welcome this opportunity to salute our Semiconductor engineers who have made such amazing progress in just a few short years. The widespread and rapidly growing uses for RCA transistors within the confines of RCA alone is exemplified by the applications described in this issue. In addition to papers by Semiconductor engineers, see articles on applications by Messrs. Deuitch, Wilson, Maloff, Flory and Wallmark. This symbolizes the wisdom of Semiconductor engineers who placed emphasis on certain types . . . and justifies their selection of the various commercial transistors.

As Dr. Malter has pointed out (see inside front cover), the history of transistors to date is a very short one. The original transistors were of the point-contact type, and were difficult to make and limited in application. The real history of transistors starts with the development of the junction transistor only a few short years ago. Although the earliest junction transistors were useful for amplification only in the audio-frequency range, natural markets for these devices existed in the fields of hearing aids and battery-powered portable radios, where size and low battery drain were of prime importance.

MANUFACTURING TECHNIQUES

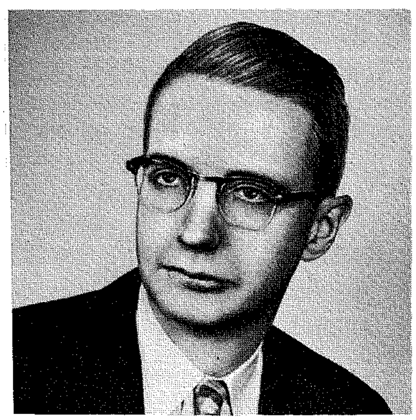
During the development of junction transistors, basic techniques of manufacture were evolved which, in many cases, had not been used elsewhere. These techniques included purification of germanium by such methods as zone refining, and special methods of growing nearly perfect single crystals of germanium. When it is considered that impurities of one part in ten million and a few crystal imperfections can cause serious trouble, the problem faced in developing these methods can be better appreciated.

Techniques for producing junctions were also developed, including the method of growing from the melt, "surface-barrier" and "rate-grown" techniques, and the technique of "alloy junctions" which has been carried to a high state of perfection by RCA. Because the surface of the transistor near the junction periphery is extremely sensitive to small amounts of impurities, methods of "etching" and stabilizing the surface were also developed. Finally, a hermetically tight case was found necessary to maintain the quality of this surface during life.

PRODUCT DEVELOPMENT AND THE MARKET

As a result of these developments, it was possible by 1955 to market junction transistors for audio-frequency use. The first commercial junction transistors included the 2N105, a very tiny unit for hearing-aid use, and the 2N109, an audio-output unit for use in the output stage of battery-powered portable receivers. Shortly afterwards, the higher-frequency 2N139 i-f amplifier and 2N140 converter were announced for use in all-transistor portable radios.

It is interesting to speculate on where transistors may be used besides these natural markets. Vacuum tubes have developed over the past thirty years from low-power, audio-frequency devices to high-power, high-frequency ones. The same trend can be expected in the transistor field over a much shorter span of years. Already, developmental units are capable of tens of watts output at low frequency, and low-power units are in development for frequencies up to hundreds of megacycles. In the high-frequency region, the "drift field" principle developed by RCA has permitted a major breakthrough.



ROBERT B. JANES received the B.S. degree in physics from Kenyon College in 1928. He did graduate work in physics at Harvard and at the University of Wisconsin where he received a Ph.D. in 1935. From 1929 to 1931 he served as instructor in physics at Colgate University and from 1931 to 1935 as research assistant at the University of Wisconsin. From 1935 to 1943, Dr. Janes was an engineer at the Harrison, N. J. plant of RCA where he worked on television camera tubes and phototubes. In 1943 he went to the Tube Division of RCA at Lancaster, Pa. He was in charge of the development and design of television camera tubes until 1950 when he was appointed Manager of the Development Group responsible for camera tubes, storage tubes, and phototubes. In 1953, he was appointed Manager, Color Design, of the Color Kinescope Engineering activity. He became the Manager of the Design activity in the Semiconductor Division in 1956. Dr. Janes is a member of Sigma Xi and a Fellow of the Institute of Radio Engineers.

As high-power and high-frequency transistors are developed, new uses for such devices are constantly being found. These uses include the computer field, where extreme reliability is needed, miniaturization in both commercial and military use, and the many military uses where low power consumption is essential.

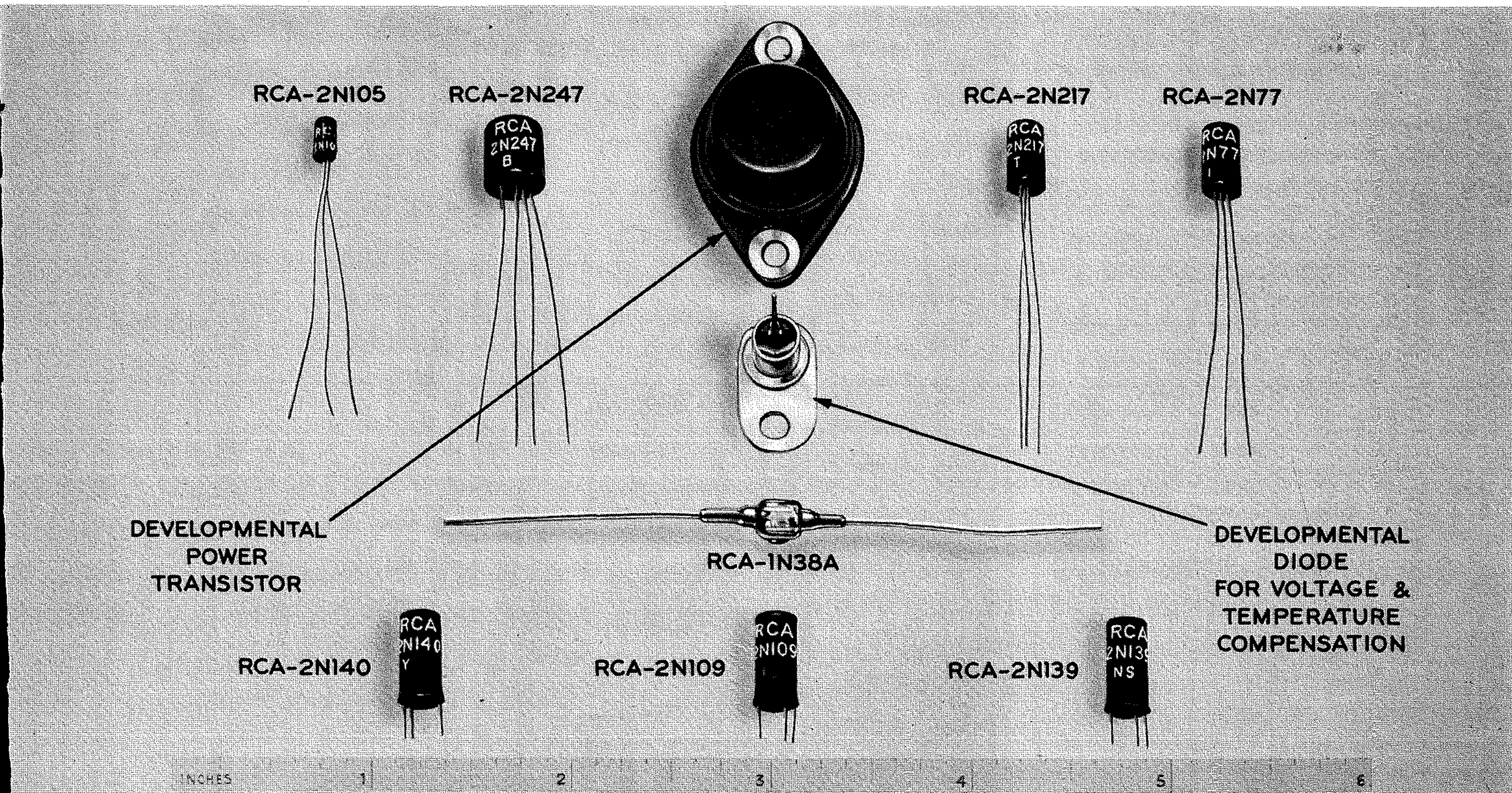
What has RCA done in these various fields? The 2N139 already mentioned found its main usefulness at 455 kilocycles. The 2N269 switching transistor for computers is an outgrowth of this type useful at a few megacycles. The 2N247 drift transistor is useful to 10 or 20 megacycles. In the power field, RCA transistors range from the 2N105 having an audio output of about 25 milliwatts to the 2N109 with 75 milliwatts, the 2N270 with 250 milliwatts, and a forthcoming output type for automobile radios with 5 watts. Various special types include the 2N206 for military use, a forthcoming semiconductor diode for temperature and voltage compensation, and a forthcoming neon indicator for computers. *The "Application Table" shows the major areas presently covered by RCA commercial transistors.* In addition to the types listed, there are in development variations of these types which differ in minor electrical characteristics or mechanical construction. This brief outline indicates a definite swing from the early types for use in the hearing-aid and entertainment fields to types for industrial, military, and commercial work.

QUALITY AND MASS PRODUCTION

One of the highlights of RCA's contributions is the excellent quality that has been obtained by careful manufacture. This quality is achieved by a consistent program of manufacturing and inspecting transistors to an established specification rather than selecting suitable units from a finished lot. Field returns on RCA junction transistors have been less than one in a thousand, and life tests indicate virtually unlimited life.

PROSPECTS FOR FUTURE

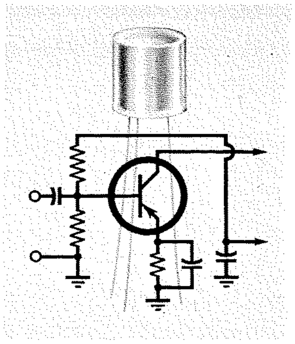
In the future, types for higher frequency will continue to be developed. The range of several hundreds of megacycles will be invaded shortly, and transistors for use at thousands of megacycles will come in the not too distant future. Power outputs of 50 to 100 watts at low frequency are also developmental objectives, as well as a combination of power and frequency capabilities for computer switching and television deflection. The temperature range and reliability of germanium transistors will be improved, and silicon transistors will gradually be developed for high-temperature use. At the same time, new techniques, mechanization, and increased volume of production will lead to a dramatic reduction in cost.



APPLICATION TABLE

Type	Typical Operation	Applications
2N104 2N215*	Low-Power A-F Amplifier	General Purpose A-F
2N105*	Low-Power A-F Amplifier	Hearing Aids
2N109 2N217*	Low-Power Push-Pull Class B A-F Amplifier or Driver, 50 mw dissipation	Portable Radios
2N139 2N218*	I-F Amplifier (455 Kc)	Portable Radios
2N140 2N219*	Converter (1.5 Mc)	Portable Radios
2N175 2N220*	Low-Noise Low-Power A-F Amplifier	Preamplifiers
2N206*	Low-Power A-F Amplifier (Tested for temperature cycling and moisture resistance)	Military
2N247*	R-F Amplifier (1.5 and 10.7 Mc)	All-wave Receivers, Computers
2N269*	Medium-speed Switching	Computers
2N270*	Medium-Power Class A or B A-F Amplifier, 150 mw dissipation	Portable Radios
†	Class A or B A-F Amplifier, 12 watts dissipation	Automobile and Aircraft Radios Industrial Applications

*Flexible-lead type. †Developmental Power Transistor scheduled for early announcement.



TRANSISTOR STABILIZATION BY DIODE BIASING

By

C. F. WHEATLEY, *Application Engineering,*
and R. E. KLEPPINGER, *Design*
Semiconductor Division, Somerville, N. J.

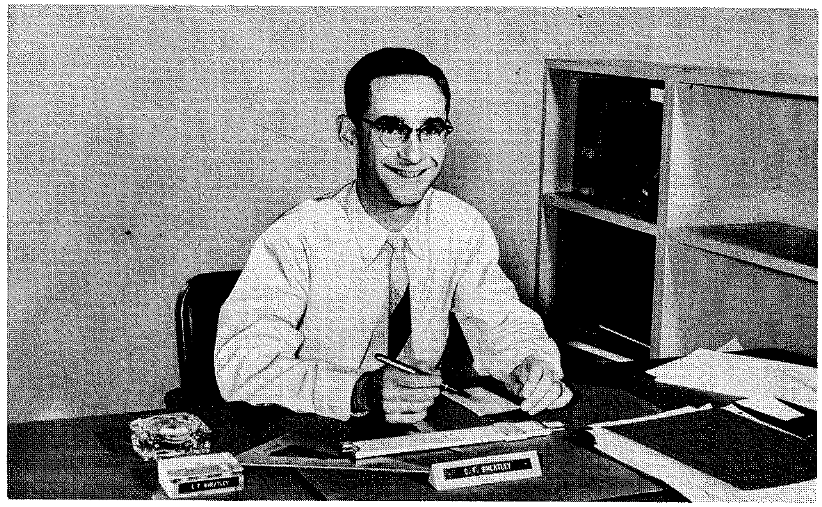
An ideal bias network for a class B transistor circuit must present a low resistance as compared to the input resistance of the transistor. It must also provide a bias voltage that varies with temperature in a prescribed manner but does not change with supply-voltage changes. This paper describes the use of a specially developed semiconductor diode which permits these network requirements to be closely approached. This biasing method, called diode biasing, was previously described by Lin, Barco, and Barton.[1,2]

CLASS B CIRCUIT THEORY

Fig. 1 shows a basic class B circuit without the bias network. Because the transistors conduct current alternately, signal current flowing through the base of the conducting transistor must also flow through the bias supply. The impedance of the bias supply, therefore, should be low as compared to the transistor input impedance to avoid unnecessary loss of signal.

The collector current of a transistor is shown as a function of the base-to-emitter voltage in Fig. 2. When the base-to-emitter, or bias, voltage is equal to zero, the collector current is negligible. A half-sine-wave signal applied to the base produces a rather distorted half-sine wave of collector current. When both halves of the class B circuit are considered, the highly distorted waveform shown at the right of Fig. 2 results. The distortion in this waveform, known as cross-over distortion, is one of the most severe forms of audio distortion with regard to the subjective effect upon the listener.

1. L. E. Barton, "An Experimental Transistor Personal Broadcast Receiver," Proc. I.R.E., Vol. 42, P. 1062, July, 1954.
2. H. C. Lin and A. A. Barco, "Temperature Effects In Circuits Using Junction Transistors," Transistors I, RCA Laboratories, Princeton, N.J., 1956, P. 369.

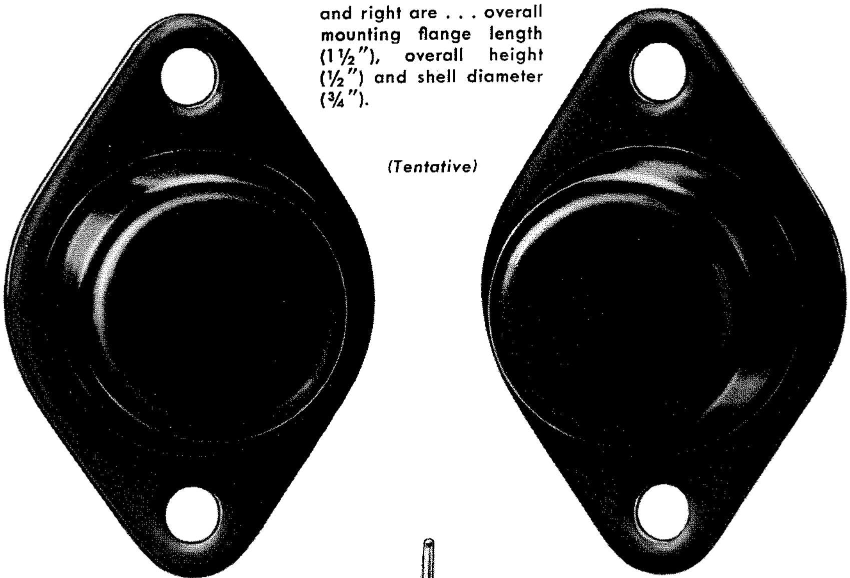


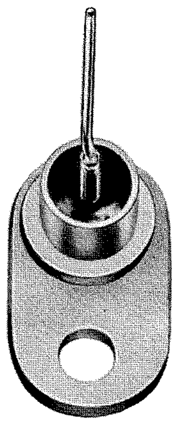
C. FRANK WHEATLEY. After serving for two and one-half years in the Army, he entered the University of Maryland and received the B.S. degree in Electrical Engineering in 1951. The same year, he joined the Tube Division of RCA in Harrison, N. J. as a design and development engineer working on transistors. He served as a production engineer on transistors from 1953 to 1954, and has since been working as an application engineer in the newly organized Semiconductor Division.

ROBERT E. KLEPPINGER received the B.S. degree in Electrical Engineering in 1951 from the University of Nebraska and M.S. degree in 1955 from Stevens Institute of Technology. He joined the RCA Specialized Training Program in 1951 and, after completion of the program, became a member of the Tube Division in Harrison, N. J., working on semiconductor devices as an advanced development engineer. He moved to the newly organized Semiconductor Division in 1955 and became a device design engineer in 1956. Mr. Kleppinger is an associate member of the American Institute of Electrical Engineers and a member of the Institute of Radio Engineers and Pi Mu Epsilon.

Approximate Dimensions of Developmental Power Transistors shown at left and right are . . . overall mounting flange length (1½"), overall height (½") and shell diameter (¾").

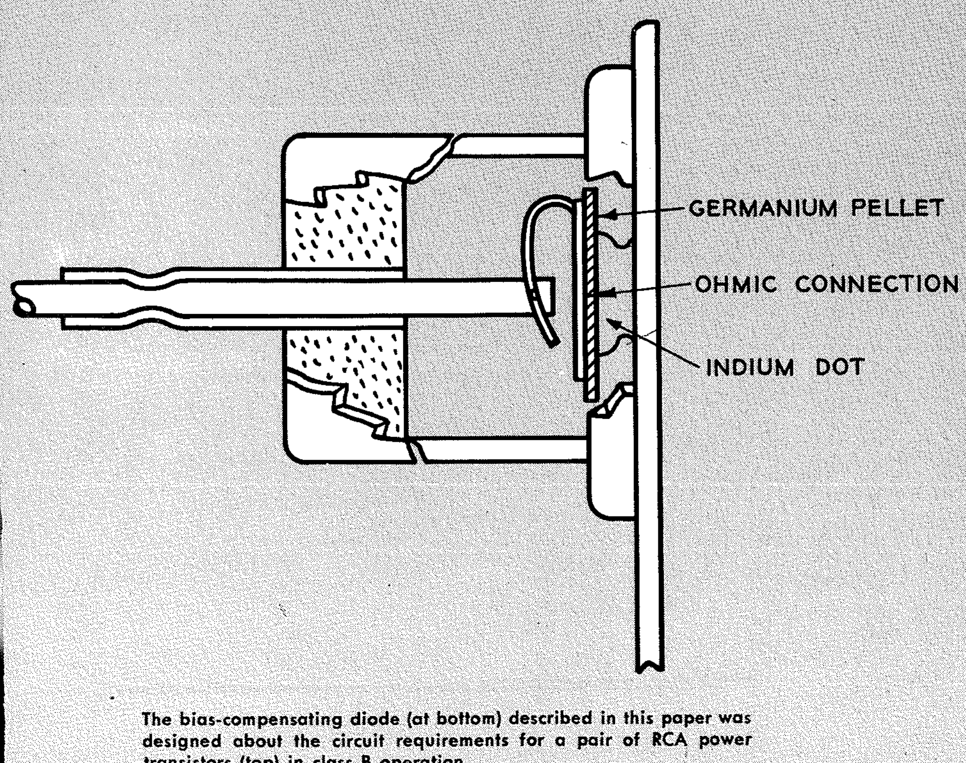
(Tentative)





Approximate Dimensions of Developmental diode above are . . . overall mounting flange length (¾"), overall height not including lead (3/10") and shell diameter (¼").

(Tentative)



The bias-compensating diode (at bottom) described in this paper was designed about the circuit requirements for a pair of RCA power transistors (top) in class B operation.

Although many circuit techniques may be employed to reduce cross-over distortion, the easiest and most effective method is the use of a bias voltage to establish a small zero-signal collector idling current. This idling current permits the conducting portion of the signal to swing over a more linear region of the current-voltage transfer characteristic. As the bias voltage is increased, the cross-over distortion decreases at the expense of an increase in idling current. The bias voltage must be selected to provide acceptable levels of both cross-over distortion and idling current.

When a satisfactory bias voltage has been chosen, the method for introducing it into the circuit must be selected. Fig. 3 shows three bias networks: (a) a conventional resistor bias network, (b) a resistor bias network using a temperature-sensitive resistor such as a thermistor, and (c) a diode biasing network in which the diode conducts in the forward mode. In all three cases, the resistor between the B supply and the bias voltage is large enough so that the rest of the network may be considered to be driven from a d-c current generator having a current equal to the supply voltage divided by the resistor.

EFFECT OF TEMPERATURE VARIATIONS

Fig. 4 shows a transistor transfer characteristic at three different temperatures. The transfer curve moves to the left as the temperature is increased, and to the right as the temperature is decreased. Because the bias voltage produced by a resistor bias network does not vary with temperature, the collector current increases rather rapidly as the temperature is increased, and cross-over distortion becomes quite pronounced at the low temperatures.

The variation of collector current with temperature may be compensated for by the use of a thermistor in the bias network. The thermistor resistance decreases as the temperature increases, so that the bias voltage is reduced and the collector current tends to remain constant. Best tracking over the desired temperature range requires the addition of series and shunt resistance. Because power dissipation within the transistor raises the junction temperature, the thermistor should compensate for internal heating as well as ambient-temperature

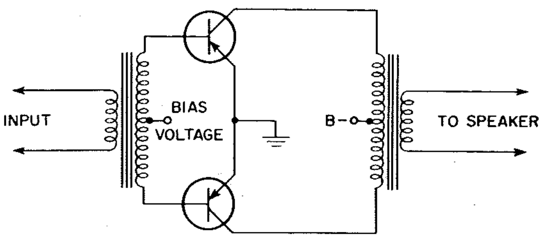


Fig. 1—Basic class B circuit excluding bias network.

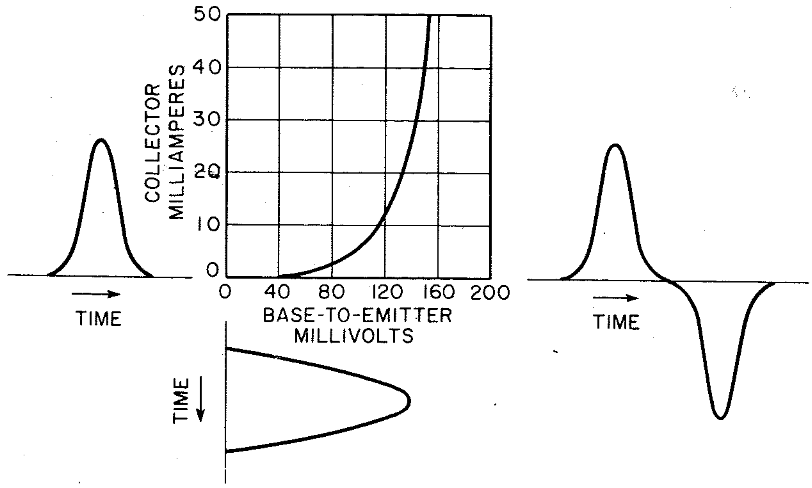


Fig. 2—Collector current as a function of base-to-emitter, or bias, voltage.

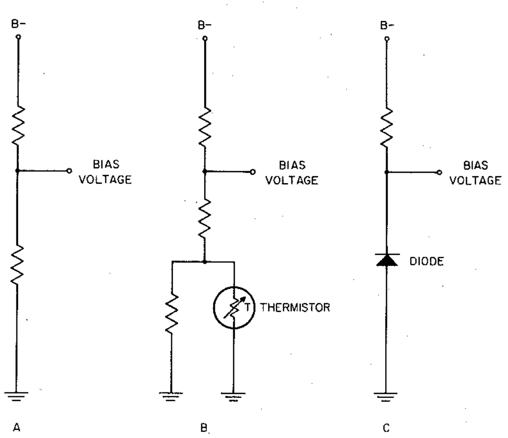


Fig. 3—Three types of bias networks: (a) conventional resistor bias network, (b) resistor bias network using a thermistor, and (c) diode biasing network.

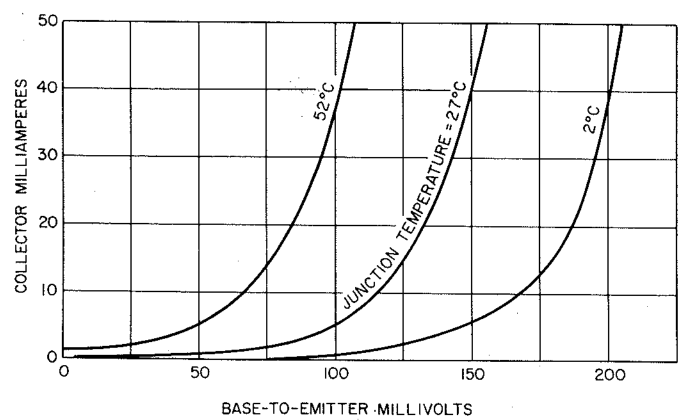


Fig. 4—Transistor transfer characteristic at three different temperatures.

variations. If the thermal resistance of the transistor is low, the thermistor should be closely coupled to the heat-sink temperature rather than the ambient temperature.

EFFECT OF SUPPLY-VOLTAGE VARIATIONS

Supply-voltage variations affect collector current in the same way as temperature variations, and must also be considered. In battery-powered portable equipment, the supply voltage decreases with use; in other applications it may increase or decrease. It can be assumed that the supply voltage decreases 50 per cent in battery-powered portable equipment. Because resistor and thermistor bias networks are simply voltage dividers at a fixed temperature, the bias voltage also decreases 50 per cent. This reduction causes a radical decrease of collector current accompanied by extreme cross-over distortion. Conversely, if the supply voltage increases, the idling current increases considerably.

DIODE BIASING

Excellent stabilization of collector current for variations in both supply voltage and temperature can be obtained by the use of a suitably designed diode operating in the forward direction in place of the resistor or thermistor network. With the diode, supply-voltage stabilization is generally better than that obtained for typical low-power class A circuits, and temperature stabilization is substantially better than that provided by most thermistor bias networks.

The transfer characteristic of a transistor is shown in Fig. 5 above the forward characteristic of a diode. These curves have been somewhat idealized for the sake of simplification. In a typical circuit, the diode is biased in the forward direction by means of a constant-current supply when a fixed supply voltage is used. This operating point is represented on the diode characteristic by the dashed horizontal line. The diode current at this point determines a bias voltage which establishes the transistor idling current. As the temperature is decreased, this bias voltage increases. However, because the transistor transfer characteristic also shifts in the same direction and magnitude, the idling current is essentially independent of temperature.

If the supply voltage changes by 50 per cent, the diode bias current also changes by 50 per cent. The resultant change in bias voltage is small, however, so that the idling current changes in direct proportion to the supply voltage (i.e., by 50 per cent). This change represents about one-fifth of the variation encountered when resistor or thermistor bias is used.

As mentioned previously, the bias network should have low impedance to avoid signal attenuation. The diode, when biased in the forward mode, presents a very low dynamic impedance, appreciably lower than that presented by the resistor or thermistor networks for the same biasing currents. When a signal is applied to the class B amplifier, however, the direction of the current flow through the diode tends to cut it off. The bias-supply impedance can be kept low by the use of a steady-state diode current somewhat greater than the peak signal current anticipated. A note of caution is in order on this subject. The transistor current transfer ratio varies from one transistor to the next and from one temperature to the next. In addition, conventional collector-to-base feedback reduces the effective current transfer ratio. Consequently, the steady-state diode current must be chosen for the peak signal current under the most extreme conditions. Transistors designed for this type of application should have relatively high current transfer ratios, preferably greater than 50 at high current levels. At these values, the diode-current requirements are quite practical.

Fig. 6 shows the collector current as a function of the supply voltage when both are normalized. The dashed line indicates the lack of voltage stabilization encountered when resistor or thermistor bias is used for a typical circuit. This line shows about a 50 per cent change in collector current for a 10 per cent change in supply voltage. The use of diode biasing thus achieves about a 10 to 1 improvement.

Fig. 7 shows the normalized collector current as a function of junction temperature. The dashed curve indicates the extreme instability for a typical circuit employing resistor bias. The solid curve shows the stability of the same circuit when diode biasing is used. A typical thermistor network produces a curve which lies between those for the diode and resistor networks. In the circuit using resistor bias, the room-temperature (25°C) value of collector current is doubled at 35°C. The diode-biased circuit, however, can operate at temperatures to 90°C before the current doubles.

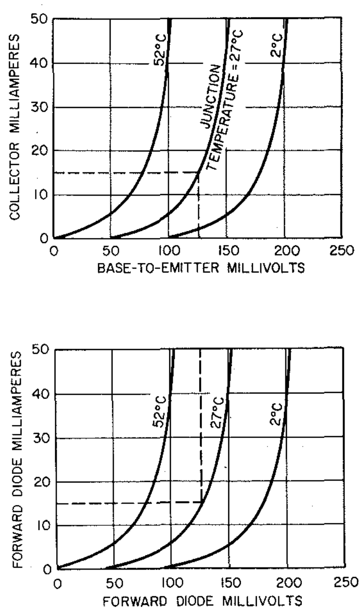


Fig. 5—Transistor transfer characteristic (top) and forward characteristic of diode (bottom). Dashed line indicates typical operating point.

CONCLUSIONS

The use of diode biasing in transistor class B power amplifiers is preferable to other biasing methods on the basis of both performance and economy. Even the use of emitter resistance combined with positive feedback to reduce its regenerative effects is technically and economically inferior to diode biasing. The diode biasing method described represents an almost ideal solution to the problem of maintaining the proper idling current in a class B transistor amplifier under conditions of varying ambient temperature, voltage-supply variation, and temperature effects due to the varying dissipation level.

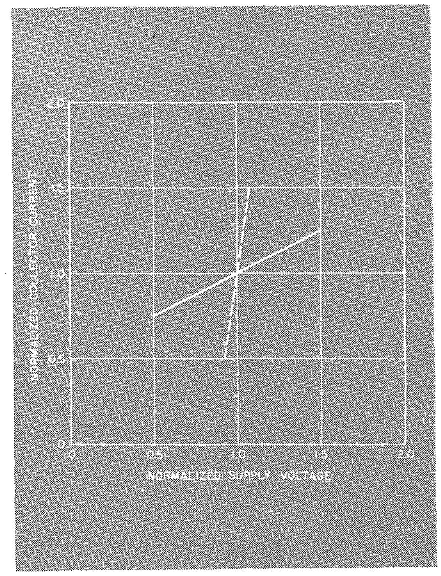


Fig. 6—Normalized collector current as a function of normalized collector supply voltage.

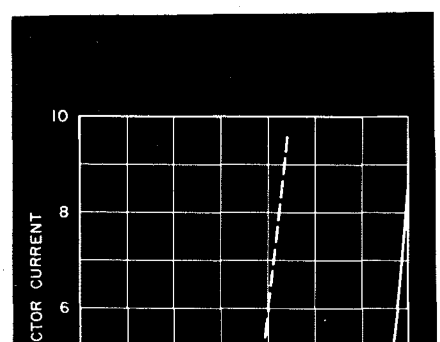
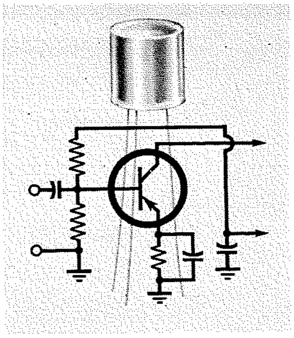


Fig. 7—Normalized collector current as a function of junction temperature.



FACTORS IN THE DESIGN OF A POWER TRANSISTOR

by

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Semiconductor Design

Semiconductor Division, Somerville, N. J.

A POWER TRANSISTOR FOR use in the output stage of an automobile radio receiver should be capable of delivering a useful audio output of approximately 5 watts in class A operation at a "heat-sink" temperature of 55 degrees centigrade with less than 10 per cent harmonic distortion. The collector dissipation of such a transistor is approximately 12 watts for a useful output of 5 watts. This paper describes the design of a new RCA power transistor for such applications which will soon be announced commercially.

DR. ADOLPH BLICHER completed his undergraduate studies in Electrical Engineering at the University of Toulouse, France and his graduate studies in Electrical Communications at Ecole Supérieure d'Electricité in Paris, France. He received his Doctorate degree in Engineering Sciences (Physics) from the Polytechnic Institute of Warsaw.

Dr. Blicher has worked in various fields of physics and electronics such as scientific instrument design, radio receivers and component development, and broadcasting transmitter design.

Prior to joining RCA, he was a senior physicist with Radio Receptor Co. Since 1955, he has been a member of the Design activity of the new Semiconductor Division, now located at Somerville, N. J.

TEMPERATURE CONSIDERATIONS

The operating temperature of a germanium transistor should usually not exceed 85 degrees centigrade. Temperatures above this value may adversely affect vital parameters such as the current transfer ratio and the collector breakdown voltage. It is necessary, therefore, to utilize an efficient method for removing heat which is generated primarily in the collector junction. Although such heat could be dissipated through air convection and radiation by proper dimensioning of cooling fins, the size of such fins would be unacceptable for most applications. Because space is at a premium, even in a car radio, the general trend is toward miniaturization of all electronic equipment.

One practical way of dissipating the generated heat is the use of a thermal connection between the collector and a "heat sink." A radio chassis made of steel or aluminum may serve as a satisfactory heat sink provided the chassis has an adequate area and is sufficiently thick.

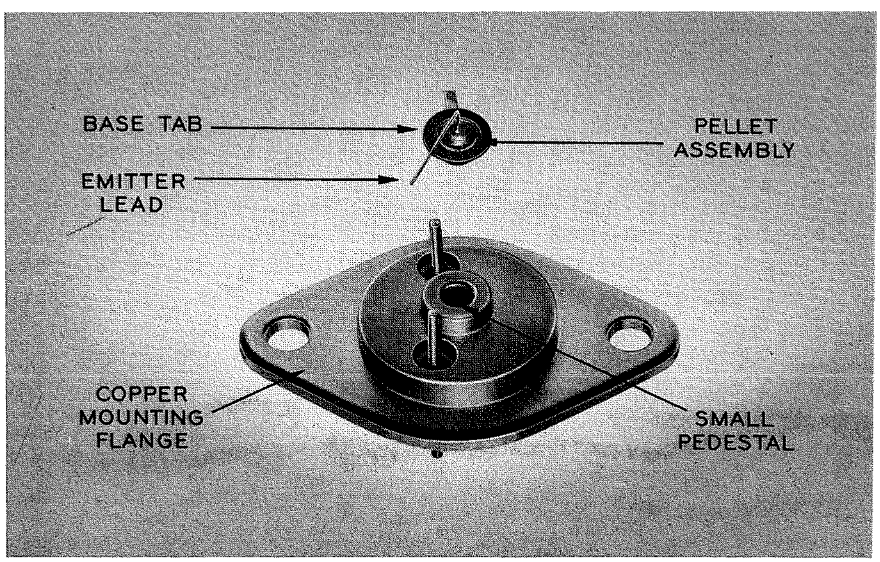
In the new RCA power transistor, the collector is thermally and electrically connected to a copper flange which is used for mounting the transistor. This electrical connection of the collector to ground does not require that the transistor operate only in a common-collector configuration. It is a simple matter to arrange the circuit for common-base or common-emitter ac operation. If some circuits require an electrically insulated collector, a thin mica or anodized-aluminum washer may be placed between the mounting flange and the chassis at the expense of only a relatively small increase in the thermal resistance of the transistor.

The thermal resistance of a transistor is measured by the increase in collector temperature above the temperature of the mounting flange for a power dissipation of 1 watt. A typical value of thermal resistance for the new RCA power transistor is 2.5 degrees centigrade per watt. If a very thin mica insulator is used as described above, this typical value increases by about a few tenths of a degree per watt.

COLLECTOR CONNECTION

In RCA p-n-p alloy-junction transistors, including the new power transistor, indium dots are used for the collectors. The simplest mechanical

Fig. 1—Pellet Assembly and Mounting Flange for new power transistor.



connection between the indium dot and the copper mounting flange would be a direct soldered joint. The presence of a large mass of metal connected to the collector is impractical, however, because the transistors are etched electrochemically after the alloy junctions are made. This etching process removes shunting paths which might degrade static electrical characteristics, and prepares the germanium surface as required for transistor operation.

In the power transistor, therefore, a short, very pure silver stud is soldered to the collector dot. The pellet assembly consisting of the germanium base, the collector and emitter dots, and the collector silver stud is then etched electrolytically. After this etching operation, the pellet assembly is inserted into the copper mounting flange shown in Fig. 1. The silver stud is placed in the hole in the small copper pedestal and swaged into place. The swaging provides a good mechanical, thermal, and electrical connection. When this procedure is used, very low emitter and collector reverse currents and high collector breakdown voltages are achieved. Typical values for the RCA power transistor are collector leakage current of 30 microamperes at — 12 volts and a collector breakdown voltage of 50 volts at 1 milliampere.

CURRENT TRANSFER RATIO

The current transfer ratio of a transistor in a common-base circuit, provided effects of carrier multiplication at the collector junction are neglected, is a product of the emitter efficiency and the transport factor (both of which are smaller than unity).

The transport factor is determined by the recombination of carriers in the base region. Not all of the injected holes in a p-n-p structure reach the collector because some holes recombine with electrons flowing through the base connection. At low current densities, the transport factor is usually dominant in determining current transfer ratio.

The emitter efficiency depends on the relative electrical conductivities of the emitter and base regions. The higher the emitter conductivity as compared to the base conductivity, the higher the emitter efficiency.

JOEL OLLENDORF received the B.M.E. degree from Renssalaer Polytechnic Institute in 1950. After graduation he entered the Navy. He joined the Tube Division of RCA at Harrison, N. J. in 1953 as a transistor design engineer. His work has been principally in the development of medium-, high-, and low-power audio, and high-frequency transistors.

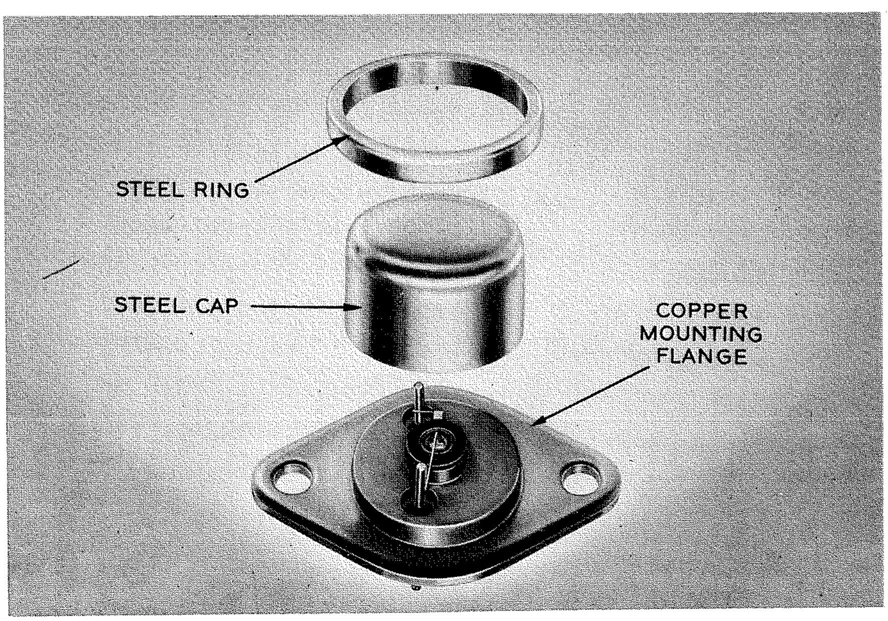
Emitter efficiency also depends on current density[1]. In a power transistor, the current density in the emitter normally varies over a wide range. At times in a p-n-p transistor, the density of the holes injected into the base exceeds that of the donor impurities in the base region. Under such conditions, a large number of electrons enters the base region through the base connection to re-establish electrical charge neutrality. The n-type base region then contains many more electrons than could be predicted from the number of donors present. As a result, the difference between the conductivity of the emitter and that of the base region becomes smaller, and the emitter efficiency decreases.

This problem can be remedied by increasing the emitter area and thereby reducing the current density, or by increasing the emitter conductivity.

The emitter conductivity may be increased by the addition of a small percentage of gallium to the indium emitter dot[1]. Gallium has a segregation coefficient several times higher than that of indium. When gallium is used, therefore, the emitter recrystallized region contains more acceptor atoms than when pure indium alone is used. Consequently, more mobile carriers are available and greater emitter conductivity is achieved.

1 L. D. Armstrong, C. L. Carlson, and M. Bentivegna. "High-Emitter-Efficiency Alloy Materials for P-N-P Junction Transistors." Transistors I, RCA Laboratories, 1956.

Fig. 2—Parts of Hermetic Enclosure.



Comparatively large emitter areas are combined with the use of gallium-indium alloy in the RCA power transistor. The use of these methods results in a large current transfer ratio at high levels of injection, and also in a relatively small change in current transfer ratio. For example, a power transistor having a collector-to-base current transfer ratio of 100 at an emitter current of 0.1 ampere would have a current transfer ratio of 70 at 1 ampere. This change represents a typical drop-off in current transfer ratio of only 30 per cent between 0.1 ampere and 1 ampere.

ISRAEL H. KALISH received the B.E.E. degree from the Cooper Union School of Engineering in June, 1953 and the M.S. degree in Electrical Engineering from Columbia University in June, 1956. He joined the Tube Division of RCA in Harrison, N. J. in 1953 as a design engineer on semiconductor devices. He has contributed to the design of a general-purpose transistor for the Signal Corps, Class A and Class B power transistors, and drift transistors. He is currently working on the development of a drift transistor for use at frequencies up to 50 megacycles. Since 1954 Mr. Kalish has been an Adjunct Instructor in Physics at the Cooper Union School of Engineering.

GERMANIUM RESISTIVITY

Although the use of high-resistivity germanium is desirable to achieve high breakdown voltages, low resistivity is necessary to obtain a low value for the resistance, $r_{bb'}$. This resistance $r_{bb'}$ may be considered as the resistance of the germanium path between the base connection and the active base region, as defined in the hybrid π equivalent circuit[2]. Because resistance $r_{bb'}$ is in series with the input, it should be kept as low as possible to conserve power. In a practical transistor, a satisfactory balance must be reached between the conflicting requirements for high breakdown voltages and low $r_{bb'}$.

The value of $r_{bb'}$ is determined not only by the resistivity of the base region, but also by several geometrical factors. For a minimum $r_{bb'}$, the diameters of the emitter and collector should be equal. In the new power transistor, however, the emitter diameter is slightly smaller than the collector diameter to avoid alignment problems. Other geometrical factors are optimized by the addition of a ring-type tab around the emitter and by the use of as large a base region (distance between the emitter and collector junctions) as consistent with other electrical parameters. A typical value of $r_{bb'}$ for the RCA power transistor is 20 ohms.

[2] L. J. Giacoletto. "Study of P-N-P alloy—Junction Transistor from D.C. Through Medium Frequencies." RCA Review, December, 1954.

HERMETIC ENCLOSURE

Even when germanium surfaces are properly treated, they are extremely sensitive to all kinds of impurities, particularly moisture. A p-n-p alloyed transistor must be very dry because the presence of moisture on the germanium surface affects the static characteristics. The transistor must therefore be placed in a hermetic enclosure, i.e., one which cannot be permeated by moisture.

Such an enclosure, having the additional feature of low thermal resistance, was developed by D. Pearson and J. Shellick. The mounting flange of this enclosure, which is all copper, is shown in figure 2. A steel cap fits snugly around the periphery of a pedestal on this flange. A steel ring is then forced down over the cap under very high pressure, squeezing the steel cap and the pedestal of the copper mounting flange together. Because both cap and flange are pre-tinned, an excellent hermetic seal is formed when the steel ring is forced into position.

This cold-seal method is used to avoid the application of external heat which could damage the transistor. Furthermore, no impurities are introduced in the process, such as fluxes or decomposition gases which are present in hot soldering, welding, or heliarc welding.

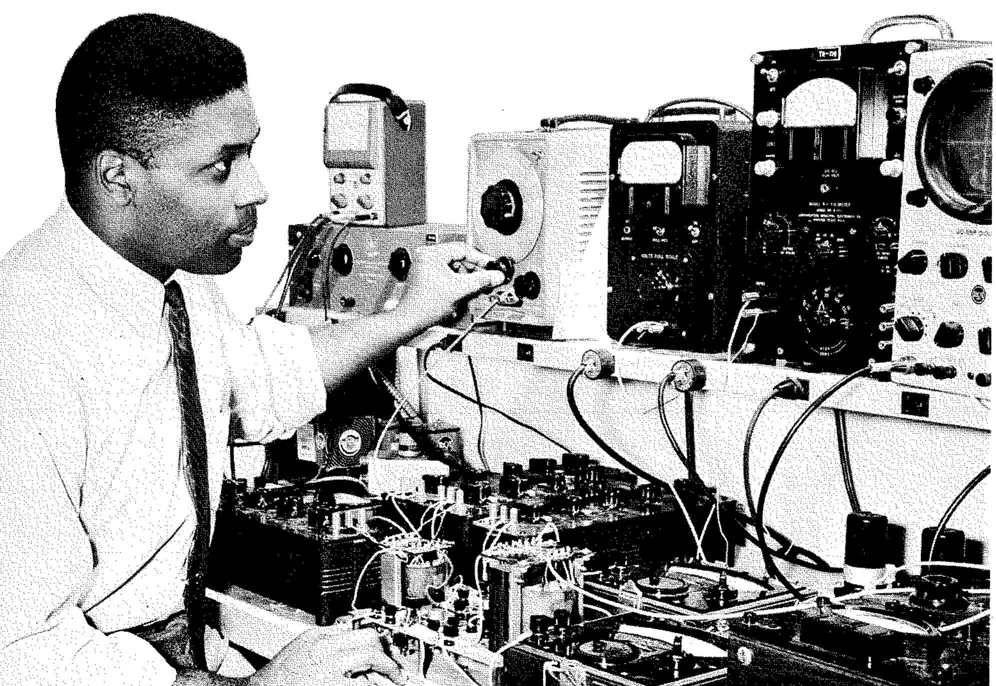
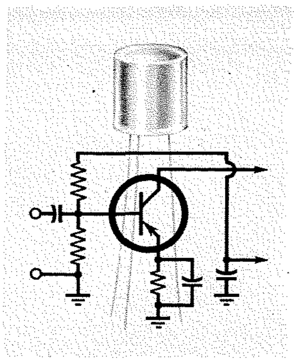


Fig. 3—Robert Minton, semiconductor engineer, is shown in the laboratory during the course of measurement work.



HEAT TRANSFER IN POWER TRANSISTORS IN TV DEFLECTION CIRCUITS

by

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THE PARTICULAR CONDITIONS of heat transfer in power transistors are rather involved and specialized and are such that applications of generalized laws of heat transfer may lead to erroneous deductions. A recognized authority[1] makes the following statement:

> "In the majority of cases of transference of heat all three modes of transference are simultaneously operative in a greater or lesser degree, and the combined effect is generally of great complexity. The different modes of transference are subject to widely different laws, and the difficulty of disentangling their effects and subjecting them to calculation is often one of the most serious obstacles in experimental investigation of heat"...

Only when the specific conditions are ascertained and unknown variable parameters experimentally determined, can the whole mechanism of heat transfer in the case under consideration be evaluated. The importance of such an evaluation cannot be exaggerated since one of the main limitations of power transistors is the maximum operating temperature of their junctions.

STATEMENT OF THE PROBLEM

It has been found that the thermal time constant of power transistors presently available is of the order of .1 sec. This removes the instantaneous power and instantaneous heat as a possible limitation of the energy delivered by power transistors in most practical applications such as TV deflection and audio circuits.

With the time element removed the problem is simplified and reduced to the case of steady state and average power. The thermal circuit may be represented as shown in Fig. 1A.

The temperature gradients may be represented as shown in Fig. 1B.

The thermal problems in operating a power transistor in the range 25 to 85°C and in thermal equilibrium are: *first,* to determine junction temperature (point "d") under operating conditions of power dissipation (from measurable values at points "a," "b," and "c" of Fig. 1B and some indirectly measured physical characteristics); and *second,* with the aid of these measurable physical characteristics of a given transistor, to determine the maximum power that it can dissipate in a given environment, in other words to give a unit a rating for a particular mode of operation.

It appears that the operating junction temperature should not exceed 85°C. The basis for this statement is the available results of a life test on power transistors in which a large number of germanium p-n-p units have been operating at 85°C for over 4000 hours without one failure. Some manufacturers specify 90°C (and some venture 100°C) as the maximum junction temperature. While there is a reason to believe that 85° is rather conservative and 90°C as a maximum junction temperature is probably safe, there are no trustworthy life test data available for the latter value.

APPLICABLE LAWS OF HEAT TRANSFER

In a transistorized deflection circuit operating at a temperature higher than that of the ambient of the still air all three principle modes of heat transfer take place as is shown in Figs. 1A and 1B. Heat is generated at the transistor junctions and is transferred by conduction to the surface of the case, then again by conduction it is transferred to surface of the chassis or some other cooling fin or fins[2]. Finally it is transferred to the free still air (the ultimate heat sink) by a combination of convection through so-called "air convection film" and radiation.

The three applicable laws of heat transfer are those of conduction, convection, and radiation. Evaporation

[1] H. L. Callendar, Prof. of Physics, Imp. College of Science, London. Article on "Heat" Enc. Brit. 1941.

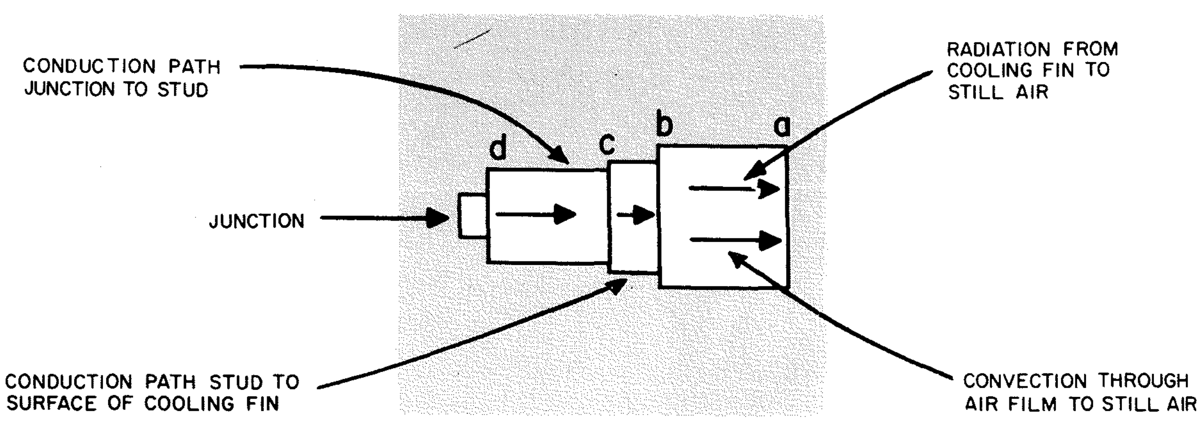


Fig. 1A—The thermal circuit of a power transistor.

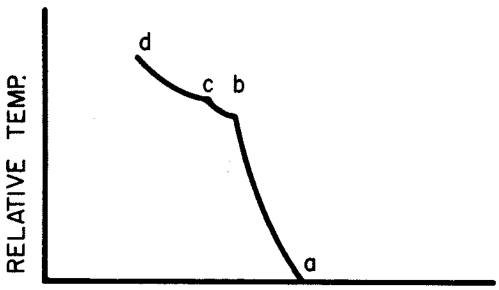


Fig. 1B—The relative temperature gradients from point to point through the circuit in Fig. 1A.

and condensation involving mass transfer, combined with heat transfer and generally classified under convection, do not enter into the problem.

The basic law of heat flow by *conduction* in the steady state is analogous to the Ohms Law:

$$q = \frac{\Delta T}{\frac{L}{kA}} \qquad (1)$$

when q is the rate of heat transfer,

- k is thermal conductivity of the material,
- A is cross-sectional area of the heat conductor,
- L is length of heat path,
- ΔT is temperature difference causing the heat to flow,

where q is analogous to electrical current, ΔT to potential difference,

and $\frac{L}{kA}$ to electrical resistance.

The basic law of heat *convection* is

$$q = \frac{\Delta T}{\frac{1}{h_c A}} \qquad (2)$$

where q is the rate of heat transfer,

- h_c is a coefficient of heat transfer by convection,
- A is the surface area exposed to convection,
- ΔT is the temperature difference between the surface exposed and the free still air (ambient).

Here $\frac{1}{h_c A}$ corresponds to resistance in the analogous electrical circuit. In convection a mass of cool and presumably still air surrounds a heated surface. At the surface there forms a relatively thin film of air varying in velocity from zero at the surface to a maximum and then again to zero (with absence of forced ventilation).

The basic equation for heat transfer by *radiation* between two non-black bodies is

$$q = F_e F_a A \, \sigma \, (T_1^4 - T_2^4) \qquad (3)$$

where q is the rate of heat transfer,

- F_e is the emissivity factor allowing for departure from black body conditions,
- F_a is a configuration factor based chiefly upon the geometry of the system,
- A is the surface of the emitting area,
- σ is a natural constant (constant of total black radiation),
- T_1 is the absolute temperature in °Kelvin of the radiating body,
- T_2 is the absolute temperature in °Kelvin of the receiving body.

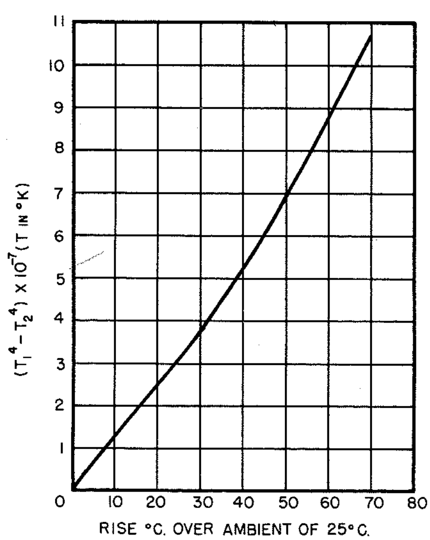


Fig. 2—Heat transfer by radiation over the range of temperature rises normally encountered.

In this equation $\frac{1}{F_e F_a A \sigma}$ corresponds to resistance in the analogous electrical circuit. The term in the parenthesis is analogous to voltage. For the range of the temperature rises encountered it is nearly a linear function of the rise in spite of the fourth power of temperatures involved since it is reckoned with respect to absolute zero. This is shown in Fig. 2.

THE MECHANISM OF HEAT TRANSFER IN POWER TRANSISTORS

The steady-state heat flow or heat transfer in power transistors may be represented by the analogous electrical circuit consisting of (1) the constant current generator equivalent to a steady supply of heat and (2) a purely resistive network since in steady state the reactive elements have constant amounts of energy stored in them and play no part in the flow. The equivalent circuit in the case of a transistor, mounted on a chassis or equipped with some other suitable cooling fin, surrounded by still air at room temperature, is relatively simple and is shown in Fig. 3.

Here R_1 is the thermal resistance causing a temperature drop between the junction and the transistor casing (heat transfer by conduction); R_2 is the thermal resistance causing a temperature drop between the casing and a place on the surface of the cooling fin from which a further transfer of heat to air takes place[3]; R_c and R_r are the thermal resistances corresponding to heat transfer from the cooling fins to the ultimate sink by means of convection and radiation respectively.

Numerical data taken from the BuShips'[4] publications gives some concept of the relative magnitude of various heat transfer processes as is shown in Table I.

[2] Lately the cooling fins have been loosely called "heat sinks." The latter term is somewhat ambiguous and its use will be avoided in this report except as "the ultimate heat sink." In general the ultimate heat sink is the earth's atmosphere or the earth itself. In our case the ultimate sink is the free air surrounding the device and unaffected by the heat dissipated by the device. The heat is not sinking in the cooling fins. It is merely conducted by them to their surfaces to be transferred by convection and radiation to the ultimate sink. Recent Army and Navy publications indicate preference for the interpretation of "heat sink" as used in this report.

[3] For copper and aluminum of limited dimensions this resistance is very small as will be shown later.

[4] A recently issued report, NavShips 900, 180 "Survey Report of State of the Art of Heat Transfer in Miniaturized Electronic Equipment" contains some very useful experimental data directly applicable to the case on hand. A summary of the data has been published in BuShips Journal (February 1956).

It may be recalled that equation (2) indicated that in Item 4 of the table only the difference in temperatures determines the rate of heat transfer; while equation (3) indicates that in Item 5 of the table, the absolute (°K) temperatures enter in the picture and that radiation becomes an important factor in the final stage of heat transfer to the ultimate heat sink. Table II gives heat conductivities, densities, and comparison on the weight basis of various materials likely to be used as material for fins or chassis.

The tables also indicate that heat transfer through copper is higher by several orders of magnitude than other means of heat transfer; therefore, the temperature drop along a cooling fin of limited dimensions (such as single copper plate 5 x 5 x $^1/_{16}$ inches) is small enough to be neglected.[5]

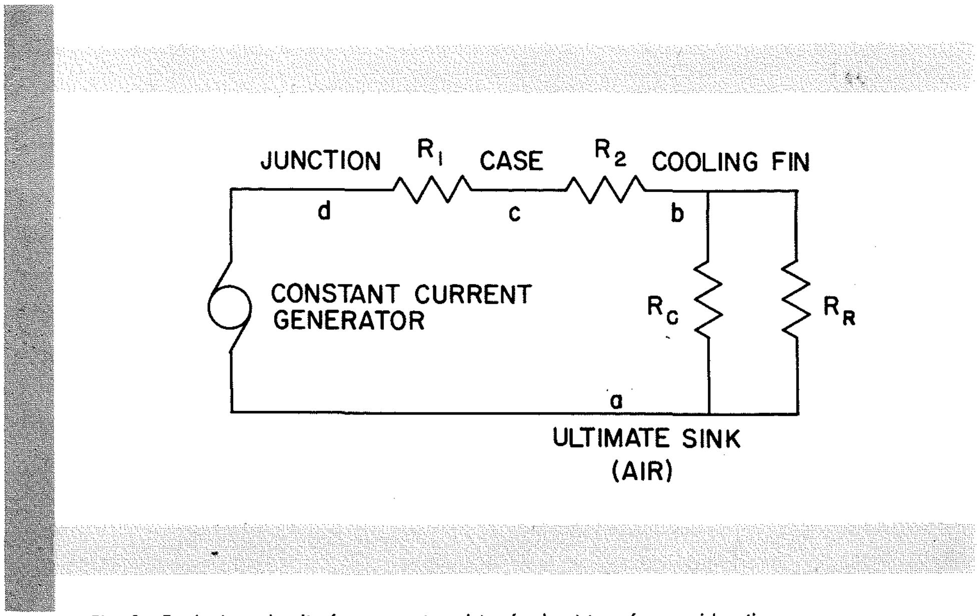


Fig. 3—Equivalent circuit of a power transistor for heat transfer considerations.

TABLE I

Mode of Heat Transfer	Magnitude of Heat Transfer in Watts per Sq. In. per °C
1. Conduction through copper 0.1 inch thick	95.2
2. Conduction through pyrex glass 0.1 inch thick	0.322
3. Conduction through cork board 0.1 inch thick	0.011
4. Free convection from 6 inch high vertical plate at 120°C, air at 80°C	0.00348
5. Radiation between two black bodies at 100°C and 50°C	0.0063

TABLE II

HEAT CONDUCTION DATA FOR VARIOUS MATERIALS AT APPROXIMATELY 65°C*

Material	Density lbs./cu. in.	Heat Conductivity K Watts/sq. in./°C/in.	Comparison with Soft Steel on Weight Basis**
Silver	0.380	10.6	6.7
Copper	0.322	9.7	7.25
Beryllia***	0.09 approx.	5.6 approx.	15.0
Aluminum	0.098	5.5	13.6
Magnesium	0.063	4.0	15.2
Yellow Brass	0.316	2.4	1.83
Pure Iron	0.284	1.3	1.11
Soft Steel	0.284	1.18	1
Mica	0.101	0.015	0.036
Paper Base Phenolic	0.0497	0.007	0.036
Polystyrene	0.038	0.0027	0.017

* Computed from data published in NavShips 900, 190 (unclassified).

** Computed as:

$$\frac{k\text{ (material)}}{k\text{ (soft steel)}} \times \frac{\text{Density (soft steel)}}{\text{Density (material)}} = \frac{k\text{ (material)}}{\text{Density (material)}} \times 0.241$$

*** Beryllium Oxide ceramic insulating material of high thermal conductivity. Relatively new.

The analogous electrical circuit shown in Fig. 3 reduces to that shown in Fig. 4.

The nature of R_1 is entirely due to the mode of heat transfer by conductance and is therefore a simple physical constant of the particular transistor.

It is often denoted as R_{TH} of a transistor or the thermal resistance from the transistor junctions to its casing. It is conveniently expressed in °C per watt dissipated at the junction and transferred to the case. *R_{TH} is a physical constant of a particular transistor and is independent of the type of the cooling fin.*[6]

Reliable experimental methods of determining R_{TH} with good accuracy have been published. Briefly it consists of two steps. The first step is that of determination of I_{co}, the collector to base current with emitter open, as a function of temperature. This is done in an oven, where the temperature is raised in steps and the oven allowed to reach a thermal equilibrium. The second step is essentially that of applying a known power to the junctions

[5] In cases of large thin chassis of relatively high thermal resistance the equivalent electrical network involves additional resistive components. While being somewhat more complicated these cases may be analyzed by the general methods described.

[6] Like many other constants such as electrical resistance, the thermal resistance varies somewhat with temperature. The thermal conductivity of copper drops 2½% for temperature change from 0 to 100°C. For iron it drops 5% for the same change, while aluminum stays the same for the interval.

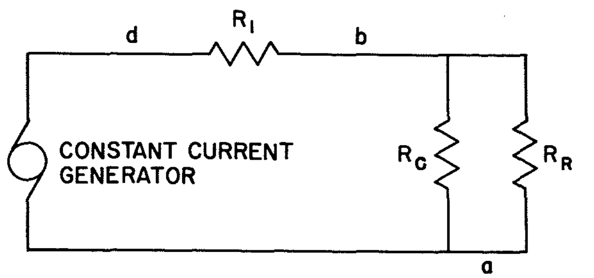


Fig. 4—Simplified heat transfer equivalent circuit for power transistors.

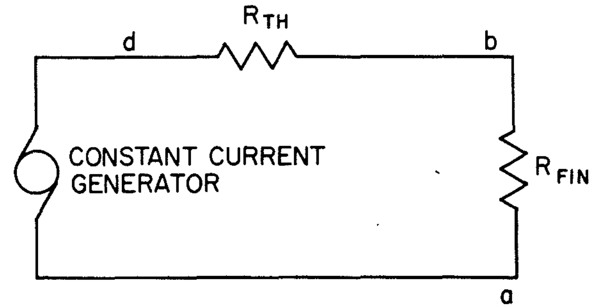


Fig. 5—Further simplification of equivalent circuit shown in Fig. 4.

from a d-c source, bringing the unit to a thermal equilibrium and quickly switching the power off and observing I_{co}.

The reciprocal of R_{TH} is the rate of heat transfer between the junctions and the casing of a particular transistor. It is conveniently expressed in watts per °C.

The nature of R_c and R_r in Fig. 4 is due to two combined modes of heat transfer from the cooling fin to the ultimate sink; namely, that of convection and that of radiation. They depend on the geometry and condition of the fin surfaces and particular surroundings; such as, still air, draft due to heat in adjoining apparatus, radiation from adjoining apparatus, etc. These two thermal resistances are rather difficult to disentangle, but their combined value for any particular case can be measured with comparative ease. In the equivalent circuit then they are replaced by one thermal resistance R_{FIN} or R_F.

The equivalent circuit is further simplified to that shown in Fig. 5. R_{TH} is the thermal resistance of the transistor, and it is uncontrollable after the transistor is made. It is under the control of the designer of the transistor and should be kept as low as possible without impairing other properties of the unit. The value of R_{TH} in a power transistor should be about ½°C or less per watt for satisfactory operation.

R_F, however, is very much under the control of the designer of the equipment since he can specify the fin and also control the surroundings to some extent. For a fin in given surroundings R_F is independent of the properties of the transistor; i.e., it will be the same for a given fin no matter what type transistor is used and what R_{TH} the latter may have.

EXPERIMENTAL DATA

As has been already stated, the thermal resistance R_{TH} of a particular transistor or transistor type is readily measured by the methods described in literature. The equipment designer has no way of influencing its value; the fin-to-the-final-sink resistance R_F; however is, within limits, under his control.

A rather large number of experimental heat runs have been taken on various transistors with various cooling fins and in various surroundings. The mechanism of heat transfer as described in the preceding section and conclusions formulated in the section following this are based on the experimental investigation described below.

To give an illustrative example several more heat runs were made. Two experimental power transistors were chosen—greatly differing in their mechanical and thermal properties. Unit 1 has a comparatively large area of contact to the fin (.75 sq. inches) and low R_{TH} of the order of .5°C per watt; unit 2 on the other hand has fin contact of only .19 sq. in. and R_{TH} of about 2°C per watt. The copper cooling fin chosen was of reasonable size, 5 x 5 x $^1/_{16}$ inches; and its surface was as received from the shop smooth but somewhat tarnished. Later it was given various surface finishes.

The temperature drop from the center of the fin and extreme edge was never more than 2°C. The temperatures given below were measured by a copper constantan thermo-couple attached with putty to the transistor casing. A small negative bias was applied to the base, and a larger negative voltage was applied to the collector. d-c voltage and current were measured at the terminals of the transistor. Transistor-to-fin-thermal contact was assured by application of heavy silicone oil.

The results of heat runs are shown by curves in Fig. 6A and B. These curves substantiate the statement previously made that the thermal resistance between the cooling fin is a constant unaffected by the type of transistor used. More important, however, these curves show that radiation plays a very important role and cannot be neglected. The relative magnitudes shown in Table I substantiate the above statement. Dull black paint reduces R_{FIN} and increases the heat transfer or removal by some 25% when compared with shiny but tarnished surface. Units for heat transfer in Fig. 6B are the same as in Table I.[7]

When compared in the same environment, the different finishes of the same copper fin 5 x 5 x 1/16 inches and dissipating the same number of watts gave the following values of temperature rises:

Mirror polish	100%
Coarse wire wheel finish shiny	90%
Tarnished, unpainted	87%
Dull gray	70%
Dull black	65%

CONCLUSIONS

Junction temperature and thermal ratings for power transistors are determined as follows:

With a known power dissipated in the transistor the temperature on its junctions is the temperature of the casing plus the product of R_{TH} and watts dissipated. With a fin of known thermal properties in given surroundings the watts dissipated may be found from a curve such as is shown in Fig. 6B. The temperature of the junctions is the product of watts dissipated and R_{TH} plus the temperature of the casing.

The maximum power dissipation rating for a given transistor with a given cooling fin in known surroundings is arrived at in the following way:

First, suppose that the casing of the unit is kept at ambient temperature by forced air or liquid cooling, then maximum permissible dissipation will be 85° less an ambient of, say, 26.5, this difference divided by R_{TH} of the unit. In the case of unit 1 the maximum power the unit can dissipate is

$$\frac{85 - 26.5}{.5} = \frac{58.5}{.5} = 117 \text{ watts}$$

With the ambient at 85°C the unit may not dissipate any power lest the safe junction temperature be exceeded.

With normal ambient say at 26.5°C and no forced cooling with rises above 20°C the R_{FIN} is nearly constant or may be taken from the curves in Fig. 6A. The value of the resistance R_{TH} is either supplied by the manufacturer or measured. The following relations hold:

$$W_{Max} \times R_{TH} + W_{Max} R_{FIN} = T_{jMax} - T_A$$

$$W_{Max} = \frac{T_{jMax} - T_A}{R_{TH} + R_{FIN}} \quad (4)$$

where W_{Max} is the maximum allowable dissipation,

T_{jMax} is the maximum allowable junction temperature, at present 85°C,

T_A is the ambient temperature.

For unit 1, with the fin used and painted dull black and the ambient of 26.5°C

$$W_{Max} = \frac{58.5}{.5 + 2.5} = 19.5 \text{ watts}$$

while for unit 2

$$W_{Max} = \frac{58.5}{2 + 2.5} = 13 \text{ watts}$$

The corresponding temperatures of the casing under conditions stated are

for unit 1—75°C
and unit 2—59°C

Another conclusion follows that the curves in Fig. 6 indicate the often overlooked and neglected importance of the radiation in the whole mechanism of heat transfer taking place. A definite need for surface finish of the cooling fins, dull and preferably black, is indicated by these curves.

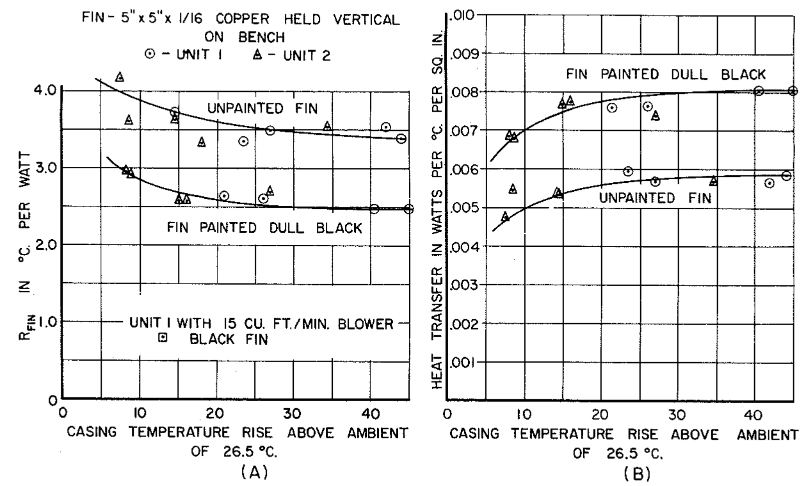


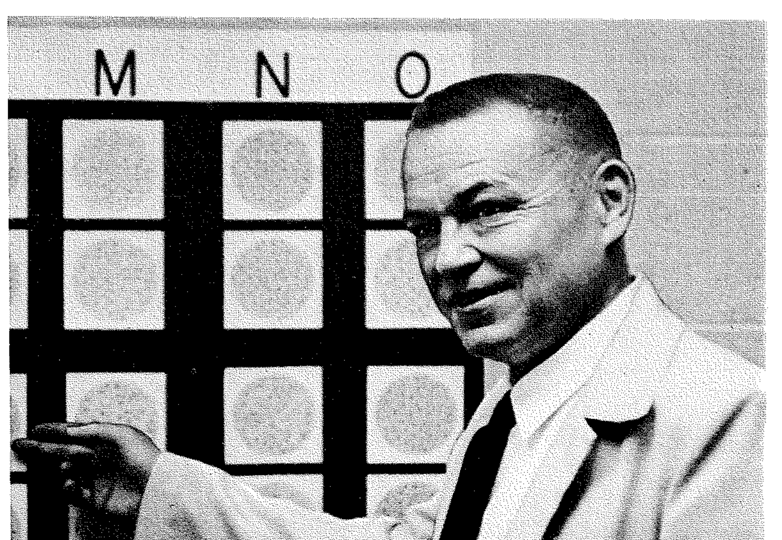
Fig. 6—Results of heat ions on two experimental power transistors.

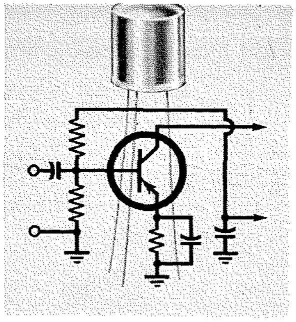
[7] This "hybrid" system of units using the watt, the degree C and the inch is the one used by the Armed Services in dealing with "electronic" heat transfer.

IOURY G. MALOFF was born in Vladivostok, Russia, and received his engineering training in the navy before coming to the U.S. He continued his studies at Union College and Columbia University. Mr. Maloff has recently completed 25 years with RCA. Before coming to RCA he was chief engineer of Colonial Radio Corp.

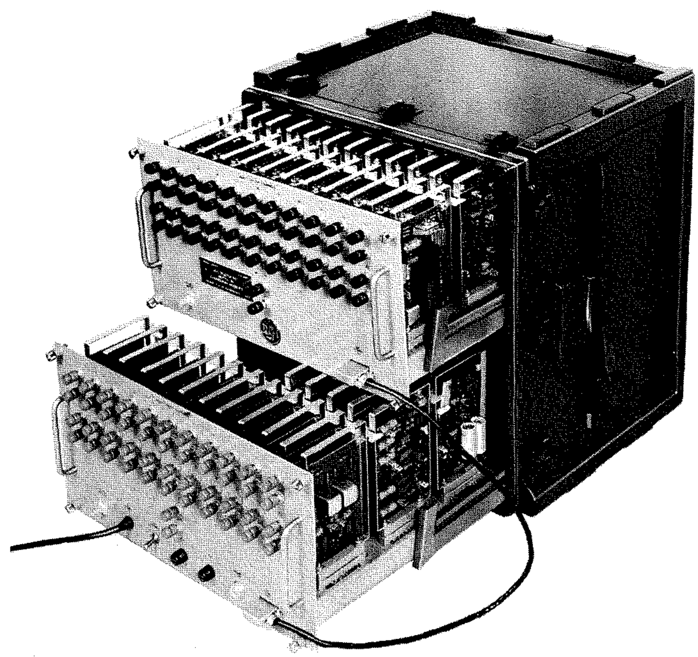
Mr. Maloff's fields of work at RCA have been magnetics, transformers, loudspeakers, optics and electron optics, and at present, power transistors. He has been awarded 16 U.S. Patents.

Mr. Maloff is a Fellow of the IRE.





COMMUNICATION CIRCUITS USING GERMANIUM TRANSISTORS



ROBERT E. WILSON
Special System and Development
Defense Electronic Products
Camden, N. J.

IN ADDITION TO providing a reduction in equipment size, weight, and power consumption, the germanium transistor has led to a substantial improvement in equipment reliability. The consequence of this has been to widen the scope of practical solutions to many engineering problems.

This paper describes several circuits used in a communication system and discusses some of the associated design problems. To provide an understanding of the circuit requirements, we will describe briefly the Time-Division Multiplex System for which these circuits were developed.

Two experimental terminal equipments for 23- and 46-channel telephone multiplex operation were developed for the Signal Corps. Fig. 1 shows two such Time-Division Multiplex terminal equipments connected by a radio link. Each terminal equipment consists of a multiplexer which converts 23 telephone input signals into one time-division signal which is fed to the radio transmitter, and a demultiplexer which converts the time division signal from a radio receiver into 23 telephone output signals.

The 23-channel multiplex signal is shown in Fig. 2a. Each of the 23 input channels is sampled at an 8 kc rate, providing a train of 23 PPM* pulses every 125 microseconds. A 24th channel is required for the synchronizing signal, which consists of two pulses spaced 1½ microseconds apart. The average multiplex pulse frequency is 192 kc, providing a 5.2 microsecond channel interval. Two 23-channel systems must be capable of being combined for 46-channel operation by delaying and inverting the polarity of one output, and mixing the two signals to provide a video signal as shown in Fig. 2b. This 46-channel operation provides a very stringent timing requirement on the system. To prevent excessive crosstalk between adjacent channels, a timing accuracy of ±0.2 microsecond is required.

The equipment must operate over a temperature range of —29° to 55°C with 95% humidity. The germanium transistor operates well over this temperature range. Their lower impedance and higher current gains allow faster circuit operation than could be obtained with a similar number of silicon transistors.

In order to achieve this timing accuracy without the use of manual adjustments, digital computer techniques have been introduced. The construction techniques used lend themselves well to automatic production methods, and therefore will lead to a low production cost.

COMMUTATOR

The portion of the multiplexer which successively gates the audio input signals into the modulators may be termed a commutator. A similar de-

*Pulse Position Modulation

Fig. 1—Time-division multiplex system

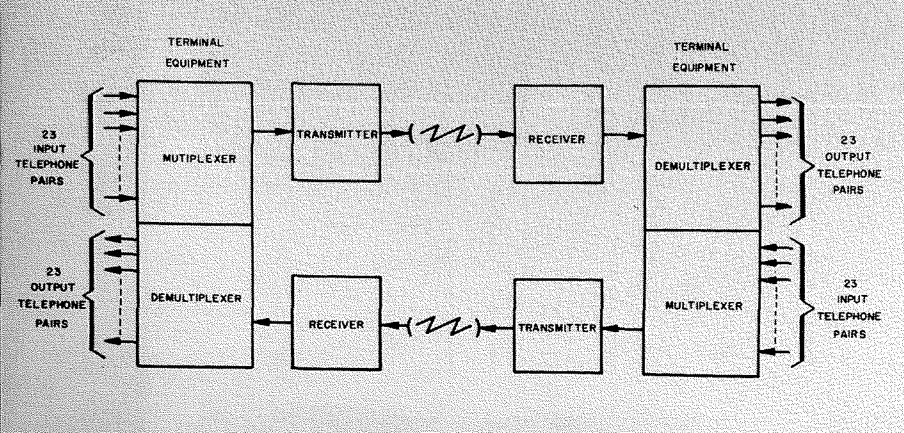
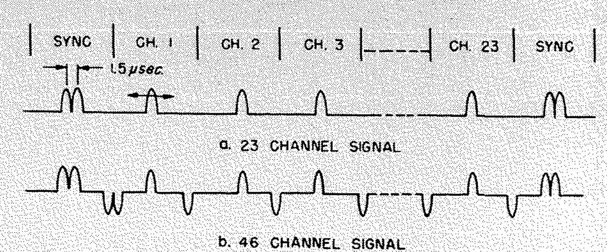


Fig. 2—Time-division signals



vice is required in the demultiplexer to gate the successive pulses into the corresponding channel demodulators. Prior to the introduction of transistors, a multitap delay line was commonly used for the commutator. This type of system depends upon maintaining essentially equal delays in the multiplexer and demultiplexer, a problem which increases with the number of channels. Frequently individual timing adjustments have been provided in each channel to correct for errors caused by original manufacturing tolerances and by component drift.

A system which prevents the accumulation of errors with increased spacing between sync pulse and channel interval will be described. This system uses an oscillator operating at a frequency equal to the product of the sampling frequency and the number of channels (counting one for sync). Counters driven from the oscillator drive matrices which generate the required commutating waveforms. Several possible circuit configurations exist.

The most direct method is to use a four-dimensional matrix as shown in Fig. 3. The four-dimensional matrix consists essentially of 24 4-input "and" gates, each having an input from each of four counters. Although this system looks very simple, it has the following disadvantages: Ninety-six (96) diodes are required, since substitution of resistors would give poor discrimination with "and" gates having so many inputs. An even more important consideration in this multiplexer application is the large number of interconnections between channels, which may lead to interchannel cross-talk.

A more desirable approach, shown in Fig. 4, uses cascaded two-dimensional matrices. The counters are used to drive two smaller two-dimensional matrices, providing selection of one-out-of-four, and one-out-of-six outputs. These two groups of outputs are then applied to a 4 by 6 matrix to provide the 24-channel connections. Fewer diodes are used in the three two-dimensional matrices shown here than in the four-dimensional matrices shown in Fig. 3. The added delay caused by going through an additional matrix in cascade has been made small enough to prevent difficulty.

The purpose of this commutator circuit is to provide accurately positioned gating pulses, and therefore extraneous circuit delays must be avoided. The ripple-carry delay which would result from operating each counter stage from the output of the previous stage as shown in Fig. 3 would be excessive. This delay is avoided by using the carry gates shown in Fig. 4. (Note: this difference in the counter arrangements is not fundamental to the types of matrix illustrated.) These gates pass a trigger pulse if previously primed by the flip-flop. The circuit diagram, Fig. 5, shows the trigger pulse input applied to the transistor emitter, and the output taken from the collector. The control signal is fed to the base, where an R-C circuit prevents a change in the state of the flip-flop from immediately affecting the pulse transmitted by the gate. The use of this high-speed carry technique reduces the delay per stage from about 0.2 microsecond to less than 0.05 microsecond, and is the feature which makes this type of counter approach feasible.

The primary matrix circuit is shown in Fig. 6. This circuit is essentially a

Fig. 4—Cascaded two-dimensional matrix commutator

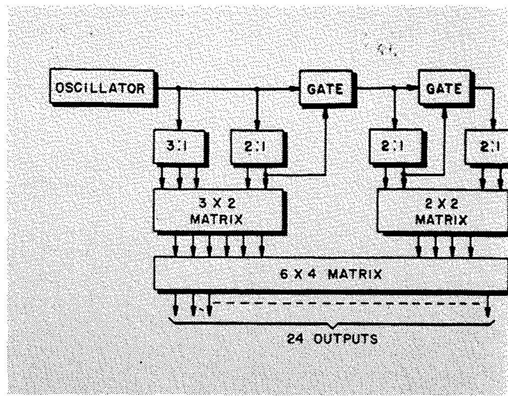


Fig. 5—High-speed carry gate

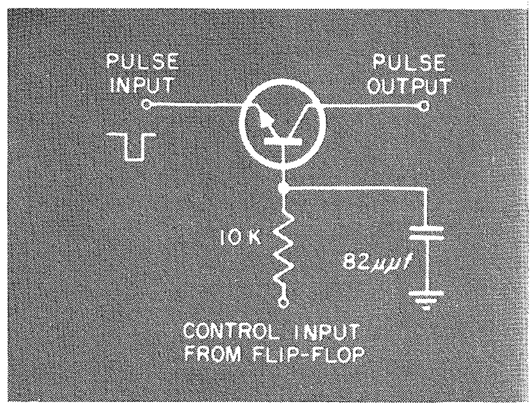


Fig. 6—Primary matrix circuit

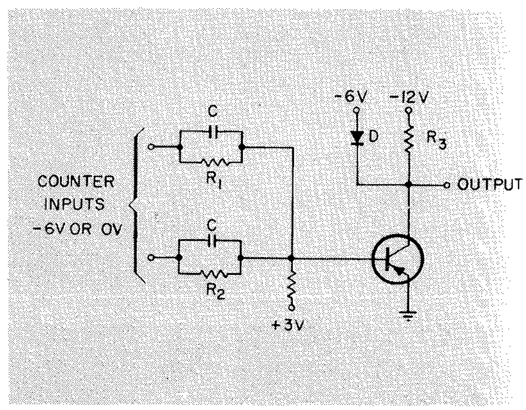
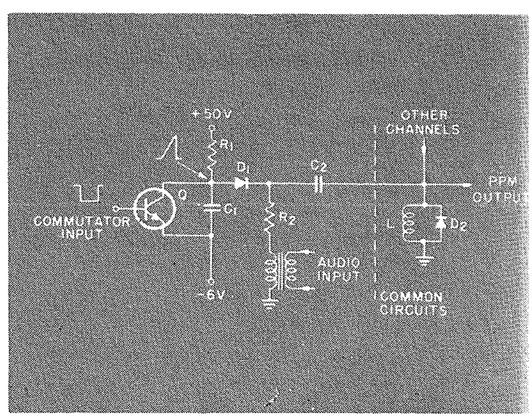


Fig. 7—Modulator



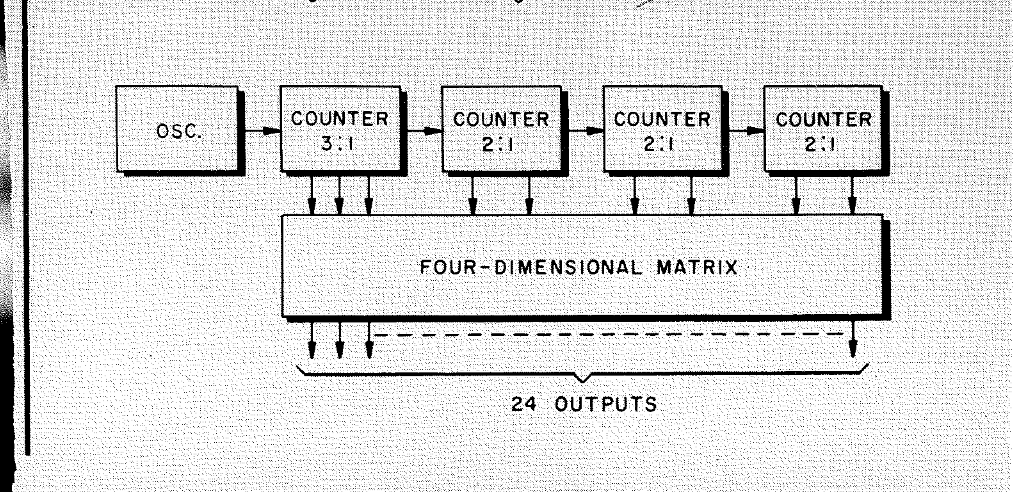


Fig. 3—Commutator using four-dimensional matrix

two-input "and" gate, and one such circuit is required for each matrix output. It is important that actuation of the output be dependent on driving the transistor into conduction, rather than non-conduction. Since the circuit operation requires that the transistor be in saturation during conduction, there will be some delay in the response of the collector circuit in turning off. The circuits are fairly insensitive to this trailing edge delay. However, it must be kept within one microsecond, which requires a reasonable control of the range of collector-to-base current gain and frequency response.

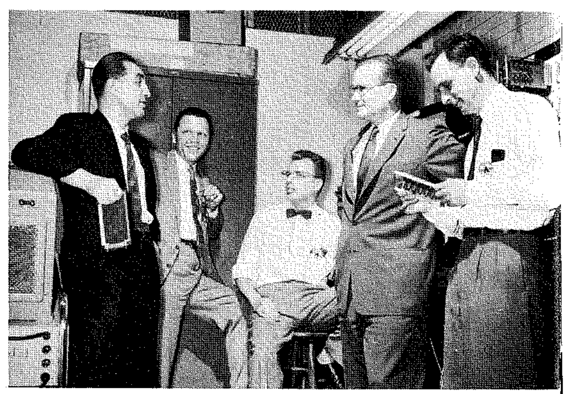
MODULATOR

The circuit used for the modulator is shown in Fig. 7. The base circuit of the input transistor is similar to the base circuit of the primary matrix circuit of Fig. 6. However, this transistor is normally conducting, thus holding the voltage on capacitor C1 fixed. When the input signal biases the transistor beyond cutoff the current through resistor R1 ceases to flow through the transistor, and causes an essentially uniform charging of capacitor C1. This reduces the back-bias on diode D1 until it conducts, transmitting the sawtooth waveform to capacitor C2 and inductor L, which constitute a ringing circuit. The conduction of D1 initiates a ringing waveform at the output, the first half cycle of which provides the desired output. The second half cycle is damped by diode D2, preventing further output. The timing of the pulse is controlled by the audio input signal, which varies the potential at the cathode of diode D1, and thus varies the point on the sawtooth at which this diode conducts.

In order to maintain timing accuracy, the parameters R1 and C1 must be carefully controlled and the back-resistance of diode D1 and the transistor must be high with respect to R1. Although supply voltages do not affect the relative timing relationship between channels, they affect the twitch* sensitivity, and the timing with respect to the oscillator, which must be carefully controlled in the multiplexer for 46-channel operation.

▲ The RCA Multiplex System was developed by (left to right) Messrs. Robert R. O'Hare, Edwin H. Miller, Fred J. Bieganski, Lester M. Glickman (standing), Nick J. Birbilis, and R. E. Wilson Mgr., Special Systems Development, DEP.

Service Test Models for the RCA Multiplex System are being designed by: (left to right) Messrs. Roy H. Fox, Group Leader; Larry Nahay, William Barnes, Harry Laiming, Mgr., and Henry Schmidt, Surface Communications, DEP. ▶



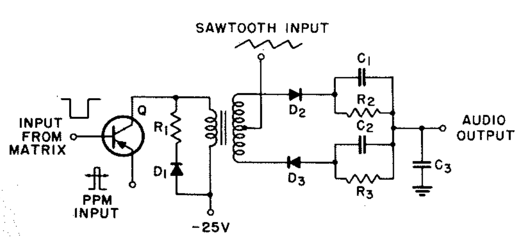


Fig. 8—Demodulator

DEMODULATOR

The demodulator circuit shown in Fig. 8 is a two-diode clamp circuit which develops a voltage on capacitor C3 essentially equal to the instantaneous voltage of the sawtooth at the time of the trailing edge of the PPM input pulse. The transistor gate circuit is primed by a base input from the secondary matrix, and is then actuated by the selected PPM channel pulse applied to the emitter. When the gate is actuated a pulse is developed across the transformer secondary winding, causing diodes D2 and D3 to conduct. This provides a low-impedance path from the sawtooth input, through the diodes and capacitors C1 and C2, to the output capacitor C3.

Thus at each sampling period the voltage on C3 assumes a value proportional to the twitch amplitude and hence to the input audio signal; and this voltage is held until the next sampling period. This is termed a "boxcar" output waveform and is shown in Fig. 9b. After filtering, the waveshape again resembles the input waveshape, shown in Fig. 9a. The boxcar output has the advantage over the commonly used alternative pulse amplitude (PAM) output shown in Fig. 9c that it contains more of the low frequency components. It is therefore more easily filtered, and requires less amplification. The boxcar output has a droop of a few db in the frequency response at the high end, but this is easily compensated for.

*Position modulation

In the design of this circuit, the time constants R2-C1 and R3-C2 must be large compared to the sampling period to maintain a back-bias on diodes D2 and D3. A good front-to-back resistance ratio is required of these diodes, so that they will offer low impedance to the pulse charging currents, and will not appreciably shunt R2 and R3 when back-biased. The Transitron type T9G diodes fulfill these requirements very well. The input impedance of the audio circuits must be high to prevent leakage from C3. Here a silicon transistor is used, the one exception to the use of germanium transistors throughout the equipment.

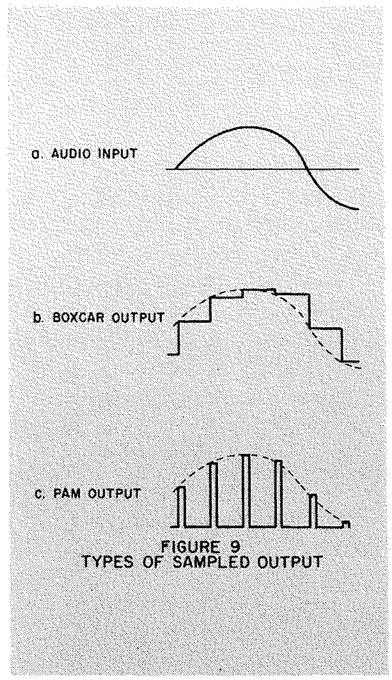
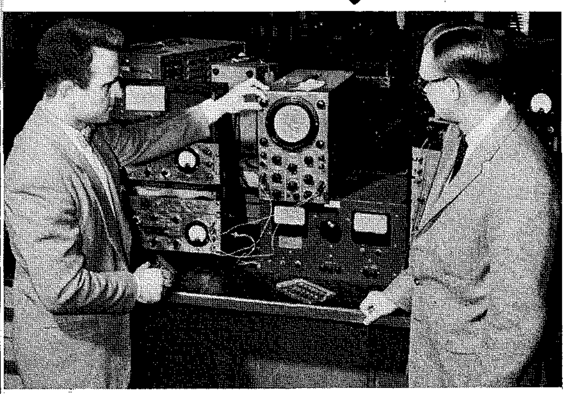


Fig. 9—Types of sampled output



Messrs. Deuitch (left) and K. E. Palm, Special System and Development, DEP, supplied early transistor circuit work on the Time-Division Multiplex project, under the supervision of Dr. H. J. Woll.

ROBERT E. WILSON, Manager, Digital Communication and Control Development, General Engineering Development, DEP, received his B.S. and M.S. degrees from M.I.T. in 1948. From 1945 to 1948 he was a cooperative student working with FM receivers at Philco Corporation. He joined RCA in 1948 and has worked in the fields of target designation, radar target detection and tracking, multiplexed communication, digital and analog computers, TV deflection circuits, and magnetic and transistor circuits. He supervised the development of a multiplexed Automatic Track-While-Scan system, and a Time Division Multiplex system.

His group is developing a high-speed digital computer for application to a future interceptor fire-control system. A PCM data-processing equipment is also being developed for military communication systems.

Mr. Wilson is a member of Sigma Xi and IRE.

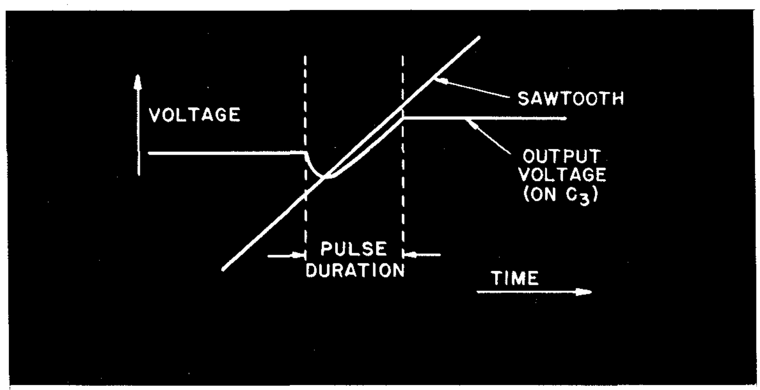


Fig. 10—Demodulator waveforms

The peak-to-peak twitch for a full-modulation signal is less than a microsecond. The usual design procedure for this type of circuit is to use a pulse which is narrow with respect to the twitch, in order that the sawtooth voltage will not change appreciably during the pulse. This approach would require an extremely narrow pulse, which would not only be difficult to generate, but would also require very large currents from the gate and the sawtooth source in order to fully charge capacitor C3 to equilibrium during the pulse. Extremely low driving impedance would be required to provide a short time-constant in conjunction with C3. Failure to meet these requirements would cause a droop in the frequency response at high audio frequencies. This effect could not easily be compensated for because it would be subject to variation with components and temperature.

To avoid the above-mentioned troubles a wide (1 microsecond) drive pulse is used (see Fig. 10). There is an appreciable variation in the sawtooth voltage during the pulse, so that capacitor C3 is charged toward a lower voltage at the beginning of the pulse, than at the end. The result is that the output is disturbed during the sampling pulse even when the twitch amplitude is zero. Although the clamp impedance or current source limitation may cause some lag between the output and the input, the pulse is wide enough so that during the pulse a steady-state is always reached which is independent of the previous voltage on capacitor C3. The final value of the voltage on C3 is dependent only on the time of the end of the PPM pulse, and any lag in the circuit will be fixed for any set of components and therefore will cause only a slight dc offset. Since this final voltage is independent of the previous value of the capacitor voltage, and therefore also of its rate of change, the circuit is not frequency sensitive.

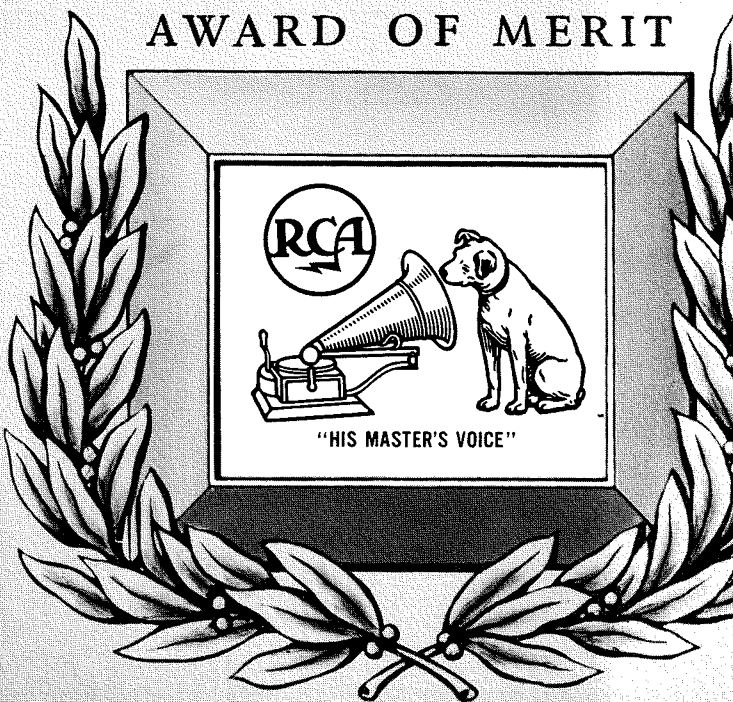
SERVICE TEST MODELS

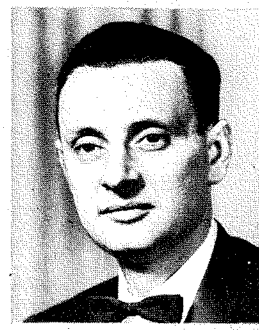
Following the development phase of the work, in June 1956 RCA was awarded nearly a million dollars by the Signal Corps for the design of Service Test Models of 23/46 channel and 7/14 channel multiplex equipment. This work is now being conducted under the management of H. J. Laiming, DEP Surface Communications.

CONCLUSION

The use of germanium transistors made possible the construction of a communication terminal equipment having approximately one-sixth the size and weight, and drawing less than one-tenth the power of previous vacuum tube units.

EIGHT RCA ENGINEERS RECEIVE




G. S. Breitweiser


Dr. H. N. Kozanowski

Contributions to national defense projects predominated in honors presented by RCA to its 20 outstanding salaried employes of the year in product, service and staff activities. The occasion was the annual dinner meeting of the RCA Victor Award of Merit Society, in the Warwick Hotel, Philadelphia, held on January 19, 1957.

Over 200 attended the ceremonies, including winners of the award in previous years and representatives of RCA top management. James M. Toney, Vice President and General Manager, RCA Victor Radio and "Victrola" Division, presided at the ceremonies, in his capacity as annual chairman of the Society. Awards were presented to winners by Arnold K. Weber, Director, Manufacturing, followed by an address by W. Walter Watts, Executive Vice President, RCA Electronic Components.

Credited with exceptional achievements were the following RCA engineers:

GEORGE F. BREITWIESER, *Manager, Electronics Engineering, RCA Missile and Surface Radar Department, Moorestown Engineering Plant.*

Mr. Breitwieser was honored for his outstandingly successful guidance of a critical phase in the development of the Talos Missile Launching System.

MR. BREITWIESER attended McKendree College, studying pre-chemical engineering in 1939. He received the B.S. degree in Marine Engineering at the U. S. Coast Guard Academy, New London, Conn., in 1942 and the B.S. and M.S. degrees in E.E. from M.I.T. in 1947. Mr. Breitwieser joined RCA as an engineer in 1949 in the Engineering Products Division. He became manager of the Components Engineering Group in 1953 and assumed his present position in January of 1954.

Mr. Breitwieser is a Senior Member, IRE, Associate Member, Sigma Xi, and a member of the Guided Missile Committees of the American Ordnance Society and RETMA.

ROBERT M. COHEN, *Manager, Application and Test Engineering, Semiconductor Division, Somerville, N. J.*

Mr. Cohen was cited for his pioneering activities in developing applications of transistors. He was also credited with contributing substantially to the reputation for quality and uniformity enjoyed by RCA transistors in commercial and military fields. A number of RCA transistor types developed for military applications have received JAN approval.

MR. COHEN graduated from RCA Institutes in 1940 and joined RCA Tube Division as a laboratory assistant the same year. He attended evening school at the Newark College of Engineering and Stevens Institute, and was promoted through engineering ranks to become Manager of the Semiconductor Applications Laboratory in 1953. Mr. Cohen assumed his present position in 1955. He is a senior member, IRE.

DAVID H. CUNNINGHAM, *Manager, Electro-Mechanical Devices Engineering, Components Division, Camden.*

Mr. Cunningham was honored for his technical and commercial leadership of RCA's speaker and relay business, reflected by an all-time production record in these two lines in 1956. Singled out was his guidance of relay designs which have won military, as well as industry, approval for high reliability and quality.

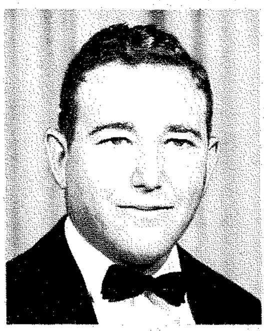
MR. CUNNINGHAM received the B.S. degree in Electrical Engineering from the University of Missouri in 1927, and joined Westinghouse Electric Corporation as an engineer the same year. Mr. Cunningham was transferred to RCA in 1929, working as a loudspeaker engineer. He has been associated with loudspeaker design for the Tube Division for the major portion of his career and is recognized as a top authority in speaker engineering.

JOSEPH M. HERTZBERG, *Manager, Airborne Systems Department, DEP, Camden.*

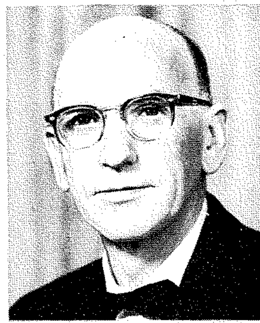
Mr. Hertzberg was honored as largely responsible for the Company's position as a major supplier of military airborne communications and fire control equipments. His contributions were also said to have included instigation of a new, topflight systems engineering activity, and planning which led to a number of major development contracts affecting future defense programs.

MR. HERTZBERG studied Electrical Engineering at the University of Michigan from 1925 to 1927. He was a Product Development Engineer

THE COMPANY'S AWARD OF MERIT

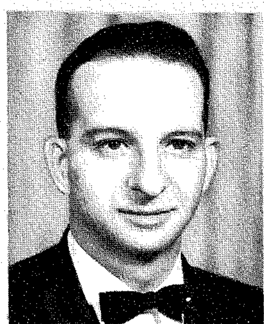


R. M. Cohen

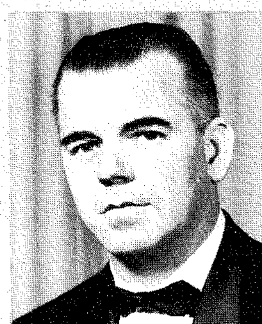


D. H. Cunningham

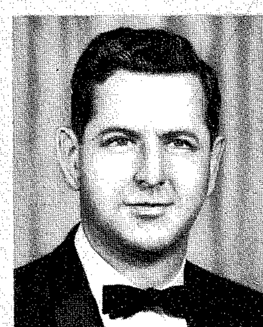
J. M. Hertzberg



R. M. Sonnenfeldt



A. W. Vose



B. Walley

with the Stromberg-Carlson Corporation from 1930 to 1936 before coming to RCA in 1945. With employment at RCA he started as a senior communications engineer and has held supervisory and managerial positions in Communications Aviation since that time.

DR. HENRY N. KOZANOWSKI, ***Manager, TV Product Advanced Development, Commercial Electronic Products, Camden.***

Honored for his primary contributions to broadcast and closed circuit color television through new products evolving from the 3-V Color TV Camera which he developed, Dr. Kozanowski was also cited for the 3-V Medical Color Camera. The first installation of this medical apparatus was made last year at the Walter Reed Army Medical Center for research and teaching uses.

DR. KOZANOWSKI received the B.S. and M.A. degrees in Physics at the University of Buffalo in 1927 and the Ph.D. degree in Physics from the University of Michigan in 1929. Dr. Kozanowski was a research engineer for Westinghouse from 1929 to 1935. He came to the RCA Manufacturing Company in Camden in 1935 and assumed his present position in 1951. Dr. Kozanowski has contributed much in the fields of high-definition TV for the Signal Corps, Color Television, Vidicon Camera Development and Image Orthicons. He is a member of the American Physical Society, the Franklin Institute, IRE, Sigma Xi and Phi Beta Kappa.

RICHARD W. SONNENFELDT, ***Advanced Development Engineer, RCA Victor Television Division, RCA-Cherry Hill.***

Mr. Sonnenfeldt was honored for the development of a synchronous detector, which was described as one of the most important contributions to the receiver art since the invention of the superheterodyne. It was said to be of enormous significance in all forms of communications and radar.

MR. SONNENFELDT received the B.S. degree from Johns Hopkins University in 1949. He came to RCA as a specialized trainee in 1949 and is now with the TV Circuits Group of the Television Division's Advanced Development Engineering. He has earned recognition among RCA and other engineers for his teaching ability and his presentation and publication of many technical papers.* The productiveness of his engineering career is underscored by his 92 patent disclosures. Mr. Sonnenfeldt is a senior member of the IRE, a member of the Tau Beta Pi and the Omicron Delta Kappa.

AUBREY W. VOSE, ***Staff Engineer, DEP West Coast Electronics Department, Los Angeles, Cal.***

Mr. Vose was honored for his instigation of RCA's highly successful weather radar for commercial airlines, following his earlier work on military weather radar apparatus.**

MR. VOSE attended RCA Institutes, N. Y., from 1937 to 1939. From 1940 until 1948 he worked with the Westinghouse Electric Corporation in Baltimore, and as a partner of Allison Associates in Los Angeles in the fields of radar systems. In 1948 Mr. Vose formed the partnership of Suffield-Vose, and under contract to the Houston Corporation set up production test for their radar system. He then was employed by the Houston Corporation as Chief Engineer. He joined RCA Los Angeles Engineering as Administrator of Systems Activities in 1950.

BERNARD WALLEY, ***Manager, Western District Field Engineering, Tube Division, Los Angeles, Cal.***

Mr. Walley was cited for his outstanding technical and organizational assistance to West Coast television and airframe manufacturers. Also singled out was his important work on tube trends in the airframe industry, which guided important RCA tube designs for military electronics.

MR. WALLEY graduated from California Institute of Technology with a B.S. degree in Electrical Engineering in 1937. He joined the Tube Division the same year as a Student Engineer, and in 1939 became a Laboratory Applications Engineer in receiving tubes. Since that time Mr. Walley has worked in Applications Engineering and Field Engineering, being appointed to his present position in 1955.

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* See articles by Mr. Sonnenfeldt in the RCA ENGINEER, Vol. 1, No. 1 and Vol. 1, No. 6.

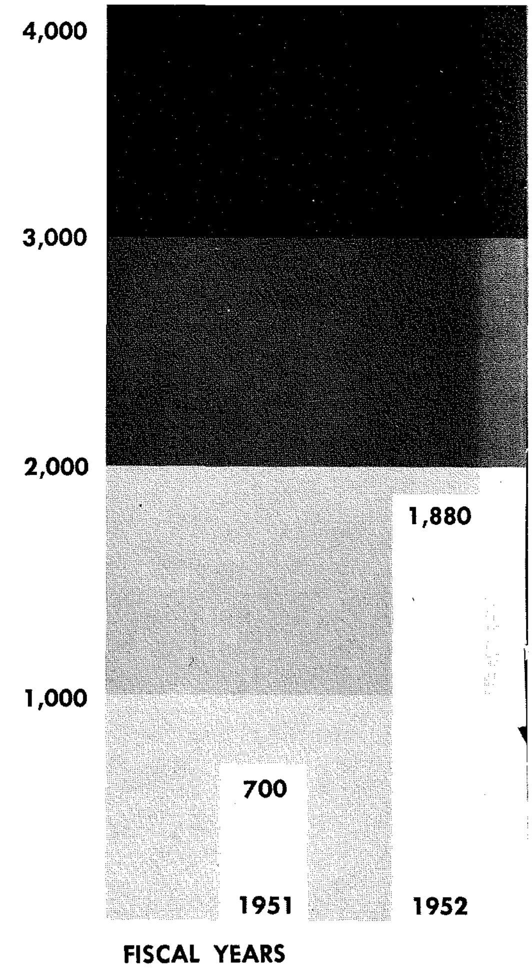
** "The RCA AVQ-10 Commercial Airline Weather Radar," A. W. Vose, RCA ENGINEER, Vol. 2, No. 2.

THE EDITORS HAVE asked us in Economic Planning to set forth our views on the present and future economic outlook for RCA ENGINEER readers. These articles will give the highlights supporting our conclusion that the electronics industry is growing about 2½ times as rapidly as the economy as a whole. We have further predicted that by 1965 this dynamic industry of ours will have attained a volume of $21 billion, double that of 1956. Naturally enough, those who guide RCA's destiny are constantly plotting a course designed to insure continuance of our current position of industry leadership. The achievement of that goal will become an accomplished fact only through the combined efforts of everyone in our Company.

The engineer is the focal point. To him is assigned the momentous task of providing the best product, the most advanced product, and at the lowest price.

In determining the growth potential of our industry, it became apparent that intelligent projections could be made only after analyzing the growth trends which will occur in our national economy—and, of course, our own economic climate *can only be evaluated after an analysis of the international situation!*

In this article we analyze first the international climate to determine the type of economy in which we shall likely live in the years immediately ahead. In a future issue, Frank Hutzel will analyze and project our national and economic growth during the next decade. In a still later issue, Dave McCarty will conclude the series with an analysis of our concept of the growth of the electronics industry during the next ten years.



THE DECADE AHEAD

THE INTERNATIONAL OUTLOOK

by **E. DORSEY FOSTER**

Vice President, Economic Planning, Radio Corporation of America, Camden, N. J.

Editor's Note: The engineer, confronted these days with increasing complexity in his daily work, is finding himself implicated more and more with the broad concepts of his business and the industry as a whole. We are pleased, therefore, to publish this series of articles by the Corporation's Economic Planning Dept. We are confident that they will aid materially in helping the engineer know "where he stands" in the broad picture.

Much of the material in this first article is dynamic, and therefore the picture can change overnight. The views set forth here are based on the situation as it stood in the latter part of January.

E. DORSEY FOSTER is a graduate of Princeton University, the Harvard Graduate School of Business Administration, and the Industrial College of the Armed Forces.

Mr. Foster was commissioned Ensign in the Supply Corps of the U.S. Navy in 1917 and advanced through the grades to Rear Admiral in 1943, and to Vice Admiral in 1949. He served in various assignments ashore and afloat, having been made Chief of the Bureau of Supplies and Accounts in 1948, and then Chief of Naval Material in 1949.

Upon retirement from the United States Navy December 31, 1950, Mr. Foster joined RCA as Director of Mobilization Planning, and a year later was elected Vice President. He is now in charge of Economic Planning for the Company.

Mr. Foster was awarded the Legion of Merit and was given the rank of Honorary Commander of the Most Excellent Order of the British Empire (Military Division), as well as various other citations.

Each one of us knows that we are living in a world in which two entirely different ideologies are engaged in a life-and-death struggle for supremacy: The Free World, whose mantle of leadership has now fallen upon the shoulders of the U.S.; and the Communist World, of which Russia is the dominant power.

Since World War II the Communists have built up a tremendous empire—⅓ of the world's people and ¼ of the earth's surface. Their last orgy of butchery, in Hungary, makes it crystal-clear that they intend to resort to any means expedient to keep what they have acquired. Their continued subversion, infiltration, and stirring up of peripheral wars almost everywhere, reflect no change in their objective of world domination, nor for the most part, in their strategy for achieving this goal. Only their tactics change.

THE SUEZ CRISIS

It so happened that, in the Middle East, the ambitions of a "would-be Hitler" fitted perfectly with the Russian strategy to obtain the foothold

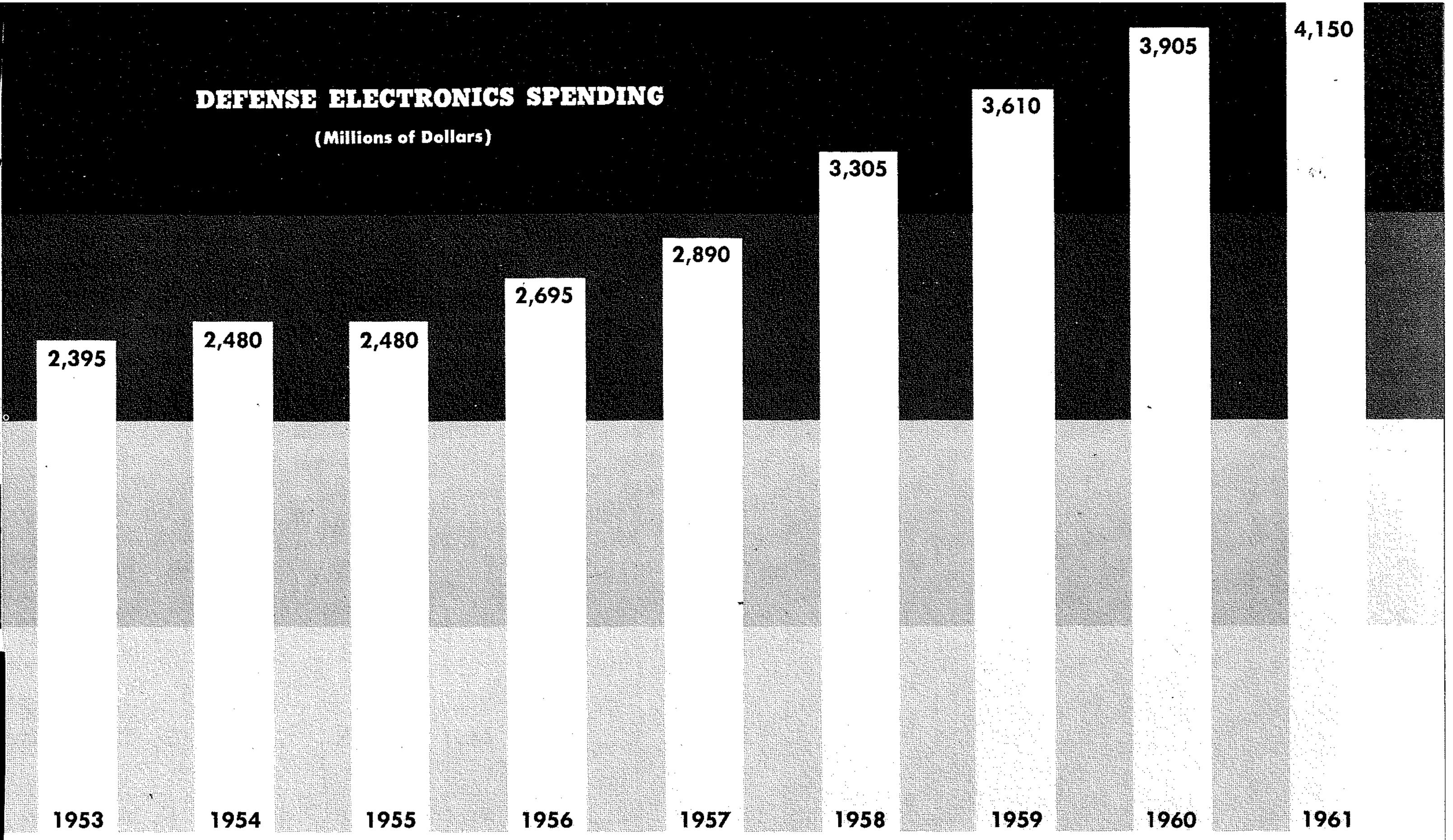


Chart 1—Defense electronics has over the past several years constituted a progressively larger share of the defense dollar, and this pattern is expected to continue indefinitely.

The rapid rise in defense electronics spending, 1951-53, was attributable to the impetus generated by the Korean war.

The near-plateau, 1953-55, reflects a period of re-appraisal of weapons' capability and the transitional lag incident to the decision to shift emphasis from the conventional to the new weapons—in which electronics plays an ever-increasing role. Defense electronics is here projected to increase by approximately 50% in the next five years. We expect this trend to continue, and by 1965 to rise to a volume more than double that of 1956.

long sought, both by the Czars and the Reds, in this most strategic area. Not only is Suez a key lifeline of world trade, but the Middle East is the reservoir of over 70% of the Free World's known oil. Oil is vital to Western Europe—and denial of Middle East oil to Western Europe would be catastrophic for the Free World.

About 75% of Western Europe's oil requirements are being met, but the 25% differential will persist until the canal is cleared, the pipe-line repaired, and the Suez issue resolved. This deficiency will not ruin the Western European economies, but they will suffer, both from reduction in flow of energy-generating oil and from loss in their dollar reserves to whatever extent they are required to pay for Western Hemisphere oil.

The Suez crisis of course has served to accelerate the chronic Arab-Israeli issue—and has contributed greatly to making this area of the world the current focal point of the relentless Soviet strategy.

HOW THE U.S. SEES IT

President Eisenhower's proposals, which doubtless will be enacted by Congress, tell the whole world that the U.S. now considers the Middle East a trigger area; that the U.S. will risk war to keep the Middle East peace, and will provide the economic aid, to promote stability, to those Middle East countries that are willing to live in peace with each other and who won't conspire with the Reds.

The U.S. is determined to preserve NATO and the UN. Had we not persuaded Britain and France to abandon the ill-conceived Suez attack, both NATO and the UN would have suffered mortal blows. The support of Britain and France are indispensable to the effectiveness of NATO. Mutual dependence of Britain and France, and of the U.S., will force healing of the breach, and stopping of the "drift." We need the front-line of defense they provide, and the bases from which a devastating retaliatory attack can be launched against the Soviet. They need both our military and economic strength for sheer survival.

Trouble always costs money and effort to repair. The U.S. must supply Europe the help needed to keep it warm and nourished, and whatever else is required to keep its economy from floundering. The Mideast, even Egypt, must get help to reduce its urge for trouble-making. Strong political ties are impossible unless economic foundations are strong. It did appear as though we were withholding action on supplying oil until they withdrew from Suez. Behind the scenes, however, tankers were being re-directed to make the most of Free World oil supply, U.S. tankers were being taken out of mothballs, and emergency plans were prepared to move over ½ million barrels per day from the Western Hemisphere to Europe. Only announcement of these measures was delayed, in order that no additional excuse might be given the Arabs to cut the one remaining pipeline which brings over 350,000 barrels per day to the Mediterranean.

The U.S. has won friends in Asia by the stand taken over Suez. The communists have lost support because of the Soviet murderous crackdown on Hungary. The communists' strategy

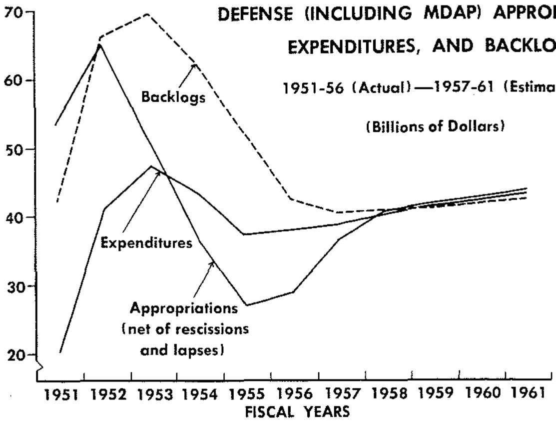


Chart 2—The Korean outbreak signalled a sizable step up in the level of appropriations for defense (including the Mutual Defense Assistance Program) with a resulting higher level of defense spending and unexpended balances of defense appropriations (backlogs).

Appropriations were curtailed in fiscal year 1953, but backlogs continued to mount due to the long lead time involved in defense procurement. Further lower levels of defense appropriations in fiscal 1954 and 1955 served substantially to reduce backlogs with a slight decline in the spending rate.

Barring an all-out war, defense appropriations, backlogs, and spending trends should reach a point of equilibrium and stability in 1958. We expect an approximate 10% rise from the current level of defense spending to be realized by 1961—and a 20% increase (above the current level) by 1965—in part due to creeping inflation, but largely because of the much greater per cent rise in the electronics segment of total defense business, shown in Chart 1.

has not succeeded in cracking the solidarity of the West. NATO and the UN have survived even the disruptive potential of the British-French push over Suez. NATO and the UN still remain powerful agencies for the preservation of peace.

U.S. policy is in a state of flux, a natural evolution from the recent eruptions in Hungary (and Poland) and the Middle East. Basically, the U.S. appears to be shifting from a strategy of merely containing Russia to one of getting at the root of the issues which threaten peace.

RUSSIA'S COURSE OF POLICY

The revolt in Hungary, Russia's appeasement of Poland, and Tito's defection have proved that not only can the Soviets no longer depend upon satellite forces for military support, but that the Soviet strategy of depth, based upon a buffer zone of satellites from the Baltic to the Mediterranean, has seriously been impaired. They are economically so inter-dependent that their troubles can't be localized. At home, as well as in the satellites, production of both capital and consumer goods has not come up to expectations. Military potential and heavy-industry gains have been achieved at the expense of gravely weakening the rest of their economy. Robbing their people of ambition and general incentive appears now to have reached the point where Soviet youth is beginning to lose faith in Communism. More and more of Soviet effort and substance will have to be devoted to consumer goods—and to keeping their satellites in line. Satellite defection, in fact, is now making them a liability to Russia rather than an economic asset for profitable exploitation. In short, considerable diversion of Soviet resources from their military and industrial build-ups appears inescapable—and that will certainly impair ability to extend the substantial economic aid they have promised, for example, to the Arabs. They likely wouldn't fulfill these promises if they could. Economic aid promotes stability, and their fundamental strategy is to keep peripheral areas such as the Middle East upset and unstable.

It is true that the communists have never abandoned war as an instrument of Soviet policy. It is significant, however, that their leaders have actually resorted to war only against small countries, when swift and sure victories were assured. To avoid a major war, Stalin appeased Nazi Germany to the limit, in the hope it could be avoided. Their present leaders are equally realistic. They value their position and power. They are thoroughly aware that a hot war would precipitate revolt of satellites and perhaps even within Russia itself.

It is also true that never before in world history have such powerful instruments of war been assembled for potential destructive use. It is undeniable that there are any number of tinderboxes which are potentially explosive and which could provide the spark for small wars: the Arab-Israeli issue to keep the Middle East pot boiling, the Algeria-Morocco-Tunisia issue, Korea, Formosa, Indonesia, Indo-China, Singapore, Cyprus, the Dardanelles. But so long as the U.S. maintains its military strength, backed by its economic might, and keeps the Free World strong and united, it is highly unlikely that the wounded Russian Bear, even as an act of desperation, will risk another world war.

It is for these reasons, I am convinced, that American business believes that it should plan on indefinite continuance of the Cold War.

SIGNIFICANCE OF CONTINUED COLD WAR TO THE ENGINEER

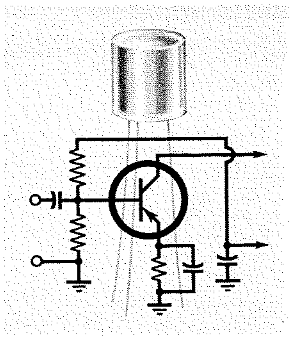
We can be assured that continuation of the Cold War will entail maintenance of at least the current level of U. S. relative military capability. Our estimate of the dollar trend of *overall* defense spending over the next several years is set forth in Chart 2.

Our conviction that the *electronics* segment of defense spending will rise much more steeply is reflected in the projections we have made in Chart 1. The emphasis now being given the ever-more complex new weapons, in which electronics plays such a predominant role, entails higher costs for defense electronics. The constantly increasing emphasis the Defense Department devotes to Research and Development assures continuance of this trend.*

Comparison of the two charts points up the fact that *whereas total defense spending is expected to increase 10% over the next five years, defense electronics expenditures by 1961 are estimated at 50% above current levels—and we expect this trend to continue through 1965.*

The role of the electronics engineer is indeed pivotal. The degree to which he accepts the challenge of this electronics-atomic age may well determine our Country's ability to maintain free world supremacy—not only in military weapons, but also in economic strength, without which military capabilities can not be sustained. In the process, he can take much satisfaction in the contributions he makes to increasing still further our standards of living, even now by far the highest in the world. His opportunities are boundless, not only for personal advancement, but also for sustaining and enhancing our free way of life.

* $600 million in '51 appropriations vs. $1.7 billion *specifically* requested for R & D in '58.



RECENT DEVELOPMENTS IN TRANSISTORIZED VIDICON CAMERAS

by **LESLIE E. FLORY**
General Research Laboratory
RCA Laboratories, Princeton, N. J.

The Vidicon has become well established as a pickup tube and offers many advantages in the form of low cost, long life and simplicity of operation as well as high signal-to-noise ratio and very long grey scale. Its small size and low deflection power have been important factors in designing compact portable equipment. Recently this work has been further extended in the development of a miniature Vidicon only ½ inch in diameter.[1] This model requires less than 1 watt of heater power and one-third the deflection field required by the standard RCA-6198 or 6326. It is, therefore, ideal for use in transistor circuits.

Two models of completely transistorized cameras have been built. One of these performs essentially as the TV Eye in that it generates a modulated r-f signal on one of the standard TV channels and produces a non-interlaced raster with sync pulses to operate a standard receiver. A photograph of this camera with an 8½ inch portable receiver is seen in Fig. 1.

The second model is a completely portable pickup unit with synchronizing generator and a 2000 mc transmitter with a range of up to a mile.[2] In operation it is similar to previous "creepie-peepie" models utilizing tube circuits. A photograph is seen in Fig. 2. Weight of the camera with monitor is four pounds and that of the pack fifteen pounds including a battery complement sufficient for five hours operation.

TRANSISTORIZED TV EYE

This unit was designed as the smallest and simplest complete camera it was possible to build at the present stage of transistor development. Eighteen transistors, all of them of types now commercially available, are used to perform the necessary circuit functions to generate a complete television signal on a 60 mc carrier.

The video amplifier is the most critical part of the system. While there are several types of transistors which can be used in the ordinary gain stages with reasonable gain and bandwidth, the input stage requires special consideration. It is a well known fact with tube amplifiers that, since the Vidicon is essentially a constant current generator, an overall improvement in signal-to-noise of the order of 15 db can be obtained by using a high input impedance so that the low-frequency signal may be 30 to 50 times as great as the high-frequency signal. The frequency discrimination of the input circuit is compensated further along in the amplifier by a circuit having a complementary time constant. This results in the improvement indicated in signal-to-noise and in addition reduces the effects of microphonics or low-frequency pickup and confines most of the noise to the higher frequency part of the spectrum. This same technique is used in our transistor amplifiers. Input impedances as high as possible are obtained by using a transistor with high β and connecting it in an emitter follower mode. By this means impedances of the order of 50 K ohms are obtained at low frequencies dropping to about 1000 ohms at 5 mc due to capacity effects internal and external to the transistor. Alternately feedback may be used to obtain the high impedance. The present 2N247 drift transistor is the best type so far found for this use. Optimum results are obtained by selecting units with high β factors and low collector to base leakage noise.

The total high-frequency gain of the amplifier shown is 100 db or an average of 20 db per stage. Bandwidth is 4 megacycles.

The deflection and blanking circuits are rather simple because of the low

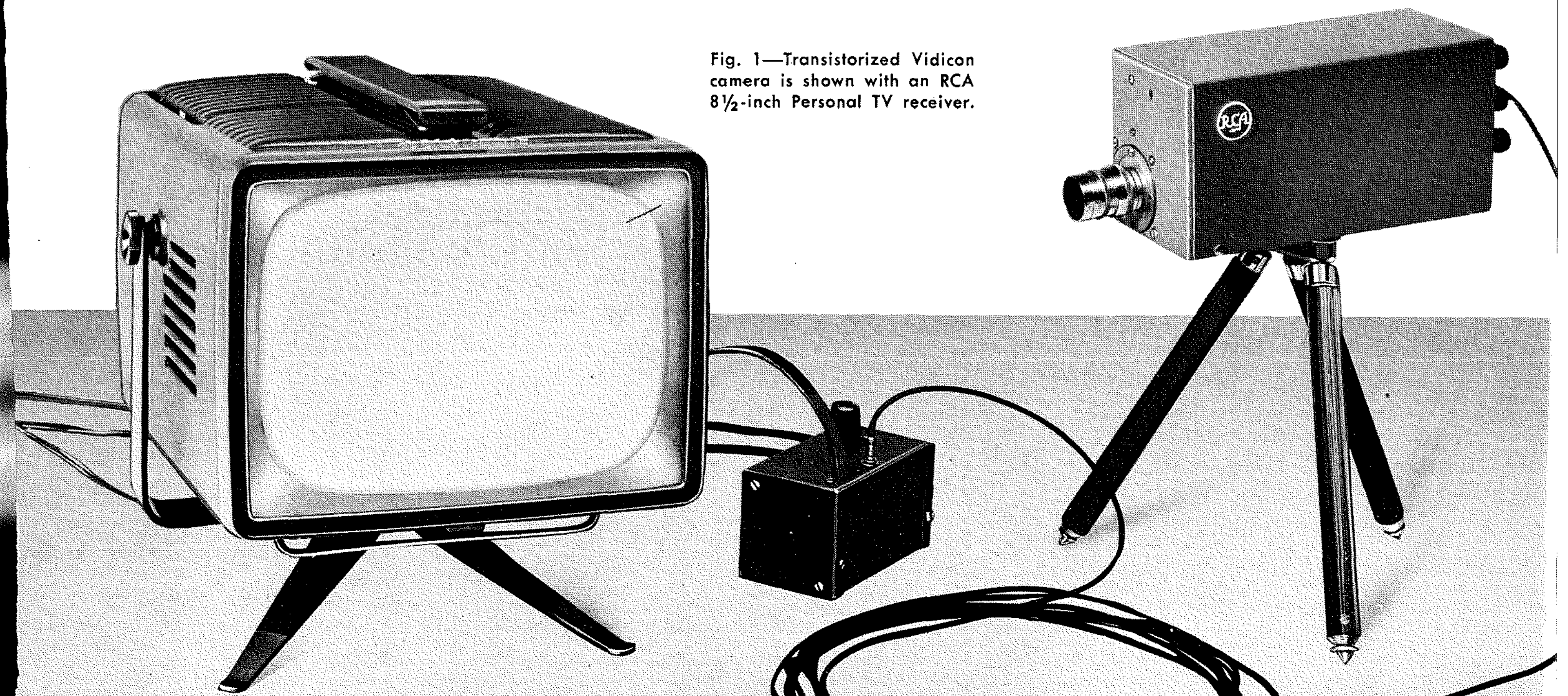


Fig. 1—Transistorized Vidicon camera is shown with an RCA 8½-inch Personal TV receiver.

power requirement of the miniature Vidicon. Horizontal oscillator stability is obtained by means of a Colpitts type circuit which has a temperature-sensitive capacitor attached thermally to the oscillator transistor. The vertical is locked to the power line.

High voltage for the Vidicon is obtained by means of an oscillator and step-up transformer giving 300 volts d-c after rectification. The main power supply of 15 volts is obtained from a transformer-rectifier circuit through a transistor voltage regulator which not only provides d-c regulation but a large share of the ripple elimination as well.

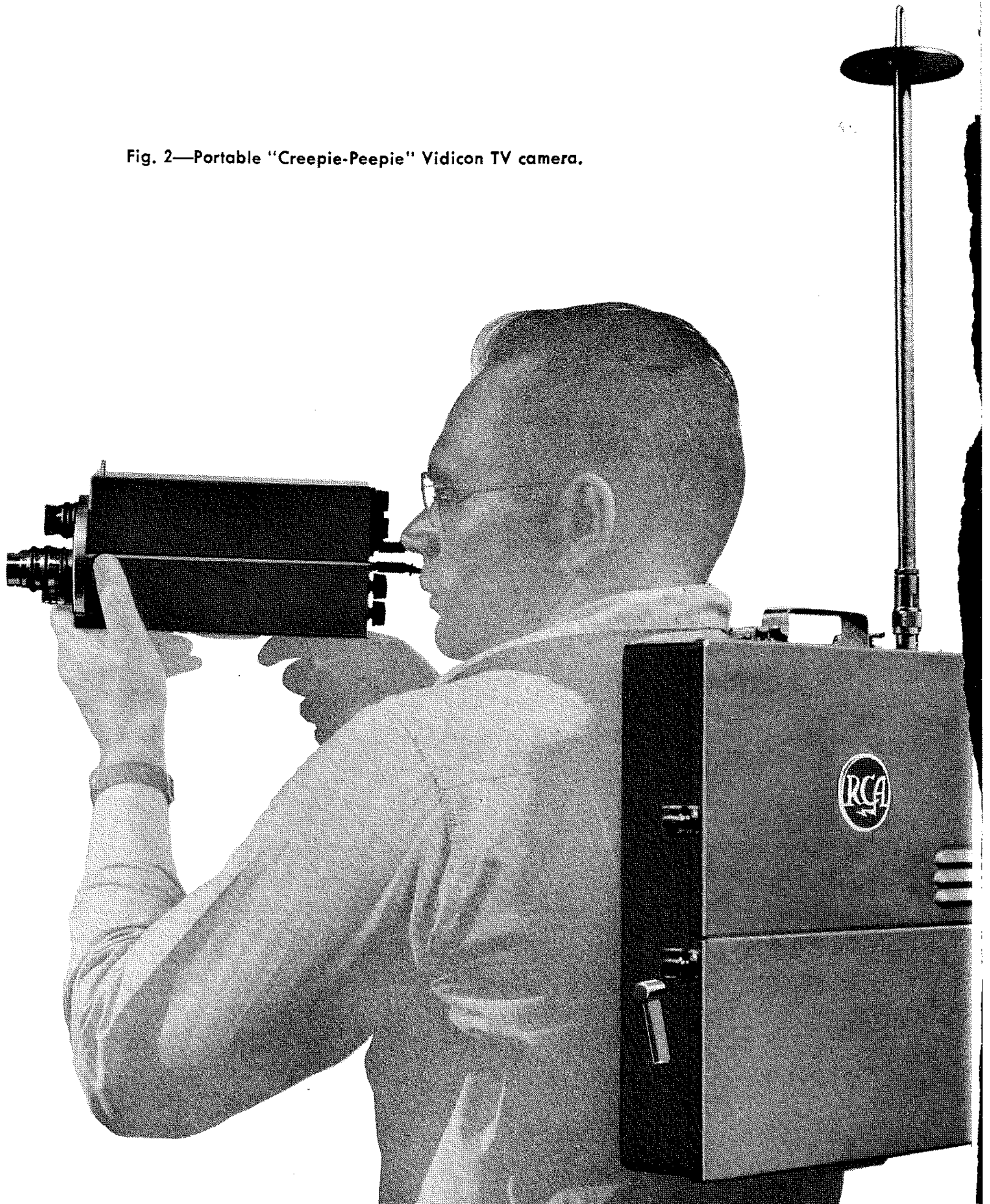
Total a-c power consumption is less than 5 watts. This low power requirement makes it practical to transmit the required power over the coaxial cable used to carry the r-f signal to the receiver. Simple filter circuits separate the signal from the power current. Any cable with satisfactory r-f efficiency will satisfactorily transmit the necessary power.

TRANSISTOR CREEPIE-PEEPIE

The portable backpack unit differs from the TV Eye type in several ways. It must transmit a high-quality picture if it is to be used for broadcast purposes. Consequently the amplifier bandwidth was made 6 mc. It must provide high-stability timing signals for a standard interlaced raster since when a network is operating from the portable unit its synchronizing signals become the master signals for the network. Thus a good synchronizing generator is required. A transmitted signal of sufficient strength to be picked up over a distance of at least several hundreds or thousands of feet must be provided. Further, the FCC requires that this transmitter must operate in the region of 2000 mc. The unit must be battery operated for full portability and the battery should have sufficient capacity for several hours operation.

A block diagram of the creepie-peepie is shown in Fig. 3. The camera contains, in addition to the Vidicon and focus assembly, the video amplifier, horizontal and vertical deflection circuits for the Vidicon and a blanking amplifier. It is connected to the backpack through a four-foot cable. The monitor is a separate unit which

Fig. 2—Portable "Creepie-Peepie" Vidicon TV camera.



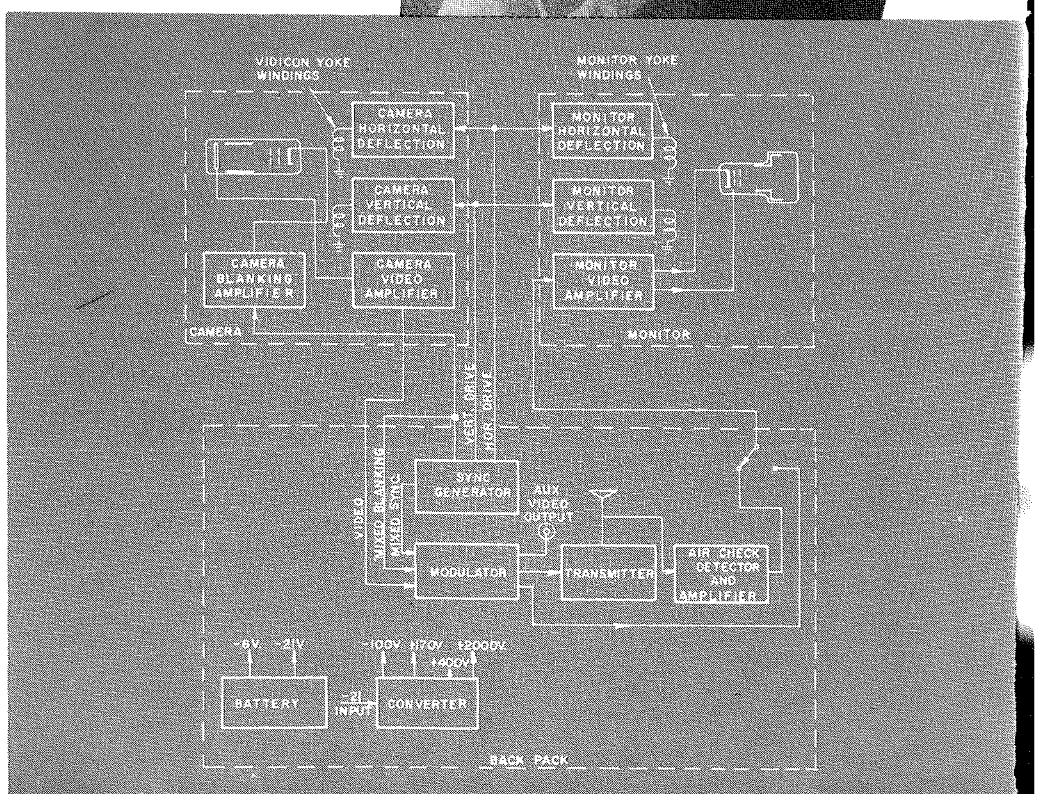


Fig. 3—Block diagram of the "Creepie-Peepie."

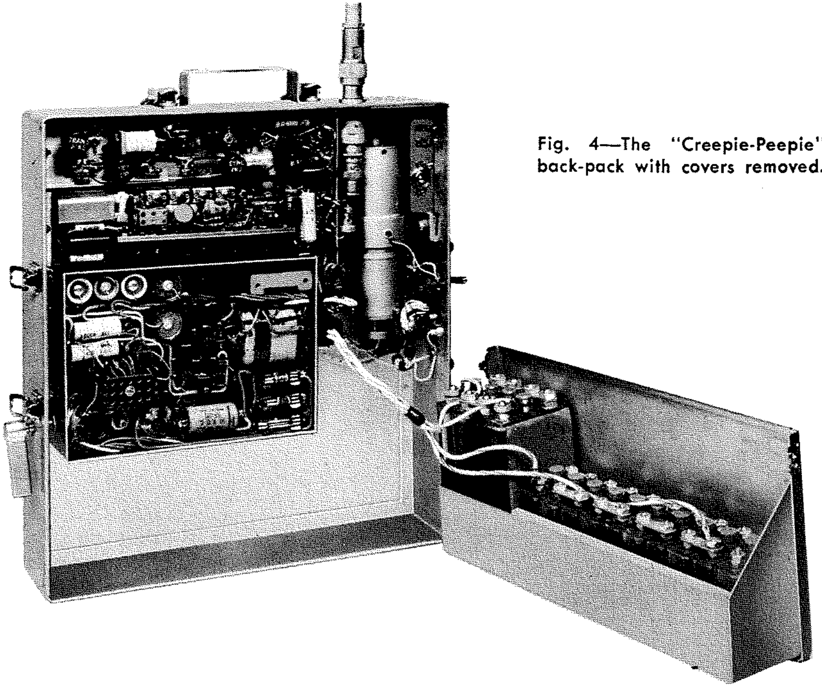


Fig. 4—The "Creepie-Peepie" back-pack with covers removed.

may be attached to the camera or may be suspended around the operators neck like a reflex camera in case it is desirable to place the camera where it is not accessible to view, such as being elevated over the head. The monitor contains a small kinescope tube and its own deflection circuit plus a video driver amplifier.

The backpack contains the synchronizing generator, the final video amplifier and modulator, the transmitter and the power supply consisting of a 20-volt battery and a power converter to supply power to the transmitter and high voltages for the Vidicon and kinescope. A photograph of the pack with covers removed is seen in Fig. 4.

The synchronizing generator has a crystal-controlled negative resistance type oscillator for stability. The divider chain consists of a series of blocking oscillators. These oscillators are of the type which has the time constant circuit in the emitter and the feedback from collector to base. This circuit is more independent of temperature than other types. Wave shaping circuits are provided which produce the necessary drive and blanking pulses and a composite sync signal with vertical serrations but no equalizing pulses.

The portion of the video amplifier in the pack serves mainly to set black level, mix in the sync pulses and provide the necessary video drives for a line, the monitor and to modulate the transmitter.

The transmitter is a triode oscillator stabilized by broad-band cavities and is grid modulated. One-half watt of peak power can be obtained with good linearity and a minimum amount of frequency modulation. Eighty to ninety percent modulation can be obtained with less than a volt of video on the grid.

The power converter consists of a pair of audio power transistors in a push-pull circuit with the bases being driven through a saturated transformer in order to obtain extremely fast transitions from zero current to maximum current. Operated in this manner, transistors are very efficient switches. Operating at a level of 15 watts the conversion efficiency is better than 90 percent. By means of several windings on a common core, the necessary voltages for various purposes in addition to the transmitter are obtained.

CONCLUSIONS

Equipments of both types described have been built and operated over a period of several months. They show that with present-day transistors it is possible to achieve a degree of operation not possible with tube circuits within weight and power limitations even approaching those of the described units. Performance is in every way the practical equivalent of corresponding tube circuits and in many circuits unique properties of transistors permit operation in modes not possible with tubes. The small closed-circuit camera has been operated many hours with standard receivers and indicates the practicality of this approach to a simple and eventually low cost closed-circuit system.

The portable "creepie-peepie" was used by NBC at both of the recent political conventions and the advantage of its size and weight together with long battery life were immediately apparent and appreciated by operating personnel.

The greater part of the work on the equipment described was done by W. S. Pike, G. W. Gray, J. M. Morgan and L. A. Boyer.

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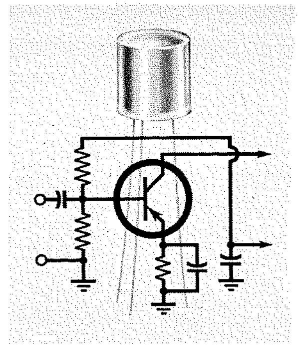
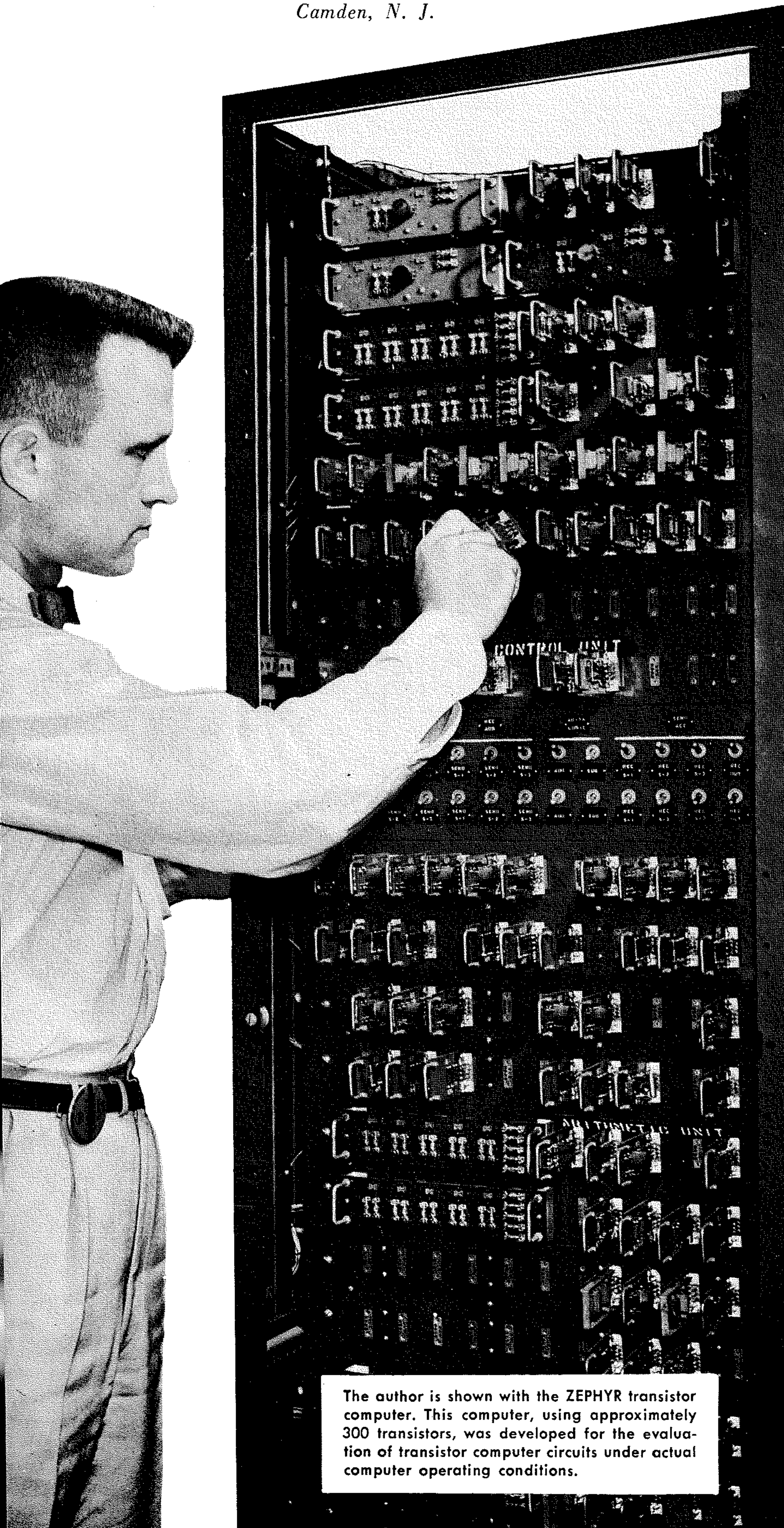
1. A. D. Cope—"A Miniature Vidicon of High Sensitivity," RCA Review Volume XVII December, 1956.
2. L. E. Flory, G. W. Gray, J. M. Morgan & W. S. Pike, "Transistorized Television Cameras Using the Miniature Vidicon," RCA Review Volume XVII pp. 469-502 December, 1956.

LESLIE E. FLORY received B. S. degree in Electrical Engineering, University of Kansas in 1930. Member of the research division of RCA Manufacturing Co., Camden, N. J. 1930-1942. During this time was engaged in research on television pickup tubes and related electronic problems, particularly in the development of the iconoscope. In 1942 was transferred to the RCA Laboratories, continuing to work on electronic tubes and special circuit problems, including electronic computers, infrared image tubes and sensory devices. 1949 to 1953 was in charge of work on storage tubes and industrial television at RCA Laboratories. Since 1953 has continued in charge of work on industrial television with emphasis on transistor circuitry. More recently has also been engaged in work on Medical Electronics. He is a member Sigma Xi, and a Fellow, IRE.

TRANSISTORS IN DIGITAL COMPUTERS



by **DON E. DEUITCH**
General Engineering Development
Defense Electronic Products
Camden, N. J.



The author is shown with the ZEPHYR transistor computer. This computer, using approximately 300 transistors, was developed for the evaluation of transistor computer circuits under actual computer operating conditions.

A VERY IMPORTANT application of transistors is in switching or pulse circuits, particularly in the Digital Computer field. Several computer manufacturers have announced prototype transistorized computers, and nearly all new developments in this field involve the use of transistors and other semi-conductor devices.

From a number of standpoints, transistors are particularly suited for digital computer circuits. Significant advantages are substantially reduced equipment size and power consumption, and substantial improvement in circuit performance.

This paper will outline the principal considerations in the use of transistors in digital computers and the basic switching properties of transistors for computer circuit operation. Several transistor computer circuits are presented to illustrate many of the useful features of transistors in this service.

TRANSISTOR TYPES

Historically, the point-contact transistor first received extensive application in digital computers.* The inherent regenerative properties and high-speed capabilities of this transistor were especially suited to many types of computer circuits.[1,2] Point-contact circuits, however, because of very wide tolerances in transistor characteristics proved difficult to design reliably, and resulted in relatively complex circuit configurations. This transistor type has consequently been replaced for the most part by the junction transistor. The *junction* transistor is a much lower-power device and has more desirable switching characteristics. Experience indicates that very high reliability may be ob-

* Notable developments here, include the Tradic computer, an experimental 1 mc synchronous computer developed at the Bell Telephone Laboratories, and the computer developments by F. C. Williams and G. B. B. Chaplin at the University of Manchester, England.

tained in junction transistor computer circuits.

New semiconductor devices are also being developed with potential application in digital computers. Among these is the Double-Base Diode which provides a regenerative switching action similar to that of the point-contact transistor.[3] The junction transistor also exhibits similar regenerative properties under certain operating conditions.[4] Tetrode transistors and other multi-terminal semiconductor devices, now in the experimental stage, may also have future application in this field.

GENERAL CONSIDERATIONS

The junction transistor has many desirable characteristics for use in computer circuits. Outstanding among these is its almost ideal "switch" property. Except at high temperatures, the transistor when cutoff may be considered an open circuit, and in the "ON" state is virtually a short circuit having terminal impedances as low as 1 ohm. This switch property greatly simplifies computer circuit design and is particularly useful in gating and clamp circuits. Transistor dissipation in switching operation is extremely low. This enhances high temperature circuit performance and minimizes thermal effects at normal operating temperatures. This is an important factor in view of the increasing use of computers in military applications with wide operating temperature requirements.

Junction transistors permit the use of small signal levels. Voltage levels of 2 to 6 volts are typical, and may be as low as .1 to .4 volts in certain applications. These low signal levels result in improved circuit switching speed, and permit substantial reduction in component size and operating requirements.

Transistors are capable of very high-current operation. Present low-power commercial junction transistors can deliver 100 to 200 milliampere pulse currents. Although power transistors can extend this range greatly, they are generally too slow in switching speed for present usage. This high-current performance, and the efficient transistor switching properties allow the transistor to switch large values of output power with very low internal dissipation.

A very important aspect is the high versatility provided by transistors in circuit logic design. The switch property and other characteristics of transistors provide many different circuit techniques. Employment of complementary transistors and transistor-diode circuits further increases this flexibility.

From the equipment standpoint, transistors permit substantial reduction in size, weight, and power consumption. Compared to conventional vacuum tube computers, size and weight reductions of 10:1 and reduction in power requirements of 100:1 for a circuit module or plug-in package are typical. These are important factors, particularly in airborne and other mobile computer applications. The small size of transistors and low-voltage and power components permit more efficient and extensive use of printed wiring construction in equipment fabrication. More compact equipment mechanization results in greater serviceability and adaptability to automatic assembly.

However, together with these useful features, transistors also impose several limitations upon computer circuit performance. Chief among these are the low-frequency and low-voltage limitations of present commercial transistors. Frequency limitations are overcome to some extent in switching operation, at the expense of increased circuit drive and more complex circuits. The voltage limitation mainly restricts the speed of transformer coupled circuits and necessitates the use of special neon or incandescent indicator circuits. High-current performance is limited by fall-off in both transistor gain and frequency response. With wide operating temperature requirements, transistor parameter variations impose careful circuit design to achieve high reliability.

These are important factors in the design and operation of transistor computer circuits. In some applications, they impose definite limitations. Nevertheless, for most digital computer circuits, transistors may be employed advantageously within these restrictions. Further, substantial improvements may be expected in future transistor types.

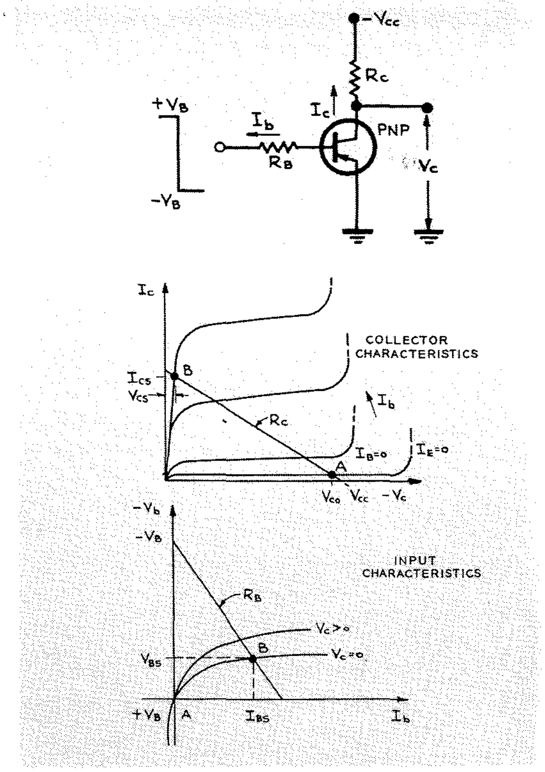


Fig. 1—Transistor Switching Operation.

TRANSISTOR SWITCHING OPERATION

The important properties of a switching circuit are the d-c conditions in the ON and OFF circuit states, and the circuit transient and gain performance in transition between these states. In some applications, the transistor may be used solely as an amplifying element with the ON and OFF circuit conditions established with clamp diodes. More often, the transistor itself is used to establish these d-c conditions.

Junction transistor switching operation is illustrated by the transistor collector and input characteristics of Fig. 1. Cutoff operation, shown at A, is usually established by reverse input bias. The terminal cutoff currents are normally less than 5 μa (at 25°C) and may be neglected except at high temperatures.

The transistor ON state is at B on the characteristics. In this condition, termed the saturation ON state, the collector-emitter voltage, V_{cs}, is extremely small (.01 to .1 volts). The collector current, I_{cs} is thus determined essentially by the collector supply voltage and d-c load resistance. The base voltage, V_{BS}, and current, I_{BS} are defined on the input characteristic curve for $V_c = 0$.

The transistor properties, in the cutoff and saturation ON states, greatly influence circuit d-c stability and switching speed. The transistor properties in the transition region between these states determine circuit switching speed, and input current requirements. In particular, the transistor base-to-collector d-c current gain, B_o is significant and may be considered as one figure of merit of the transistor in switching operation.

D-C PROPERTIES

The transistor properties in the cutoff state are shown in Fig. 2A. Associated with both collector and emitter junctions are leakage resistances, R_{cl} and R_{el}, reverse thermal currents, I_{ct} and I_{et}, and junction transition capacitances, C_{co} and C_{eo}. The total emitter and collector currents, I_{eo} and I_{co}, include both leakage and thermal currents and are supplied by the base current, I_{bo}. The magnitudes of the junction transition capacitances are dependent upon the reverse junction voltages and become quite large at small values of voltage bias.* When driving the transistor from a cutoff condition, these capacitances may introduce an appreciable time delay in the output signal.

The transistor saturation ON state is established when the collector load voltage becomes sufficiently low to cause the collector junction to become forward-voltage biased.[5] In this condition, both emitter and collector junction diodes may be represented by constant diode potentials, V_{je} and V_{jc}, together with the series diode resistances, r_{es} and r_{cs}, as shown in Fig. 2B. At low junction currents, the collector emitter voltage is essentially the difference between the respective junction voltages. The series resistances are normally less than .1 ohm for alloy junction transistors. In grown junction transistors they may be 20-200 ohms. The resultant high-saturation voltage and dissipation place much greater restraint on the use of this type of transistor for switching circuits.

High-voltage transistor operation is limited by avalanche breakdown or a "punch through" condition.** The avalanche breakdown condition is shown in the high-voltage region of the collector characteristics in Fig. 1. In either case, the breakdown condition, although not harmful in itself, may result in excessive transistor dissipation.

High-current transistor operation is restricted by reduction in current gain. In low-power alloy junction transistors, this effect may become severe for currents greater than 40 to 50 ma. In grown junction and surface barrier transistors considerable loss in gain may occur at currents as low as 5 ma.

The effects of temperature upon transistor characteristics are important in switching circuit operation. The junction thermal currents double for each 8 to 11° C. temperature rise. This affects both d-c circuit stability and timing in monostable and astable circuits. The transistor current gain also varies with temperature, decreasing at low temperatures, particularly in grown junction transistors. The value of B_o at the lowest operating temperature should therefore be considered in evaluating circuit input requirements and d-c stability. A third temperature effect is the variation in junction diode voltages at constant current. This variation, which occurs at approximately 2.5 millivolts/degree C, also affects circuit input requirements and is an important consideration in direct-coupled circuit operation.

TRANSIENT PERFORMANCE

In the transition region between cutoff and saturation, the major restrictions upon fast transient response of the junction transistor are the frequency limitations of minority carrier diffusion and the collector junction transition capacitance. A transistor equivalent circuit for this region is shown in Fig. 3. The emitter junction is considered an ideal diode, which is a reasonable approximation for switching operation involving junction currents greater than 1 ma. Diffusion frequency effects are incorporated as a time constant, T_{ce}, in the α_{ce} current generator where:

$$\alpha_{ce} = \frac{\alpha}{1 + j\omega T_{ce}}$$

The diffusion time constant, T_{ce} is related to the transistor frequency response by:

$$T_{ce} = \frac{1}{2\pi f\alpha}$$

where $f\alpha$ is the frequency at which the a-c emitter-collector current gain is .707 of its low-frequency value, α.

The collector capacitance in conjunction with the load resistance forms a second time constant, T_o, where:

$$T_o = [R_L + r_{b'}]\, C_C \cong R_L C_C$$
$$\text{for } R_L \gg r_{b'}$$

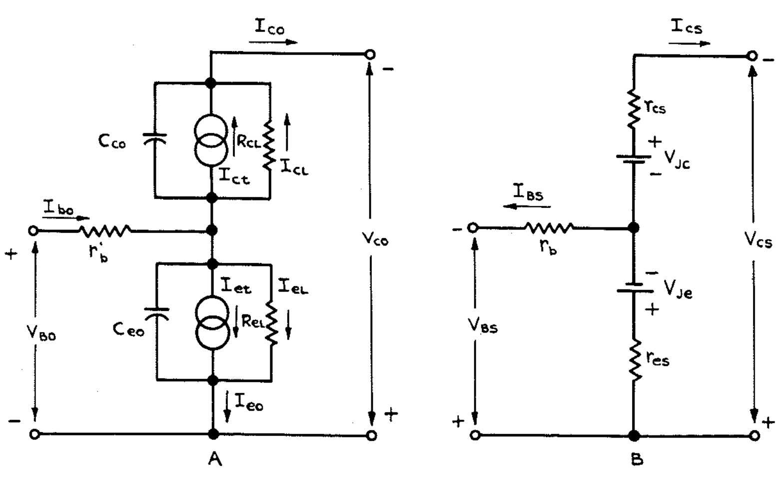
The effect of these time constants on the transient response of the common base (CB) stage is additive and assuming an applied step of emitter current of magnitude, I_E is given approximately by:

$$I_C = \alpha_o I_E \left[1 - \frac{t}{\varepsilon^{T_c}} \right]$$

where $T_c = T_{ce} + T_o$ and α_o is the d-c emitter-collector current gain.

For the common emitter (CE) stage the same considerations apply except that the time constants, T_{ce} and T_o are both magnified by the base-collector current gain. The time constant, T_c defining the 63% response in CB operation then becomes $B_o\, T_c$ in CE operation. In the common collector (CC) stage, the transient response is intermediate to that of the CB and CE

Fig. 2—Cut-off and Saturation Conditions.



* In alloy junction transistors, the junction transition capacitance is inversely proportional to the square root of the reverse junction voltage.

** Avalanche breakdown is a precipitous increase in junction current due to ionization multiplication of junction currents. Punch through occurs when the collector and emitter electrostatic fields make contact.[6]

cases depending on the relative magnitudes of source and load resistances. The time constant, T_o, is not magnified by the circuit gain in this case.*

SWITCHING SPEED

In switching operation, the transistor is overdriven so that the output response becomes limited by the transistor cutoff or saturation ON states or by corresponding clamped conditions. The OFF-ON circuit switching time may be reduced considerably from the response with linear operation. However, with saturation ON operation, the ON-OFF circuit switching speed becomes greatly restricted by storage conditions in the transistor.[7,8]

Typical switching waveforms for a CE amplifier are shown in Fig. 4. The OFF-ON switching time, T_s, is dependent on the stage transient response and on the amount of input drive. For both the CB and CE stages, the OFF-ON switching time for a step of input current of magnitude I_{in} is given approximately by:

$$T_s = \frac{I_o}{I_{in}} [T_{ce} + T_o]$$

where I_o is the collector load current.

For specified load conditions and transistor frequency response, the input current for a required output voltage, V_o, current, I_o, and switching speed, T_s, is approximately :

$$I_{in} = \frac{I}{T_s} \left[V_o C_t + \frac{I_o}{\omega \alpha} \right]$$

where $C_t = C_c + C_{load}$ for common base operation, $C_t = C_c + (1-\alpha) C_{load}$ for common-emitter operation, and $\omega\alpha = 2 \pi f\alpha$.

At the termination of the input pulse, the transistor introduces a storage delay, T_v in the ON-OFF transition of the circuit. This storage delay is a definite restriction in high-speed switching operation. It results from the high minority-carrier charge density established in base region of the transistor in the saturation ON state. This "stored" charge keeps the collector junction forward voltage biased following the input signal, thereby maintaining the transistor in saturation ON condition. Appreciable time may be required for this excess charge density to decay such that the collector junction may reform. A further result is that the subsequent decay time, T_d, may be relatively long.

The storage conditions are dependent on the magnitude of input current and collector current together with the frequency response and gain of the transistor. The relationship of these factors to the storage delay and decay times has been formulated with sufficient accuracy for use in circuit design.[7,8] The reader is referred to the references cited for further description and analysis of effects.

Methods to minimize this storage effect in switching circuit operation are important. The use of reverse input bias greatly reduces the storage delay and particularly the storage decay time. This necessitates larger input signal currents and increases the cutoff time delay as described previously. Collector ON clamping may be employed to avoid the saturation condition. Storage delay is reduced by this method, however, transistor dissipation is subsequently increased and the useful property of low transistor saturation impedance is lost. A very effective means of reducing storage effects is to employ a parallel RC network in the base or emitter. Fast switching times are achieved by the high-current drive provided by the low capacitive impedance during the transition times of the input signal. The degree of saturation becomes resistance limited during the intervening period. Proper circuit design using this technique may virtually eliminate storage effects.

The design of transistor computer circuits is usually a compromise between drive requirements to achieve required circuit switching speed, and the output capabilities of a driving stage to supply a prerequisite number of load stages. Presently the limited transistor frequency response and especially the storage effect place a premium on circuit input requirements and storage compensation techniques to achieve fast circuit operation.

TRANSISTOR PULSE AMPLIFIER CIRCUITS

Pulse and level current amplification are important circuit functions in digital computers. The gain and operating speed of such circuits strongly influence the maximum computer pulse repetition frequency (PRF) and determine the manner and extent of intercoupling of associated logic circuits.

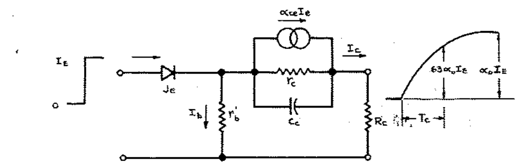


Fig. 3—Transistor Equivalent Circuit In The Transition Region.

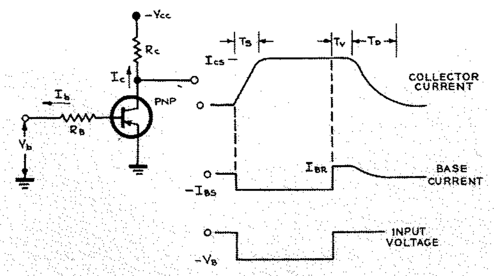


Fig. 4—Transistor Switching Response.

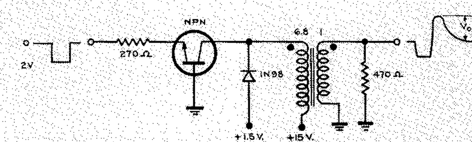


Fig. 5—Common Base Pulse Amplifier.

A transformer-coupled CB pulse amplifier stage is shown in Fig. 5. This circuit provides the best transient performance for this application. The circuit shown has a current gain of 4 with a negative 2-volt input pulse of .5 microsecond duration. Using NPN transistors with $f\alpha > 6$mc, output rise and fall times with a 300 $\mu\mu$f and 100-ohm load are .1 microsecond. Circuit recovery time is 1.2 microsecond which allows a PRF of 500kc. The recovery time is limited by the permissible overshoot voltage, V_o, as determined by the transistor breakdown voltage.

The CC or emitter follower stage shown in Fig. 6 is useful for pulse amplification, particularly as buffer stages from flip-flops under high-load conditions. Normally, this stage is not overdriven so that its video response defines the maximum circuit operating speed. Because the CC response varies inversely with circuit current gain, a compromise must be made between these factors. The output will

* A more extensive treatment of transistor transient response is given in reference 7.

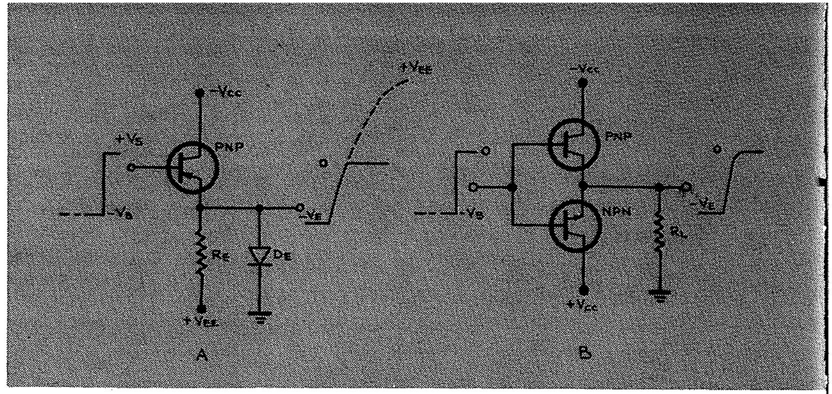
suffer a loss in voltage level because of the base-emitter voltage drop, V_{be}. This limits the maximum load current and makes the use of high-gain transistors desirable for this application.

An important limitation in circuit speed occurs due to load capacitance. The output voltage then decays more slowly than the input, causing the emitter junction to become reverse biased. The output voltage then decays with the load time constant, as shown in Fig. 6. Relatively long decay times may result with high-capacitance loads.

Two circuit techniques to decrease the decay time in emitter follower response are shown in Fig. 7. The circuit in A utilizes emitter clamping. Following the input pulse, the load voltage decays toward V_{ee}, becoming clamped, by diode, D_e, during the early portion of its exponential decay. In using this technique, a compromise must be made between desired decay time and the additional loading from the diode current.

The circuit in Fig. 7-B uses complementary transistors to decrease the emitter follower response time. With the positive input step, the PNP unit becomes reverse biased, as before. However, the NPN stage, then conducts and provides emitter follower action to reduce the output decay time.

Fig. 7—Methods To Improve Emitter Follower Response.



TRANSISTOR GATE CIRCUITS

Gate Circuits comprise a large percentage of the total circuit complement in a digital computer. The permissible number of gate inputs and the input current requirements are important criteria, and determine, to a large extent, the type of computer circuit logic which is used, as well as the design requirements of amplifier and flip-flop stages.

Transistors have particularly useful features for AND and OR gating circuits. The low input impedance of the CB and CE stages permits the use of resistive inputs while maintaining satisfactory input isolation. The CB pulse amplifier is shown in abbreviated form in Fig. 8-A with resistance OR inputs. The output transformer limits the gate operation to pulse OR logic. The CE stage shown in Fig. 8-B is useful for level OR operation. Resistance values for the CE stage must be higher than those for the CB stage for the same input isolation because of the higher input impedance. CB and CE stages may be paralleled in either case to increase the gating capacitance.

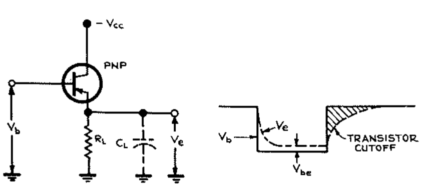


Fig. 6—Common Collector Pulse Amplifier.

A very useful transistor AND gate is shown in Fig. 9. The transistor is used here as a controlled switch in shunt with the signal line. Resistive inputs are again employed. In the inhibit gate condition, one or more inputs is at $-V_b$, holding the transistor in a potential saturation ON condition. A negative signal applied to input C is then shorted from the output by the low transistor saturation resistance. With all base inputs at zero or positive, the transistor is cutoff, and is isolated from the circuit. A signal at C then produces an output through the (R_C-R_L divider, where R_L may be the input impedance of a following transistor stage. A large number of gate control inputs may be obtained by paralleling transistor stages.

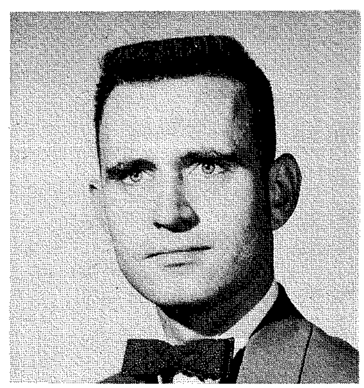
A series AND gate configuration employing transistors as cascaded switches is shown in Fig. 10. With one or more base inputs at zero or positive, the corresponding transistor(s) are cutoff. With all inputs at $-V_b$, each transistor is "on" and the output follows the input waveform of the shortest duration. Control current requirements become somewhat larger for the bottom stages since they supply the base currents for the stages above in addition to the output current.

Another type of AND control is shown in Fig. 11, using the CB pulse amplifier. With the base control level at $-V_b$, the emitter junction is reverse biased preventing pulse amplification. When the control level is at zero, the circuit is unbiased and pulse amplification occurs normally. The base capacitor, C_B, improves the circuit transient performance by providing a low base impedance during circuit transition times. The input pulse rate, however, is limited by the charge and discharge times of R_B and C_B and the transistor cutoff capacities.

The use and design of these transistor gate circuits are compromises between input current requirements and operating speed. The utilization of transistor switch properties and current gain, however, results in important advantages in these applications. The different types of gate control provided by these circuits are useful in implementing circuit logic.

TRANSISTOR FLIP-FLOP CIRCUITS

Transistors have very important advantages for use in flip-flop circuits. Their switching properties greatly en-



DON E. DEUITCH received the B.S. in E.E. Degree from Purdue University in 1950. He joined RCA in October of the same year and worked on the design of a UHF Magnetron Transmitter until 1952. Since that time, Mr. Deuitch has been concerned with the investigation of switching properties of transistors and the development and design of transistor computer and other switching circuits. He has made several presentations and written three papers for publication on these subjects. Mr. Deuitch is a member of the IRE, Tau Beta Pi and Eta Kappa Nu.

hance circuit designability and operating reliability, while allowing wide component and voltage tolerances. Transistor flip-flops may be designed to supply relatively high d-c load currents. For high-speed operation, high trigger currents may be required, particularly for commutating or counting operation.

A low-speed saturating flip-flop circuit is shown in Fig. 12. The ON stage, T_2, is held in saturation by the current bias from the cutoff stage, T_1, which in turn is cutoff by the +3 volt base supply. The low saturation impedance of T_2 greatly simplifies circuit d-c design and provides efficient ON clamping. Insensitivity to noise and transient signal is provided by storage in the ON stage.

This circuit using low-frequency transistors, such as the RCA-2N109, operates at trigger rates up to 50 kc. Resistance trigger coupling is used with a negative 6 volt, 2 microsecond, trigger pulse. For a collector OFF voltage of —12 V (OFF clamping not shown), the circuit will supply OFF and ON d-c load currents of 1 ma. with switching times less than 4 microseconds. The circuit speed is limited mainly by the large cross coupling capacitors, C_s. The required value of C_s is determined by the transistor frequency response, the trigger signal characteristics and the circuit loading.

A high-speed flip-flop stage is shown in Fig. 13. Using high-frequency transistors, such as the RCA-2N140, this circuit is capable of 700 kc operation. With the OFF collector voltage clamped at —6V, the circuit supplies 2 ma ON and OFF d-c load currents. The reduced value of the cross coupling capacitors produces circuit switching times less than 1.5 microseconds, under maximum load conditions. Diode trigger coupling is employed to obtain d-c isolation from the trigger source.

These circuits illustrate many of the important features of junction transistors for digital computer circuits. They, however, by no means cover the wide scope of transistor application to this field. Complementary transitor circuits and circuits utilizing symmetrical transistor properties have important use in many computer circuits. New semiconductor devices, as mentioned under *Transistor Types,* are receiving increased use. Direct-coupled transistor computer circuit operation is a useful transistor computer technique.[9] This type of operation results in extreme circuit simplicity, although is limited in speed and operating temperature range.

SUMMARY

Transistors have many desirable features for digital computer service. Their unique switch property and low-voltage and high-current performance result in operational improvement in many computer circuits. Their small size and low-power requirements are desirable features from both the circuit and equipment standpoint. Although limited in frequency response and high-voltage operation, transistors have useful application to most digital computer circuitry.

The important switching properties of junction transistors were described, including d-c characteristics and the factors influencing transient and switching performance and the storage effect. Basic amplifier, gating and flip-flop circuits were presented to illustrate many of the important features of transistors in these applications.

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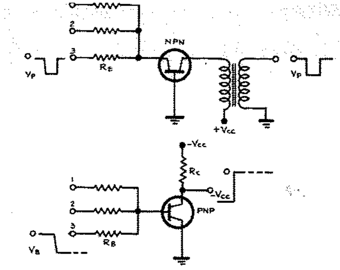


Fig. 8—Resistance Or Gates.

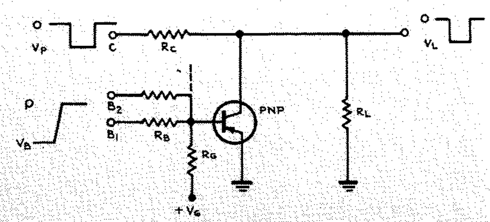


Fig. 9—Shunt And Gate

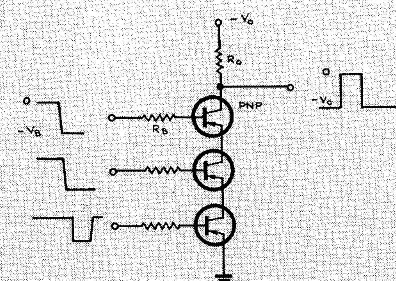


Fig. 10—Transistor Series And Gate.

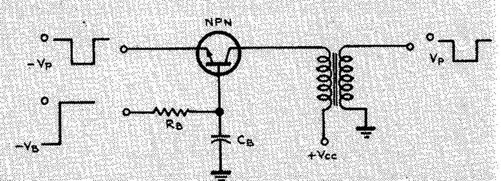


Fig. 11—Pulse Amplifier And Control.

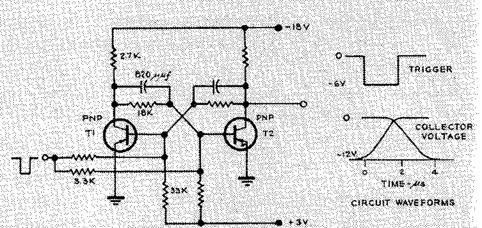


Fig. 12—Low Speed Flip Flop Stage.

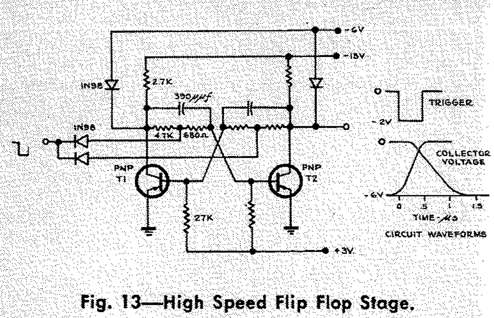
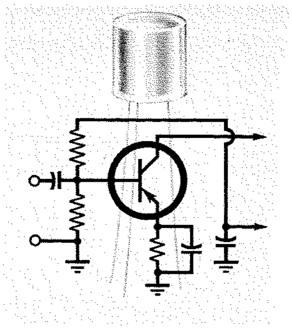


Fig. 13—High Speed Flip Flop Stage.



A NEW PHOTOCELL USING LATERAL PHOTOEFFECT

by

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PHOTOSENSITIVE DEVICES are one of the company's main interests, as witnessed by the large number of commercial types now marketed by RCA—from simple phototubes, vacuum or gas-filled to more sophisticated forms like multiplier phototubes, image orthicons, vidicons, etc.

This article describes a new development which, as yet, has only reached the laboratory stage, namely a photocell that uses an *interesting new effect in semiconductors, the lateral photoeffect.* The cell is different from ordinary photocells in that it not only senses the strength of a light source, but also the direction to the light source. Photocells that sense direction to a light source (so-called differential photocells) are not new in principle. They have been known for 25 years, however, not many applications have been found for them, because of several serious shortcomings. It now appears that the cell employing the lateral photoeffect, described in this article, is free from many of these shortcomings and in addition has novel features which should be valuable in practical applications.

Before the photocell is described, a short look at the physical principle on which it is based, namely the lateral photoeffect, is in order.

THE LATERAL PHOTOEFFECT

When a light is incident on a semiconductor close to a p-n junction, the hole-electron pairs injected by the light will be separated by the junction creating a voltage across the junction. This is the well known "photovoltaic effect." However, the interesting fact underlying the new lateral photocell is that, with a small spot of light and a large junction, not only is a voltage created across (transverse to) the junction, but also parallel to the junction in a lateral direction. This is illustrated schematically in Fig. 1.

Voltmeter 1, connected between the n-type and the p-type regions, will read the photovoltaic voltage. Voltmeter 2 connected between any two points along the surface of the n-type region will read a lateral voltage. The potential will be lowest at the light spot and rise toward the sides.

THE NEW PHOTOCELL—HOW IT WORKS

The use of the lateral photoeffect in some experimental photocells will now be described. The construction is

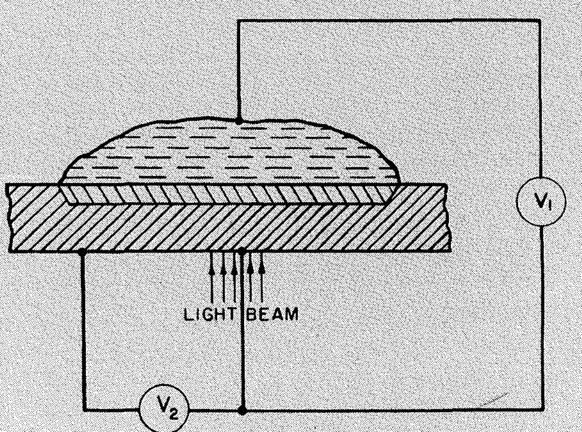


Fig. 1—The light beam incident on the germanium surface gives a transverse photovoltage measured by the voltmeter V_1 and a lateral photovoltage measured by the voltmeter V_2.

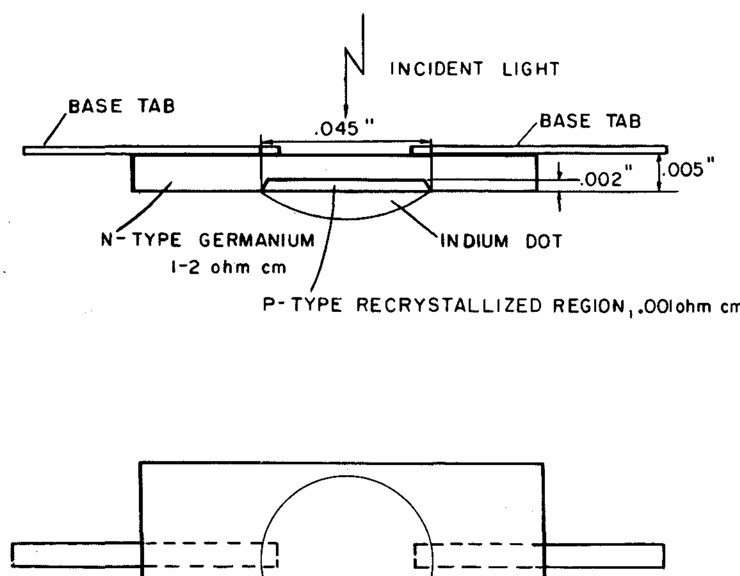


Fig. 2—Photocell utilizing lateral photoeffect. Notice that materials and dimensions are similar to those used in most transistors.

shown in Fig. 2. The cell consists of a germanium wafer, of 1 to 2 ohm-cm resistivity of transistor dimensions, i.e., approximately .005″ thick and ¼ inch square. An indium dot .045″ in diameter is alloyed onto the wafer to a depth of .002″. Two base contacts are applied symmetrically. Some experimental cells are shown in Fig. 3.

Now let us consider how the photocell works. Assume first that a light spot hits the cell at the point A indicated in Fig. 4. Then a voltmeter connected between the two base contacts (see Fig. 4) will measure the difference between two lateral voltages. One voltage exists between the light spot and the left end of the photocell, and the other voltage and larger one appears between the light spot and the right end of the cell. Therefore the output voltage will rise to a value of 1.5 mv as indicated by the curve in Fig. 4.

Now let us move the light spot to the center of the cell indicated by the letter B. Then the voltmeter will measure the difference between two equal and opposite voltages, that is to say, zero. This corresponds to the crossover point of the characteristic. Finally, when the light spot is moved to the point C, the left-hand lateral voltage will be larger than the right-hand one, and the output voltage will be negative as indicated by the characteristic. The resulting curve is a straight line except at the ends, where stray effects cause a fall-off.

With four base contacts on the photocell (the fifth lead is connected to the dot) as shown to the right in Fig. 3, the output voltage from one pair is proportional to the light spot position in a horizontal direction, while the output voltage from the other pair is proportional to the light spot measurement in vertical position.

MEASURING DIRECTION TO A LIGHT

The most obvious application of such a photocell is to measure the direction to a light source as indicated in Fig. 5. Here the light from a distant light source is focused by a lens onto the photocell. When the light falls on the center of the cell, no output voltage will be read by a voltmeter between the two base contacts. But, when the light is off to one side of the symmetry axis, a positive voltage will result. This voltage is larger the further away the light is from the symmetry axis. When the light is on the other side of the symmetry axis, a negative voltage will be shown by the voltmeter.

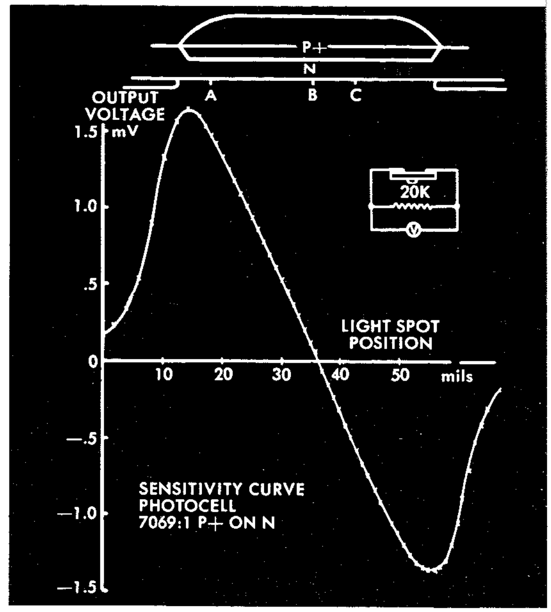


Fig. 4—Light sensitivity of a lateral photocell. Output voltage is plotted versus light spot position.

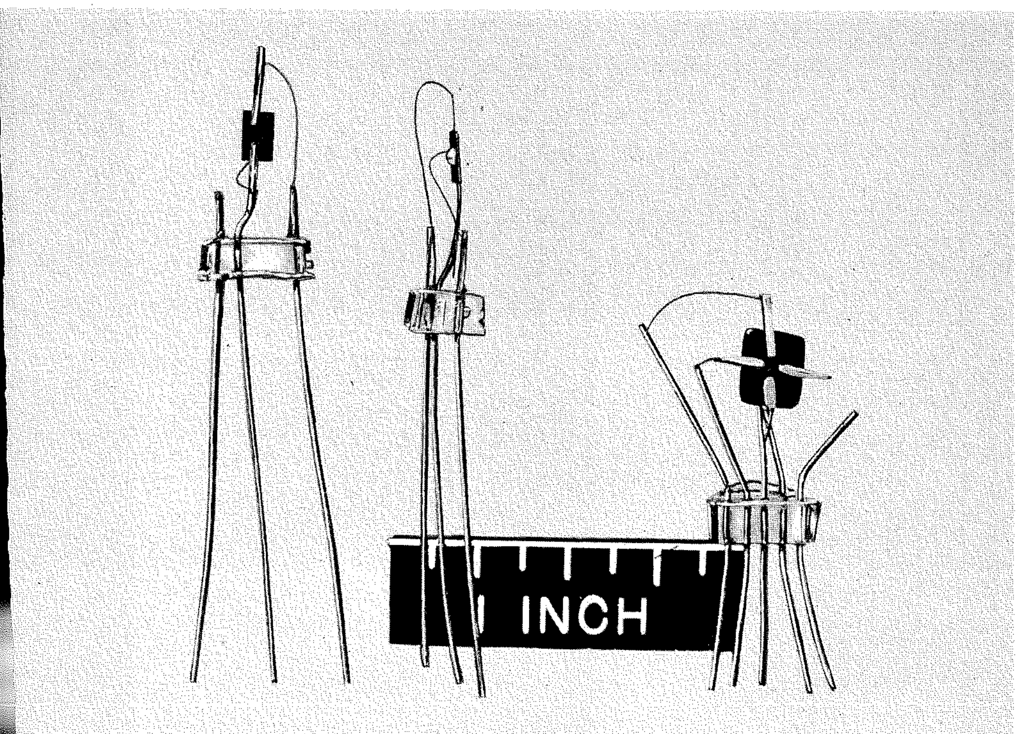


Fig. 3—Some experimental photocells. To the right a cell with two pairs of base tabs for measuring light spot location in two coordinates simultaneously.

The resultant voltage (either positive or negative) becomes larger as the light is moved away from the symmetry axis. This means that the direction to a light can be found by turning the photocell until the output voltage is a minimum, indicating that the cell is pointed directly towards the light. The accuracy of this direction finding is better than 0.1 second of arc, which is considerably better than that accomplished by even a good optical range finder. This high accuracy means that the light spot on the photocell can be located to better than 100 Å. Using a four-base photocell, the direction can be measured in two coordinates simultaneously.

ELECTRONIC SWEEPING

In many cases it would be very desirable to be able to find the direction to a light of short duration, say a few milliseconds, such as the light flash from a gun on a battlefield. Of course, to rotate the cell in that short time would be very difficult. However, as indicated in Fig. 5, the turning could be simulated if by some means we could shift over the characteristic curve. Then a light off the symmetry axis as in Fig. 5 could be located by shifting the characteristic a certain amount until the output voltage reads zero. The amount of shift would be a measurement of the direction to the light. This can actually be accomplished with the lateral photocell by sending a current between the base contacts. The result is shown in Fig. 6. This means that we have accomplished an electronic analogue to turning the photocell, let us call it electronic sweeping.

However, this solution has one drawback. The sweeping current is applied between the base contacts, where the output is also measured and the two get mixed up. The obvious and often used way out is to use a light chopper that chops the light and converts the desired signal to a-c so that it can be filtered out from the applied sweeping current. But, although we have avoided a mechanical turning of the photocell, we have introduced a mechanical chopping of the light, a somewhat doubtful gain. However, it is also possible to make an electronic equivalent of the light chopping.

ELECTRONIC LIGHT CHOPPING

To accomplish the electronic chopping of the light signal, the alloyed dot is used. When a forward current is sent through a balanced arrangement as shown in Fig. 7, this current does not contribute to the output signal. However, the voltage drop caused by the current hinders the holes from reaching the p-type region and therefore reduces the sensitivity of the photocell. In other words, the higher the forward current through the junction, the lower the slope of the characteristic shown in Fig. 7.

This means that if we apply a square wave to the dot so that during part of the wave the dot is biased in the forward direction, and during part of the wave unbiased or in the backward direction, the sensitivity of the cell and the output signal will vary with the square wave. As a consequence, the output signal can be filtered out and separated from the sweeping signal.

The net result is that with the lateral photocell an entirely electronic method of finding the direction to a light source is possible, without any moving parts.

APPLICATIONS OF THE LATERAL PHOTOCELL

Although as yet no applications have been worked out in detail, it is interesting to investigate those fields in which the special merits of the lateral photocell may be advantageous.

1. LIGHT FINDER FOR BLIND TELEPHONE OPERATORS.

Recently it has been suggested to equip blind telephone operators with a small photocell mounted on a fingertip which would enable them to find lighted switchboard lamps indicating that a call should be connected or disconnected (see Fig. 8). The lateral photocell in this application would make it possible to steer the hand in a straight and rapid course to the lamp by listening for a minimum in a tone in the phone. If several lamps flash at the same time, approaching the hand to the switchboard will bring one after another of the lamps outside the visibility angle of the cell until only one remains, making it possible to locate the lamps one by one. For speedier operation two photocells could be used simultaneously, one on each hand, and giving a slightly different tone in the earphone.

2. LIGHT LOCATOR.

A light locator is shown in Fig. 9. It consists of two lateral photocells with sweeping and chopping circuits. Assume a sudden flash of light at a distance, e.g. from the firing of an enemy gun. Then both photocells give signals which may be used to vary the interbase sweeping currents in the cells until the signal is zero. The two interbase currents then define two angles, or two lines, intersecting at the point of light. Since the speed of response of the photocell should be good to approximately 1 mc/s, enough time is available during the duration of the light flash (some milliseconds) to accurately measure the directions. As the photocell is sensitive out to ap-

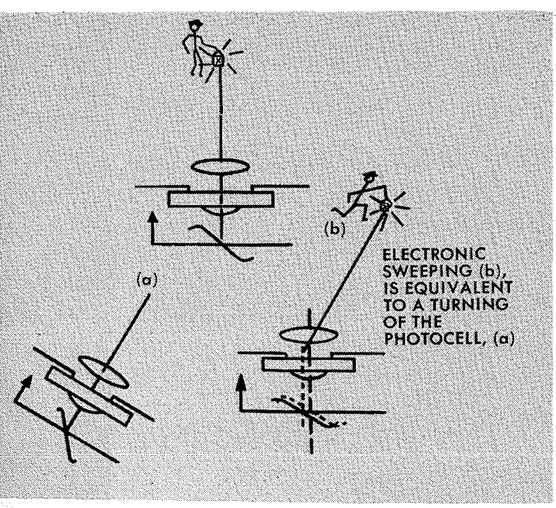


Fig. 5—Electronic sweeping principle: At top photocell is lined up with light source. When source is moved to position "A" (turning the photocell) it is same as "B" (shifting of characteristic curve).

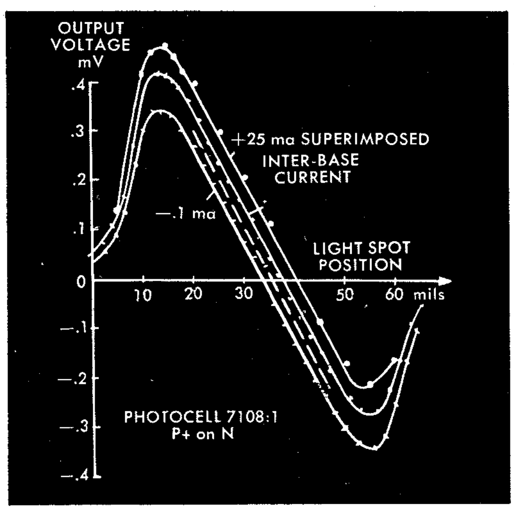


Fig. 6—As shown above, shifting of the sensitivity curve for superimposed interbase current can be accomplished with the lateral photocell.

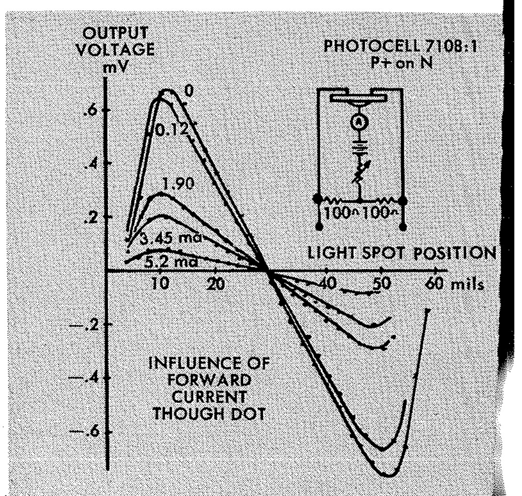


Fig. 7—The above curves represent a lowering of the sensitivity by influence of forward current through the dot (illustrating electronic light chopping principle).

proximately 1.9μ, infrared light can also be detected.

3. VIBRATION DETECTOR.

A vibration detector for investigation of microphonics in electron tubes, for example, is shown in Fig. 10. A small spot of light is used as a probe, and is focused on suspect tube elements while the photocell is used as a detector to detect vibration of the illuminated part. The output from the photocell may be viewed on an oscilloscope and directly compared with the output from the tube under test. The photocell can tell not only which tube element vibrates and how much, but also determines in which direction.

4. FUNCTION GENERATOR.

A function generator for analog computers is shown in Fig. 11. The desired function is drawn on paper, a photographic negative is made and mounted inside a transparent cylinder which rotates around a filamentary lamp. A slit transmits one point of the curve at a time onto the photocell. The output current then represents the desired function. In an application of this type, linearity is the main requirement. The linearity has been measured by connecting two experimental cells in opposition, measuring only the difference between the two, and it was better than 1.5% in spite of the primitivity of the experimental cells.

J. TORKEL WALLMARK received the degree of Teknologie Doktor from the Royal Institute of Technology, Stockholm, Sweden in 1953. From 1944 to 1945 Dr. Wallmark was a tube designer with the A. B. Standard Radiofabrik, and from 1945 to 1953 he was with the Royal Institute of Technology as a research engineer working on electron tubes. He was also connected to Statens Tekniska Forskningsrad working on research administration and Elektrovarmeinstitutet working on semiconductors.

In 1947 and 1948 Dr. Wallmark was a fellow of the American-Scandinavian Foundation at RCA Laboratories. In 1953 he returned to the Laboratories and is presently working on surface phenomena on semiconductors.

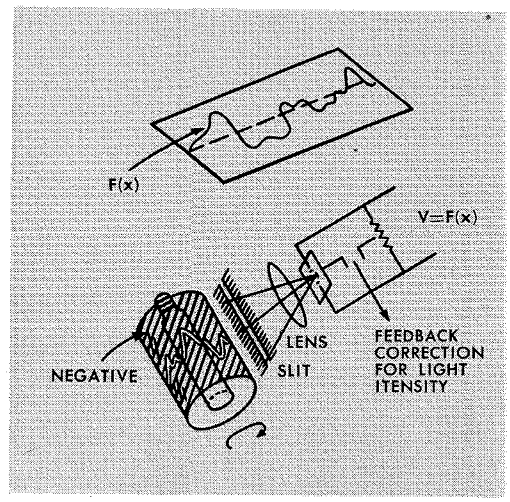


Fig. 11—Function generator. The desired function is drawn, made into a negative and wrapped around a lamp. When the negative is rotated the output from the photocell directly gives the function.

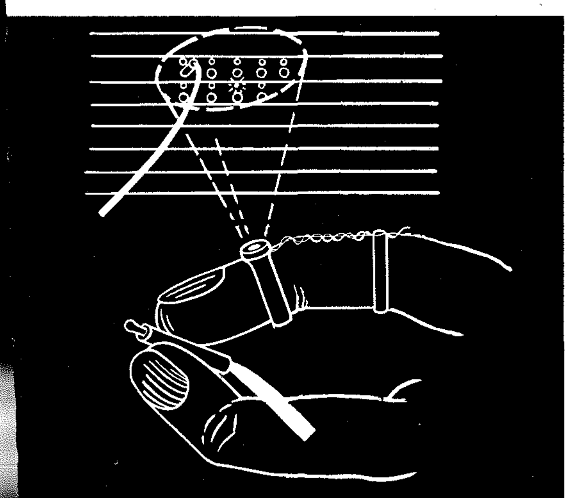


Fig. 8—Aid for blind telephone operators. The photocell mounted on a finger senses the direction to lighted switch board lamps giving a minimum tone in the headphone for correct approach.

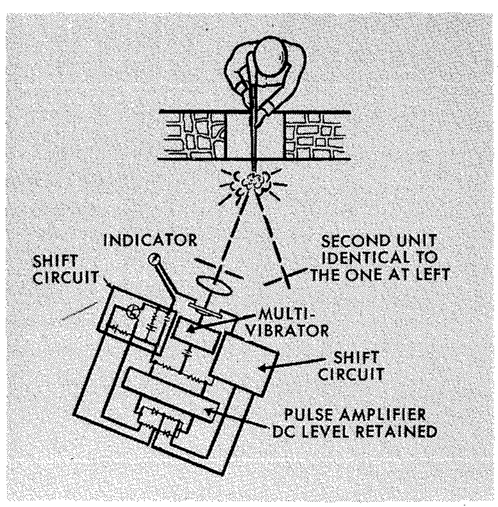


Fig. 9—Light locator. A sudden flash of light operates two independent lateral photocells. The shift of the characteristic curve necessary for minimum signal indicates bearing to the light.

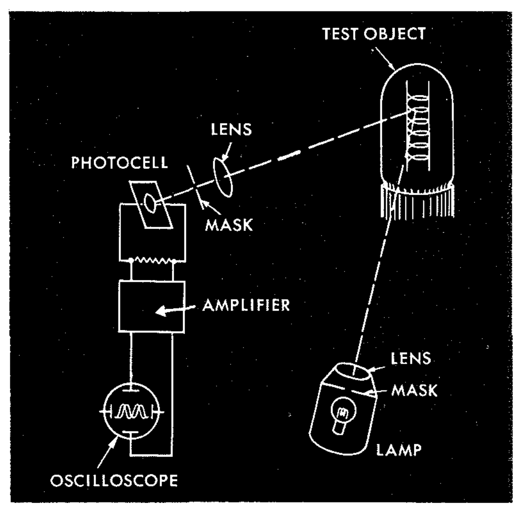


Fig. 10—Sketches showing vibration detector principle. A vibrating part that is illuminated causes a signal from the photocell with a frequency and an amplitude characteristic of the vibrating part.

USE OF X-RAY DIFFRACTION IN SOLID-STATE CHEMISTRY

by
DR. PAUL G. HEROLD
Chemical and Physical Laboratory
Tube Division, Lancaster, Pa.

In the brief time of sixty years since Röntgen discovered X-ray, these invisible rays have become a powerful tool for the chemist delving into the structure of materials. Little did Röntgen realize that his unique discovery would one day be useful in the orientation of metallic crystals for use in transistors, or in the identification of the various crystalline forms of zinc orthophosphate for use as the red phosphor in color television kinescopes. Röntgen did foresee the use of X-rays in medicine, called radiography, in which the invisible rays reveal broken bones and diseased organs in the body.

It was not until 1912 that X-rays were known to be diffracted by the atoms arranged in a regular array in crystalline materials. This discovery opened up an entirely new method of identification of crystals and provided an insight into the forces causing a crystal to form and to change under various externally applied conditions. Soon it was found that when X-rays were allowed to impinge on a crystalline material a complex array of low-intensity X-ray beams were diffracted by the rows of atoms arranged in planes within the crystal. It was shown that each crystalline material gave a characteristic diffraction pattern which was unique and could be used to identify that particular crystalline material, much as fingerprints are used to identify individual human beings. The diffraction patterns or "fingerprints" for several thousand crystalline substances have been recorded in a card index supplied by the American Society for Testing Materials. Thus, as long as a material is listed in the ASTM file, it can be absolutely identified by X-ray diffraction methods.

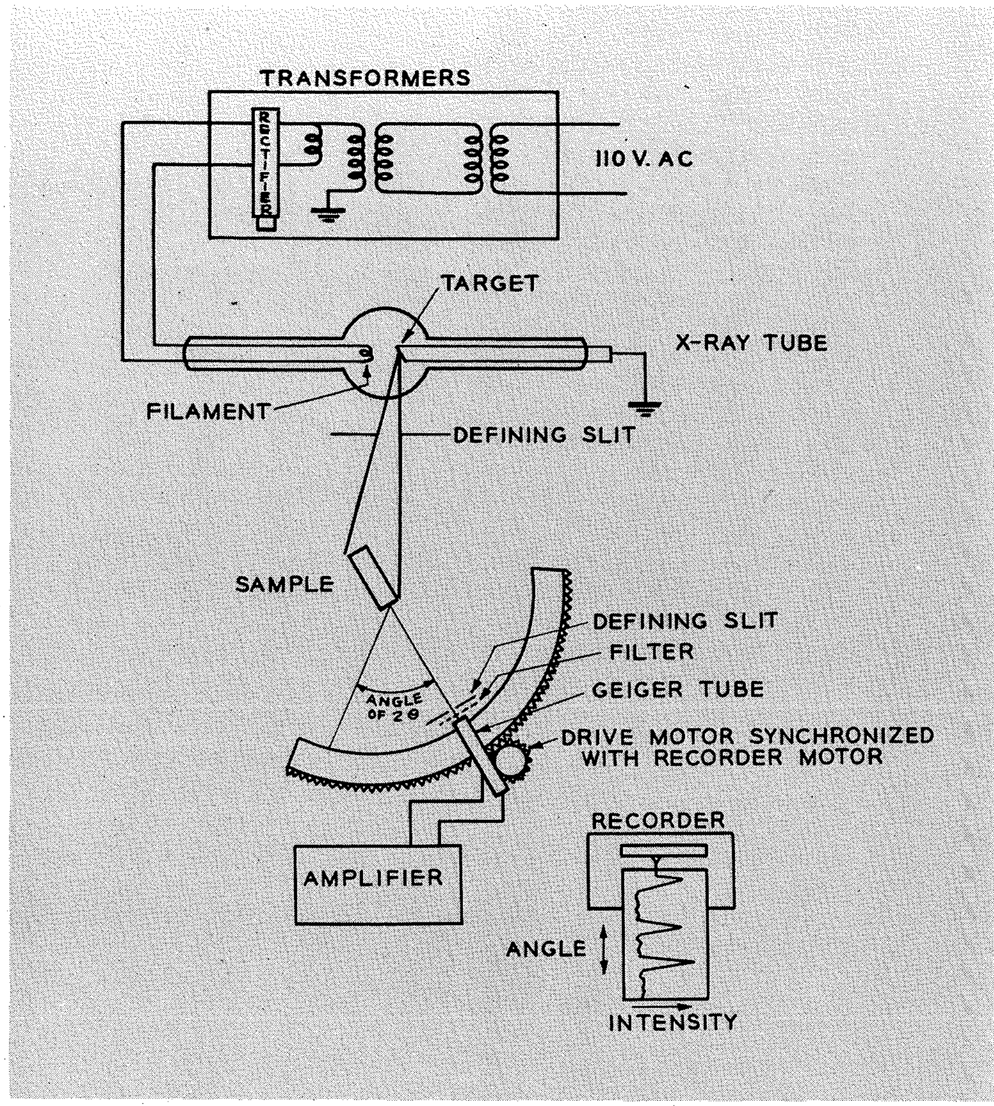


Fig. 1—Arrangement of X-ray equipment.

DIFFRACTION EQUIPMENT

In any diffraction equipment, there are three essential components required to obtain the diffraction pattern. First of all, a source of pure, high-intensity X-rays is required. This source is usually an evacuated sealed tube containing a tungsten filament which provides the electrons, and a metal target against which the electrons are hurled to generate the X-rays. X-ray tubes for diffraction work are usually operated somewhere in the vicinity of 40,000 volts and 20 milliamperes and have a target of copper, iron, or molybdenum. The various metal targets produce X-rays having different wavelengths. Second, a method of holding the sample material is required. This method usually comprises a very simple device for positioning the solid or finely ground sample in a definite relationship to the source of X-rays, and to the device used to record the diffracted X-rays coming from the sample.

The third requirement is a recording device so that the X-rays being diffracted from the sample can be recorded to show the angle between the X-ray beam coming from the source and the diffracted rays. Also, a record is needed of the intensity of each diffracted X-ray coming from the sample. The recording device is usually a photographic film which is sensitive to X-rays, or a geiger counter which is passed through the diffracted X-ray beams to indicate angle and intensity. The latter device is the one usually favored nowadays, several commercial models of which are available. The arrangement of equipment is shown in Fig. 1.

Because the filter placed in front of the geiger tube is opaque to beta X-rays generated by the tube, but transparent to alpha radiation, it is used to produce a diffraction pattern free of beta radiation. This technique simplifies the diffraction pattern obtained.

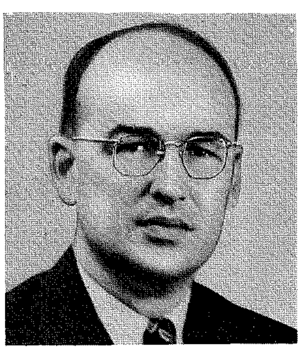
The type of diffraction pattern obtained with the equipment shown in Fig. 1 is a plot of angle versus intensity. The values usually reported in the literature, however, are "d-values" versus relative intensity. The d-values refer to distances between planes of atoms in the crystalline substances being investigated and can be calculated from the well-known Bragg equation:

$$\lambda = 2d \sin \theta$$

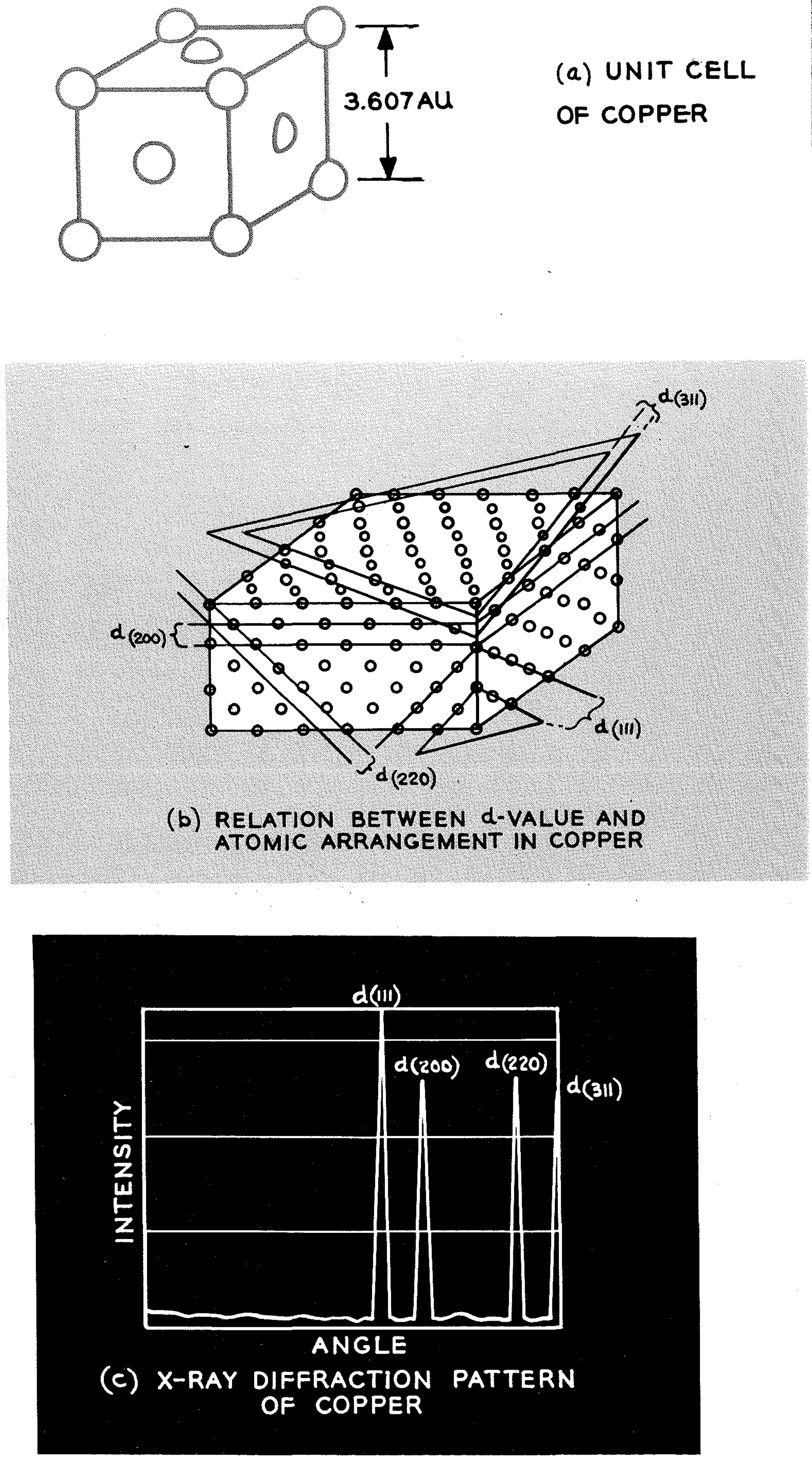
where λ = wavelength of the X-rays

θ = one-half the angle between the undeviated X-ray beam and the diffracted X-ray beams.

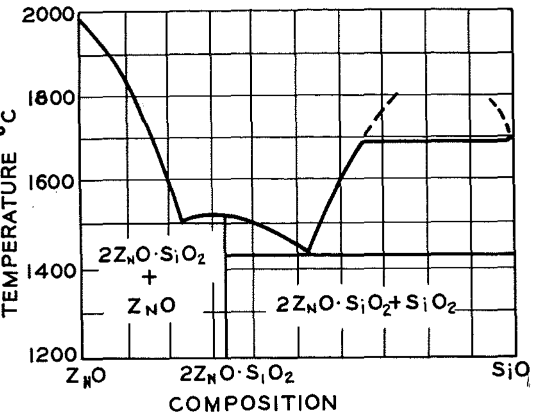
d = distance between two planes in the crystal.

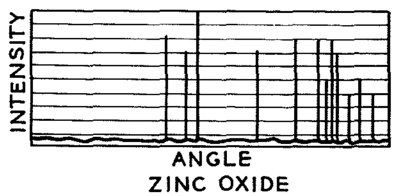


PAUL G. HEROLD was awarded the Ph.D. degree by the Ohio State University in 1934, and the M.S. and B.S. in 1932 and 1931 respectively. His major work was Ceramic Engineering with interest in Mineralogy and Geology. Dr. Herold has served with General Motors in the Spark Plug Division, with Western Electric Company working on ceramic dielectrics, and is now with RCA, Lancaster in the Advanced Development of Phosphors. Immediately before coming with RCA, he was Chairman of the Ceramic Engineering Department of the School of Mines and Metallurgy, University of Missouri and Director of the Missouri Clay Testing and Research Laboratories. He is a Fellow of the American Ceramic Society and a member of Sigma Xi and Tau Beta Pi.



Figs. 2a, b and c—Atomic arrangement of copper.





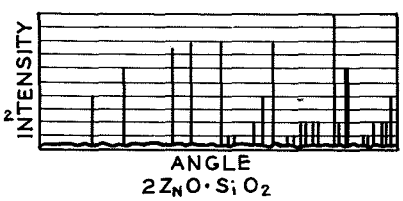
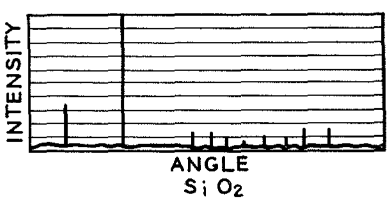
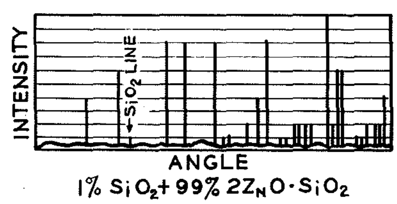


Fig. 3—Phase system of ZnO · SiO₂ with X-ray diffraction patterns of crystals in the system.





For instance, let us look at a very simple material, copper, which crystallizes in the cubic system and is known to have a body-centered atomic lattice. Fig. 2 (a) gives the appearance of a unit cell of copper, while Fig. 2 (b) shows the relationship between the atomic arrangement and *d*-value or distance between planes, and Fig. 2 (c) shows the X-ray diffraction pattern.

SOME PROBLEMS WHICH HAVE BEEN SOLVED BY X-RAY DIFFRACTION METHODS

Identification of Crystalline Phases Present in a Mixture:

Often it is necessary to know whether there is more than one crystalline substance present in a sample and also to know the identity of the substances. An excellent example is the manufacture of zinc orthosilicate which is the mineral willemite. This material, when activated with a small amount of manganese, produces the standard green phosphor used in the screen of the color television kinescopes. Fig. 3 gives the phase diagram of the system zinc oxide-silicon dioxide in which the zinc orthosilicate occurs. This diagram shows that during manufacture it is possible to produce zinc orthosilicate ($2ZnO \cdot SiO_2$) with an excess of either zinc oxide (ZnO) or silicon dioxide (SiO_2). In either case the luminescent intensity of the resulting green phosphor is seriously affected. Fig. 3 also shows the X-ray diffraction patterns of the three crystals. The patterns are quite different from each other. The fourth pattern shows a zinc orthosilicate sample containing about one per cent excess of silica. The X-ray diffraction pattern thus can be used as a check on the manufacturing technique to tell when the zinc orthosilicate phosphor has been prepared properly.

Identification of Polymorphic Phases:

In 1951, Dr. A. L. Smith* published the important discovery that zinc orthophosphate activated with manganese could crystallize in any one of three crystalline forms depending on the amount of manganese introduced into the zinc orthophosphate. This discovery was important because zinc orthophosphate is the red phosphor used in the color television kinescope. He found that the alpha form of zinc orthophosphate produces a green color, the beta form an intense red color, and the gamma form a weak red color. The X-ray diffraction patterns of these three polymorphic forms are given in Fig. 4. A comparison of the three X-ray patterns revealed the presence of these forms. These results were then related to manufacturing methods so that the present red phosphor would be made with consistent light output of high intensity.

Solid Solution of Two or More Phases:

In some cases two or more crystalline substances will mutually dissolve in each other under the influence of heat, producing a single crystalline phase. The resulting solid solution usually possesses physical properties intermediate between the properties of the end members. Also, the X-ray diffraction pattern shows a shift in angle of all the lines depending upon how much of each crystalline material has entered into the solid solution. Usually there will be continuous solid solution between two crystalline substances if they crystallize in the same crystal system and the atomic sizes of the atoms do not differ by more than 20 per cent. For instance, zinc sulfide (ZnS) and cadmium sulfide (CdS) both crystallize in the hexagonal system when heated to high temperatures. The zinc atom has a radius of 0.83 AU and the cadmium atom a radius of 0.99 AU; the difference, therefore, is about 16 per cent. There is a continuous solid solution between these two sulfides as shown by X-ray diffraction patterns, a few of which are shown in Fig. 5 Also shown is the shift in cathodoluminescent color of the zinc cadmium sulfide solid solution when activated with silver.

The Determination of the Percentage of Crystalline Substances Present In a Mixture

Many times it is necessary to know not only *what* is present in a mixture but also *how much* of each material is present. This knowledge can be obtained easily by X-ray diffraction technique. For instance, it was necessary to know the amount of free zinc

*"Luminescence of Three Forms of Zinc Orthophosphate: Mn" by A. L. Smith, RCA Lancaster, Journal-Electrochemical Soc. Vol. 98, p 363, 1951.

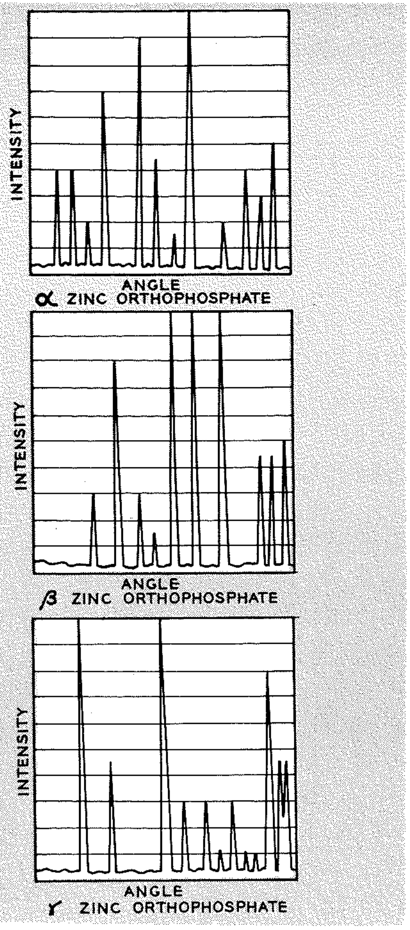


Fig. 4—Three forms of zinc orthophosphate.

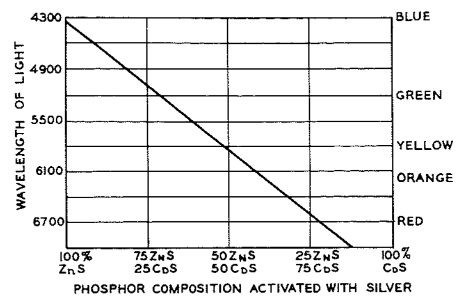
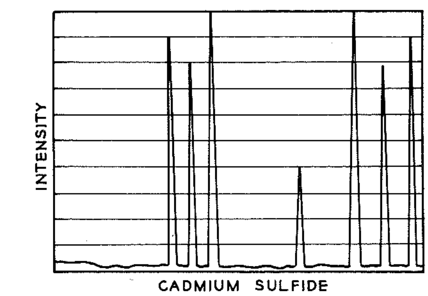
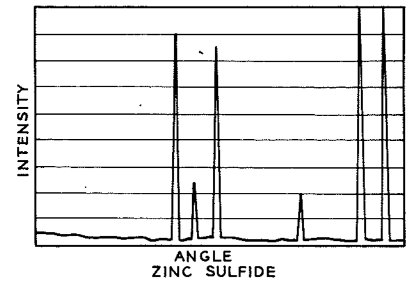
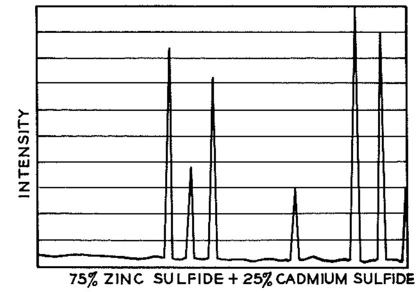


Fig. 5—Solid solution in the system ZnS-CdS versus cathodo-luminescent colors.







oxide present in zinc orthophosphate. This amount could perhaps be measured indirectly by a chemical analysis for phosphorus and zinc followed by a calculation of the amount of excess zinc present above that required for the zinc orthophosphate. This method, however, is subject to considerable error. Consequently, the X-ray method which has been used with considerable success is preferred. In this method, some mechanical mixtures of the two end members covering the likely range of composition of the unknown sample are first made. An X-ray pattern of each mixture is then made, and the area under the curve for a strong line of each one of the end members is measured. This procedure gives a ratio of areas for the two materials versus the amount of the two materials in the mixture. The same procedure is followed for the unknown mixture. When the ratio of areas under the two peaks is determined for the unknown, it can be compared to the known compositions and a direct answer obtained. Fig. 6 shows the determination by the X-ray diffraction method for zinc oxide in zinc orthophosphate.

SUMMARY

A few of the very interesting applications of X-ray diffraction have been illustrated. These cover identification of polymorphic phases, identification of crystalline substances in a mixture, determination of percentage of crystalline substances in a mixture, and identification of solution between crystalline materials. There are many other equally interesting applications which would require volumes to explain and illustrate. Such items as the orientation of crystals to be cut into oscillator plates, orientation of crystals in ferromagnetic materials, and the tracing of defect structures as heat changes one crystalline phase into another are all problems upon which the tool of X-ray diffraction throws some light.

It is no wonder then that the number of X-ray determinations made by the Lancaster Chemical & Physical Laboratory has increased from 200 in 1954 to 1200 in 1955. As more engineers become aware of the possibilities of the X-ray diffraction tool, more and better solutions to problems are obtained.

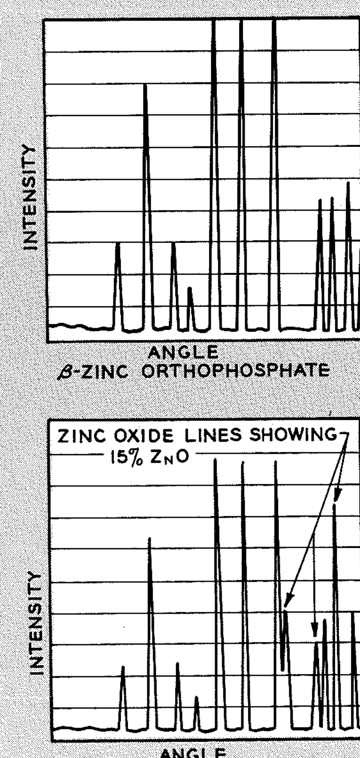


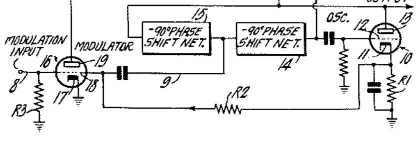
Fig. 6—Fifteen percent zinc oxide in β-zinc orthophosphate determined by the X-ray diffraction method.

Patents Granted
TO RCA ENGINEERS

Based on Summaries Received over a period of about two months

UNIVERSAL DRILLING JIG (Patent No. 2,749,781) — granted June 12, 1956 to George G. Herzl, Commercial Electronic Products, Camden, N. J. The jig comprises a base having vertical supporting and guiding members. A V block is vertically adjustable with respect to the base and supports a cylindrical workpiece. A drill guide bushing is disposed above the V block and is mounted in a cover mounted on the vertical supporting members. A shaft, fixed to the cover, provides a hinge connection between the cover and one support member. The workpiece is clamped laterally by a pair of horizontally aligned spindles which are rotatably supported. One spindle includes an externally threaded sleeve having an internally threaded pinion mounted thereon. The pinion is fixed against axial movement and is mechanically coupled to the cover shaft. When the cover is closed, to a horizontal position, the one spindle is moved inwardly to clamp the workpiece between the spindles. A lever is provided for rotating the spindles through predetermined angles whereby the workpiece is rotated through the same angles. When the cover is raised, the workpiece is unclamped.

REACTANCE TUBE CONTROLLED OSCILLATOR (Patent No. 2,758,211) — granted August 7, 1956 to Daniel Hochman, Defense Electronic Products, Tucson, Arizona. As oscillator tube ages, the oscillator frequency increases. To counteract this, a part of potential across oscillator tube cathode resistor is applied to grid of reactance tube connected to provide inductive reactance.

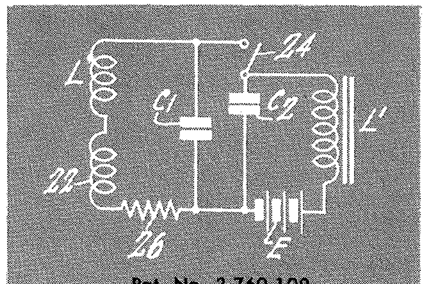


Pat. No. 2,758,211

RADIO COUPLING SYSTEM (Patent No. 2,758,283) — granted August 7, 1956 to Charles J. Starner, Commercial Electronic Products, Camden, N. J. Has single centrally-positioned primary loop and two U-shaped secondary loops one on each side of primary loop. Shield in form of 2 channels has sides extending between centrally-positioned loop and other loops. Secondary may be connected either in series or parallel by sliding switch plate arrangement. Both primary and secondary loops are tunable by means of uni-controlled slidable shorting bars which contact inside surfaces of loops.

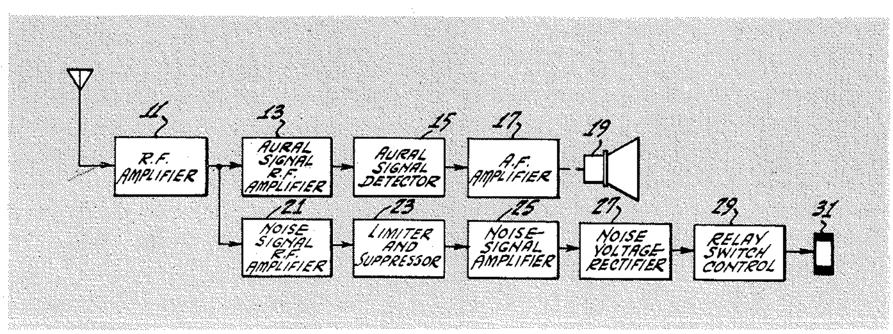
OPTICAL SYSTEM FOR IMAGE PROJECTION DEVICES (Patent No. 2,743,648)—granted May 1, 1956 to Donald J. Parker, Defense Electronic Products, Camden, N. J. The optical system includes a two-stage relay condenser lens system of special design. Each stage comprises two air-spaced condenser lenses. An intermediate image of the light source is formed in a plane between the two stages. A shutter is positioned in this plane to interrupt the light source.

KINESCOPE DEFLECTION CIRCUITS (Patent No. 2,760,109)—granted August 21, 1956 to Otto H. Schade, Tube Division, Harrison, N. J. In wide angle deflection kinescopes, uniform velocity of electron beam tip projection, as modified by tube face curvature, is effected by a selected portion of a sinusoidal deflection current, as opposed to sawtooth current of prior art. The scanning deflection current is produced in coil L at the resonant frequency determined by parallel combination of C_1 and C_2. The deflection current during retrace is a portion of another sinusoidal wave having a frequency determined by the yoke L and capacitance C_1. The switch is open during retrace time and closed during scansion.



Pat. No. 2,760,109

SERVO SYSTEM WITH FEEDBACK CONTROL (Patent No. 2,759,135)—granted August 14, 1956 to Harold D. Albrecht, Robert W. Harralson, Defense Electronic Products and Roger H. Fricke, Commercial Electronic Products, Camden, N. J. The servo system of this invention combines the advantageous characteristics of tracking and position servo systems. The former precisely track moving targets but overshoot in response to quick changes in target position. The latter come to rest on target without overshoot but, during tracking, lag the target position. The servo system of this invention operates as a conventional, rate-damped tracking servo system for error signals of relatively low amplitude. However, when the error signal exceeds a predetermined amplitude, the ratio of the damping signal to the error signal is substantially increased as the system approaches zero error. The slewing time for 180° error was reduced from 8½ seconds to 4½ seconds, with no overshoot, in a practical system incorporating this invention.



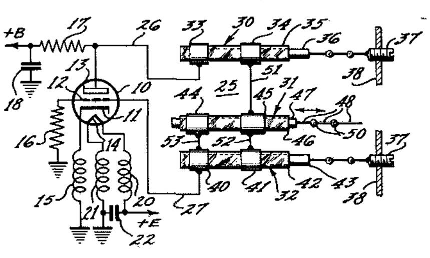
Pat. No. 2,761,060

AUTO ALARM SYSTEMS (Patent No. 2,761,060)—granted August 28, 1956 to George G. Bradley and R. G. Berge, Commercial Electronic Products, Radiomarine Engineering, New York. Receipt of noise (in absence of carrier) keeps alarm off. Alarm turned on either in response to incoming carrier signals of proper duration or in response to failure of circuit components to amplify or translate noise through the receiver.

TUNABLE MAGNETRON (Patent No. 2,759,-122)—granted Aug. 14, 1956 to HANS K. JENNY, TUBE DIVISION, Harrison, N. J. Two of the cavities of a multi-cavity magnetron are coupled to the legs of a U-shaped coupling cavity having a movable base for tuning the cavity and means for projecting a modulating electron beam through the cavity adjacent to the base.

VOLTAGE STABILIZATION MEANS FOR HIGH VOLTAGE POWER SUPPLIES (Patent No. 2,756,350)—granted July 24, 1956 to JOHN H. REISNER, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. In a power supply of the type comprising a source of unidirectional voltage, a filter network comprising an element of relatively low impedance connected across said source, elements of relatively higher impedance connected in circuit with said network, and a tank filled with a dielectric fluid and containing said elements; the combination therewith of an electrode surrounding said higher impedance elements and electrically connected to said element of relatively low impedance.

ELECTROPLATING RACK (Patent No. 2,751,-345)—granted June 19, 1956 to MITCHELL G. OSMAN, RCA VICTOR RECORD DIVISION, Indianapolis, Indiana. The rack includes a disc-like base having a radial handle and two masking members, each having a radial handle. Electrical contact plates are mounted on each side of the base and are electrically connected to a hook at the end of the base handle. Three locking cams are spaced around the periphery of the base disc on each side thereof. Each masking member includes a masking ring and a shielding ring spaced from each other. A plurality of radial flanges are spaced around the periphery of the masking ring. These flanges engage the locking cams to position the masking member with respect to the base into predetermined positions. Adjustment of the masking members is accomplished by rotating the masking member with respect to the base.



Pat. No. 2,729,746

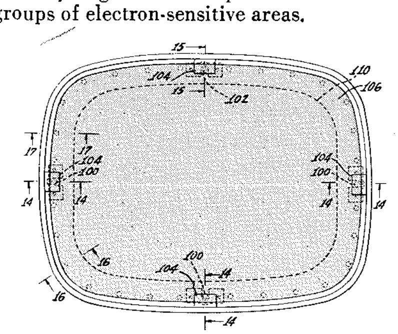
MULTI-CHANNEL UHF OSCILLATORS (Patent No. 2,729,746)—granted January 3, 1956 to WEN YUAN PAN, RCA VICTOR TELEVISION DIVISION, Cherry Hill, N. J. The UHF oscillator is adapted to be tuned to either one of two predetermined fixed frequencies. The tuning circuit includes a first, a second and a third capacitance means. The second capacitance means includes a first and second spaced capacitance members and a conductive core which is movable to a first position adjacent both of said members and to a second position adjacent one of the members only, depending upon which UHF channel is selected. The third capacitance means is connected in parallel with the second capacitance means and is effectively short-circuited when the core is in the first position thereof.

COLOR CORRECTION SYSTEMS (Patent No. 2,740,832)—granted April 3, 1956 to KENNETH E. ANDREWS, DEFENSE ELECTRONIC PRODUCTS, Moorestown, N. J. The invention consists of optical beam imaging device applicable to color correction systems for the purpose of imaging a flying spot on the corresponding areas of three transparencies. In a color correction scanning system, the beam from a flying spot scanner is simultaneously imaged on corresponding areas of three transparencies by separate symmetrical lens clusters. The transparencies are mounted in the same plane and have the same orientation. The lens clusters are located substantially midway between the plane of the transparencies and the screen of the scanner for unit magnification. When so operated under unit magnification, symmetrical lenses are substantially free of distortions.

PRINTED CIRCUITS (Patent No. 2,758,074) granted August 7, 1956 to OTIS D. BLACK and RICHARD M. WALSH, COMPONENTS DIVISION, Camden, N. J. A copper sheet 4 is cemented to a phenolic base 2, and uniformly plated with silver 8. A photographic acid resist pattern is placed on the silver. The silver is removed from exposed portions of the surface by deplating in aqueous sodium thiosulfate. The copper is then etched in ferric chloride solution. The acid resist protects the covered silver surface during deplating, and the silver protects the covered copper during etching.

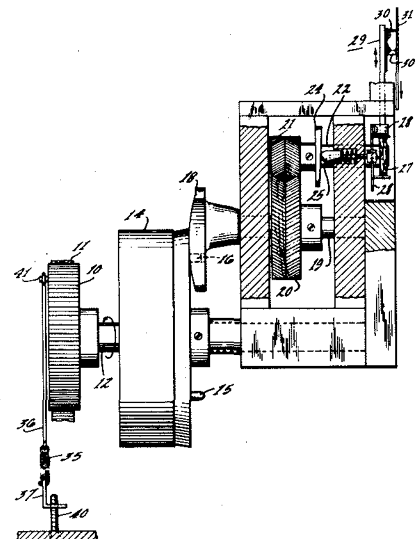
POWER SUPPLY (Patent No. 2,753,511) granted July 3, 1956 to SPURGEON H. BUDER, DEFENSE ELECTRONIC PRODUCTS, Moorestown, N. J. The power supply functions as a typical regulated power supply for load current up to a critical value. For loads beyond the critical current value, a diode in series with the load is caused to stop conducting, whereby the voltage across the load is caused to drop sharply.

TARGET ASSEMBLIES FOR COLOR KINESCOPES (Patent No. 2,733,366)—granted January 31, 1956 to ALBERT C. GRIMM and MILTON J. GRIMES, TUBE DIVISION, Lancaster, Pa. A target assembly comprising: a first target-element containing a multiplicity of systematically arranged apertures, a second target-element having a target surface made up, effectively, of a multiplicity of electron-sensitive areas disposed in a systematic pattern which is geometrically related to the pattern of apertures in said first target-element, fixed supporting means for one of said target-elements, and universally adjustable supporting means for bringing the other of said target-elements to a position whereat said apertures are accurately aligned with respective ones of said groups of electron-sensitive areas.



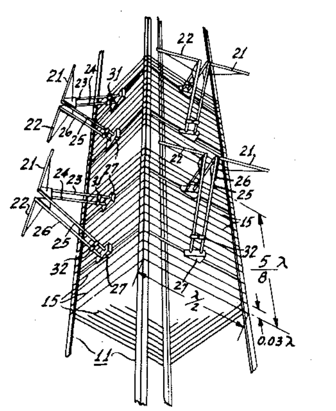
Pat. No. 2,733,366

FILM PULL-DOWN EQUALIZER (Patent No. 2,757,569)—granted August 7, 1956 to WARREN R. ISOM, DEFENSE ELECTRONIC PRODUCTS, Camden, N. J. Since film pulldown periods occur alternately in 2/60 and 3/60 of a second, the load on the motor driving the intermittent mechanism is variable, and it will lag the retrace times for the short periods and overshoot for the longer periods. The particular combination of pin wheel-star wheel drive in series with a cam-claw mechanism is disclosed and claimed in ISOM patent No. 2,712,771, of July 12, 1955. The present invention adds a spring having one end fixedly anchored and the other end attached to the pin wheel of the pin wheel-star wheel unit so that energy is absorbed by the spring on the long cycles, which energy is released on the short cycles.



Pat. No. 2,757,569

ANTENNA SYSTEM (Patent No. 2,757,369) —granted July 31, 1956 to WOODROW DARLING, COMMERCIAL ELECTRONIC PRODUCTS, Camden, N. J. An antenna in accordance with the invention comprises a tower-supported antenna array consisting fundamentally of one-half wavelength dipoles mounted in front of conductive surface elements or reflecting screens mounted on the sides of the supporting tower. The dipole elements are slanted or tilted in the ezimuthal plane at an acute angle with respect to the reflecting screens.



Pat. No. 2,757,369

MULTIPLE POSITION SWITCH (Patent No. 2,740,005)—granted March 27, 1956 to Edward S. Leslie and James L. Pettus, Commercial Electronic Products, Hollywood, Calif. To interconnect any one of a plurality of load motors in an interlock motor system to any one of several distributors, a square ended switch knob movable in a slot to actuating switch rods disconnects previous circuits before making new circuits.

MAGNETIC SWITCH (Patent No. 2,734,185) —granted February 7, 1956 to Charles S. Warren, Defense Electronic Products, Camden, N. J. A switch core is linked by two separate input windings. Each winding also is linked to a different one of two dummy cores. An output winding links all three cores. Cancelling voltages are produced in the output winding except when signals are coincidentally applied to both input windings.

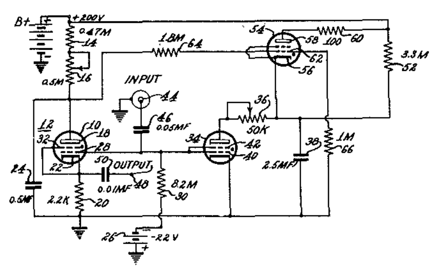
SEAL FOR COMPOSITE CATHODE RAY TUBES (Patent No. 2,753,073) — granted July 3, 1956 to Richard D. Falkner, Tube Division, Lancaster, Pa. The invention is directed to a glass and metal envelope comprising a faceplate sealed to a flanged portion of a hollow metallic shell member in which the shoulder formed between the body of the metal shell and the flange of the shell meets the periphery of the glass face plate in a sectional portion of the face plate.

CATHODE RAY TUBE (Patent No. 2,745,978) —granted May 15, 1956 to David D. Van Ormer, Tube Division, Lancaster, Pa. In a masked-target color kinescope, the mask is spaced farther from the screen at the outer edge than at the center, to minimize color dilution due to distortion at the screen.

METHOD OF MAKING PHOSPHOR SCREENS (Patent No. 2,757,103)—granted July 31, 1956 to George S. Briggs and Daniel J. Donahue, Tube Division, Lancaster, Pa. A luminescent viewing screen including a phosphor unstable at ordinary bake out temperatures is manufactured by mixing the phosphor with an organic binder, such as ethyl cellulose, depositing the phosphor-binder mixture on the plate and baking to remove the binder. In this invention, temperature-unstable phosphors, such as zinc selenide, are baked under forced air circulation at a temperature of 350° to 400° C. for 8-30 minutes including a maximum of 375° to 400° C. for only 1-5 minutes.

COLOR CORRECTION SYSTEMS (Patent No. 2,740,828)—granted April 3, 1956 to Harold E. Haynes, Defense Electronic Products, Camden, N. J. This invention consists of a CRT deflection system applicable to color correction for the purpose of maintaining the same geometrical relationship of the deflections of scanning and recording cathode ray tube beams during scanning at different times. In a color correction system a flying spot scanner scans three separation positives simultaneously to provide signals for a color correction computer. The computer provides four outputs each of which corresponds to a different color corrected signal. Each output is applied in succession to an exposing cathode ray tube and a different film is exposed to the tube to provide a color corrected negative. The deflection of the scanner tube and exposing tube are completely synchronized by connecting the horizontal deflection coils in series and the second anodes in parallel. As a result any variations in deflection current are the same in both CRT's. Therefore, the four color corrected negatives that are recorded are in register.

WAVEFORM GENERATOR (Patent No. 2,748,275)—granted May 29, 1956 to I. Maron, Defense Electronic Products, Camden and H. S. Broadwell, Defense Electronic Products, Moorestown, N. J. The invention consists of waveform generators applicable to pulse signalling circuits for purpose of producing a predetermined number of pulses in response to a signal. A relaxation oscillator having a first gas tube is controlled by the state of conduction of a second tube. When the second tube is conducting, the grid is above the critical voltage; and by direct connection so is the grid of the first tube. The oscillator produces a predetermined adjustable number of output pulses during conduction in the second tube. This second tube conduction may be periodic or may be initiated by an input pulse and continues for a period determined by the time constant of the r-c network. The invention relates to the control of the grid voltage of one thyratron by the grid voltage of the second thyratron through a direct grid connection.



Pat. No. 2,748,275

TUNING CONTROL MECHANISM (Patent No. 2,756,599) — granted July 31, 1956 to Edward J. Sperber, RCA Victor Television Division, Cherry Hill, N. J. For UHF and VHF television receivers, it is the general practice to provide separate UHF and VHF tuners. The VHF tuner in addition to having a main channel selector control is provided with a fine tuning device. In accordance with the invention a first tuning drive shaft is permanently connected with the channel selector control of the VHF tuner and a second tuning drive shaft is connected to the fine tuning device through a clutch member. A drive mechanism for the UHF tuner is constructed for selective engagement by the second tuning drive shaft and is operable to move the tuning elements of the UHF tuner at a relative fast or slow rate with reference to the movement of the second tuning drive shaft.

SIGNAL CONVERTER CIRCUIT (Patent No. 2,760,061)—granted August 21, 1956 to Wen Yuan Pan and Harold M. Wasson, RCA Victor Television Division, Cherry Hill, N. J. The converter includes a low-pass filter which is connected between the signal mixer and the output terminal of the mixer. The input leg of the filter includes a conductor and a capacitance connected to form a series circuit resonant at a frequency in the range of frequencies to be received, thereby providing a low impedance output circuit for the mixer to enhance the conversion efficiency. The oscillator signal is injected into the mixer circuit through the conductor. The low-pass filter is designed to transfer the converted i.f. signal but cuts off the oscillator and signal frequencies.

PROTECTIVE CIRCUIT (Patent No. 2,756,378) — granted July 24, 1956 to Howard M. Scott, Defense Electronic Products, Moorestown, N. J. In ordinary operation of a graphecon tube 10, the gun (i.e., cathode 12 and grid 14) is operated at high negative potential. To eliminate excessive flow of current when the high negative voltage is applied to cathode 12, invention provides a triode 46 to afford a short time constant charging path for blocking capacitor 28 leading to grid 14. The triode 46 is rendered conductive by the high negative voltage and permits rapid charging of capacitor 28, during which time the graphecon is kept cut off. Once capacitors 28 and 24 have reached their stabilized charge, triode 46 is cut off by drop across resistor 58, thereby permitting graphecon 10 to conduct.

ULTRA-HIGH FREQUENCY CONVERTER SYSTEM HAVING CRYSTAL DIODE MIXER (Patent No. 2,760,060)—granted August 21, 1956 to Gilbert C. Hermeling, RCA Victor Television Division, Cherry Hill, N. J. and Charles W. Wittenburg, (formerly of RCA). The UHF converter includes a crystal mixer which is coupled to the cathode of a grounded grid amplifier by a series resonant circuit tuned to the intermediate frequency. The local oscillator signal for the mixer is coupled to the inductive portion of the series resonant circuit. A parallel resonant circuit also tuned to the i.f. is connected from the cathode of the grounded grid amplifier and ground. By properly selecting the ratio of inductance to capacitance of the parallel resonant circuit, optimum impedance matching to the grounded grid stage is achieved thereby minimizing spurious detuning effects.

INTERMITTENT FILM ADVANCING MECHANISM (Patent No. 2,756,629)—granted July 31, 1956 to Warren R. Isom, Defense Electronic Products, Camden, N. J. This invention is an intermittent film advancing mechanism which prevents mutilation of the film when the loose loops are lost. This is accomplished by resiliently mounting a film pressure shoe to be tiltable about its center so that when both loops are simultaneously lost, the film will be pulled away from the claw teeth. When the lower loop is lost, the spacing between the sprocket teeth and claw teeth is such that the upper claw tooth will enter a sprocket hole and advance the film to form the lower loop while the pressure shoe is pulled away from the aperture plate. When the upper loop is lost, the claw teeth cannot reach the film until the proper loop is formed and the pressure shoe returns to its normal position. The tension of the pressure shoe is adjustable, while a framing adjustment mechanism is provided.

ELECTRONICALLY TUNABLE MAGNETRON (Patent No. 2,759,123)—granted August 14, 1956 to Hans K. Jenny, Tube Division, Harrison, N. J. A magnetron having a plurality of radial cavities is provided with means forming a space coupling at least one pair of cavities together to form a cavity resonator and means for projecting a modulating electron beam through the coupling space.

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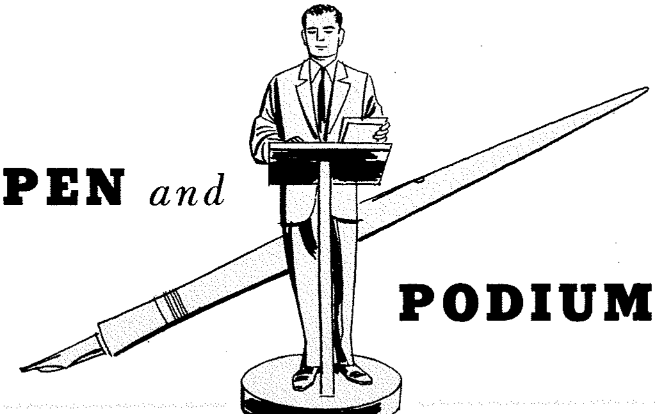


Based On Reports Received Over a Period of About Two Months

SPEECH COMMUNICATIONS IN NOISE: SOME EQUIPMENT PROBLEMS . . . By M. E. Hawley, DEP, Moorestown, N. J. Published in the November 1956 issue of the Journal of the Acoustical Society of America. The design of a speech communication system begins with an operations analysis of the communication problem. When speech has been chosen as the means and when the needed linkages have been determined, the designer chooses the best compromises among the frequently conflicting factors of intelligibility, safety, comfort, quality, reliability, and economy. Optimum results can be obtained only if the whole system is designed together, with consideration given to correcting high noise levels at the listener and the transducer, as well as within the communication equipment.

A NEW HIGH-GAIN MULTIPLIER PHOTOTUBE FOR SCINTILLATION COUNTING . . . By W. Widmaier and R. G. Stoudenheimer, Tube Division, Lancaster, Pa. Published in the December 1956 TRANSACTIONS of IRE Professional Group on Nuclear Science. This paper describes the RCA-6810, a head-on type of multiplier phototube having an S-11 response and intended for use in high-speed scintillation counting. This tube features a 2-inch diameter, semi-transparent cathode, and has a fourteen-stage, inline, electrostatically focused, silver-magnesium dynode structure. With a supply voltage of 2000 volts, the 6810 is capable of multiplying feeble pulses 12.5 million times and has a luminous sensitivity of 750 amperes per lumen.

DESIGN TECHNIQUES OF IF AMPLIFIERS—TUBES AND TRANSISTORS . . . By Dr. W. Y. Pan, RCA Victor Television Div., Cherry Hill, N. J. This talk was presented on November 15, 1956 to the Fall Study Group in New York City jointly sponsored by AIEE and IRE. It covered considerations of i-f amplifiers for broadcast, communications and microwave receivers of various services. Particular reference was made to the relative performance characteristics between vacuum tubes and transistors.

ANALYTICAL APPROACHES TO LOCAL OSCILLATOR STABILIZATION . . . By W. Y. Pan, and D. J. Carlson, RCA Victor Television Div., Cherry Hill, N. J. Published in the December 1956 issue of RCA REVIEW. The behavior of local oscillator tubes and associated circuit elements under complex conditions of heat flow can be treated analytically. By means of such an analytical treatment, local oscillators operating at frequencies up to and beyond 1,000 megacycles may be stabilized methodically with conventional temperature-sensitive elements. The resultant frequency stability is satisfactory for most practical purposes. The analytical approaches to local oscillator stabilization in general, and special considerations at UHF, are demonstrated by application to two types of commercial television tuners. After two minutes of operation, the VHF tuner exhibited a maximum residual frequency deviation of ± 50 kilocycles, while that of the UHF tuner was ± 100 kilocycles. It is believed that the same general approaches and considerations can be utilized to stabilize local oscillators for other applications.

HISTORICAL HIGH POINTS IN THE EXTENSION OF COMMUNICATION TECHNIQUES AND THEORY TO SYSTEMS INVOLVING VISION . . . By O. H. Schade, Sr., Tube Division, Harrison, N. J. Presented at Symposium on Optics and Microwaves, George Washington University, Wash., D. C., on November 14-16. The extension of communication techniques and Fourier theory to the measurement and specification of optical and photographic elements is traced as a logical development of television engineering, prompted by the desire to design the "perfect" television system. Although the basic mathematical tools for the analysis of information networks such as a natural communication system involving vision and a variety of transducer types have been available for a long time, there are always difficulties in learning to apply an abstract science in agreement with psycho-physical observations. A "perfect" television system, for example, makes the best use of a limited electrical frequency spectrum for the transmission of optical information to the eye. The visual system is, hence, a part of the system transmitting this information, and its characteristics must be included in a system analysis, perhaps in the form of an analog.

ELECTROMECHANICAL FILTERS FOR SINGLE-SIDEBAND APPLICATIONS . . . By Don L. Lundgren, CEP, Camden, N. J. Published in the December issue of PROCEEDINGS OF THE IRE. In discussing some of the basic properties of electromechanical filters, both longitudinal and torsional modes of vibration are considered. In view of their advantages, torsional mode filters designed to operate at a carrier frequency of 250 kc are an excellent choice for filter type single-sideband equipments. Performance parameters are discussed.

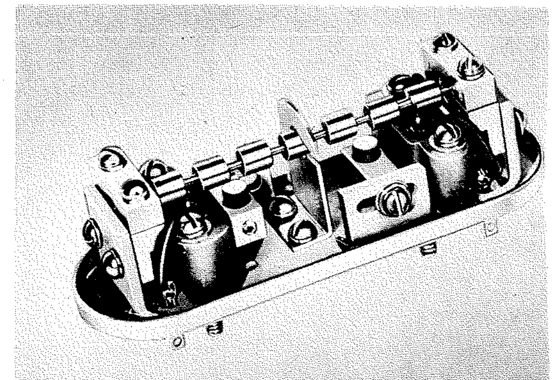
THE TRANSISTOR—WHAT IT IS—WHAT IT DOES . . . By A. Mohr, Semiconductor Division, Somerville, N. J. Presented at N. J. Science Teachers' Association, Manville, N. J., December 3, 1956. This paper discusses the background of the transistor industry and its growth in recent years. The properties and preparation of germanium are described, including the source and cost of the raw material, germanium refinement and crystal growth, and "doping" effects. The construction of both point-contact and alloy-junction transistors is discussed, and special designs for various applications are mentioned. The advantages of transistors, and present and future uses are described.

CONVERSION OF AIRBORNE H-F RECEIVER-TRANSMITTER FROM DOUBLE SIDEBAND TO SINGLE SIDEBAND . . . By H. A. Robinson, DEP, Camden, N. J. Published in the December issue of PROCEEDINGS OF THE IRE. In the past, the problem of frequency, accuracy and stability has been the major deterrent in the effective utilization of SSB, suppressed carrier techniques for h-f air-ground communications. This paper describes briefly the AN/ARC-21 airborne h-f, double sideband, communication equipment, and the associated frequency-control system. The improvement in the stability of this frequency-control system and the modifications of the several major subassemblies, essential to the conversion to the SSB mode are described.

CLINCH NUTS FOR USE IN THIN, SOFT MATERIALS . . . By G. H. Lines, DEP, Camden, N. J. Presented in the November issue of ELECTRICAL MANUFACTURING Magazine. Four styles of clinch nuts were investigated to determine their holding power when used as a means of obtaining a load-carrying thread in various types of aluminum alloy sheet. Axial strength and torsional resistance of each type nut installed under varied pressures were ascertained.

TUBE TYPES FOR AUDIO USE . . . By M. B. Knight, Tube Division, Harrison, N. J. Published in RADIO AND TELEVISION NEWS, November 1956. This paper describes the pertinent characteristics that determine the choice of tube types for high-fidelity equipment circuitry. Noise characteristics are discussed in relation to low-level amplifier stages. Common sources of tube hum are described, including leakage in heater-cathode insulation, heater-to-grid capacitance, and both internal and external magnetic fields. Microphonic characteristics are explained, and several popular tube types are evaluated for use in critical circuits. Triodes, pentodes, and beam power tubes are evaluated for use as power amplifiers.

Electromechanical Filters—Lundgren.



PEN and PODIUM
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THE DILEMMA OF ENGINEERS IN MANAGEMENT . . . By A. N. Curtiss, West Coast Electronic Products, DEP. Presented on October 16 before the Dayton Professional Group on Engineering Management. Differences in training and environment between an engineer and a manager, by education, function and personality were highlighted. The question was discussed of how the future should be faced in bridging the gap between the highly specialized engineer and his liberal-educated manager, and how management could be trained with sufficient technical skill to release technical minds for scientific pursuits.

AN ALL-TRANSISTOR OPERATED MAGNETIC CORE MEMORY . . . By W. A. Helbig, C. S. Warren and W. G. Rumble, DEP, Camden, N. J. Presented on Oct. 1, 1956 at the National Electronics Conference, Chicago, Ill. A brief introduction to coincident current memory systems is presented, giving advantages of transistors in driving and switching circuits. A 6500-bit all-transistor operated memory and associated circuits is described with an explanation of the memory cycle. The transistor switch circuit and current driver are described plus operating conditions of the transistors. The transistor logic circuits are described briefly. The regeneration circuits are also given attention. The timing pulse generator is outlined in block diagram form. Specifications are included for the magnetic cores. Conclusions on uses of transistor operated memories are given.

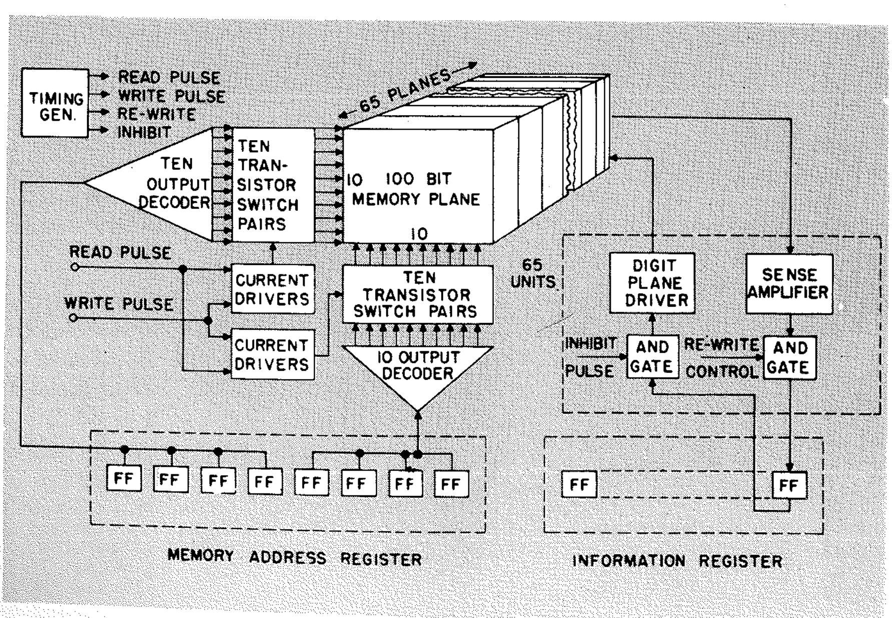
THE RCA COMMERCIAL AIRLINE WEATHER RADAR . . . By R. W. Kissinger, Tube Division, Harrison, N. J. Presented at Air Force Officers' Reserve Training Unit, Brooklyn, N. Y., November 13, 1956. This paper describes the need for weather radar equipment and gives a brief history of the RCA-AVQ-10 Weather Radar system. Factors determining such design criteria as reliability, frequency, and power output are discussed. The "Iso-echo" contour feature of the radar set is described in terms of both application and data interpretation. A simplified, basic theory of magnetron operation is presented and illustrated in terms of the RCA-6521 tube used in the AVQ-10 system.

A HIGH CURRENT SWITCH FOR A TRANSISTOR OPERATED MAGNETIC MEMORY . . . By W. A. Helbig, and W. G. Rumble, DEP, Camden, N. J. Presented on October 1, 1956 at the National Electronics Conference, Chicago, Ill. The problem of switching large currents with commercially available, high-frequency transistors is discussed with reference to a transistor-operated magnetic memory. The equivalent circuit of the transistor, while operating during the quiescent portion of the drive pulse, is reviewed to show the method used to insure minimum dissipation in any transistor used as a high current switch.

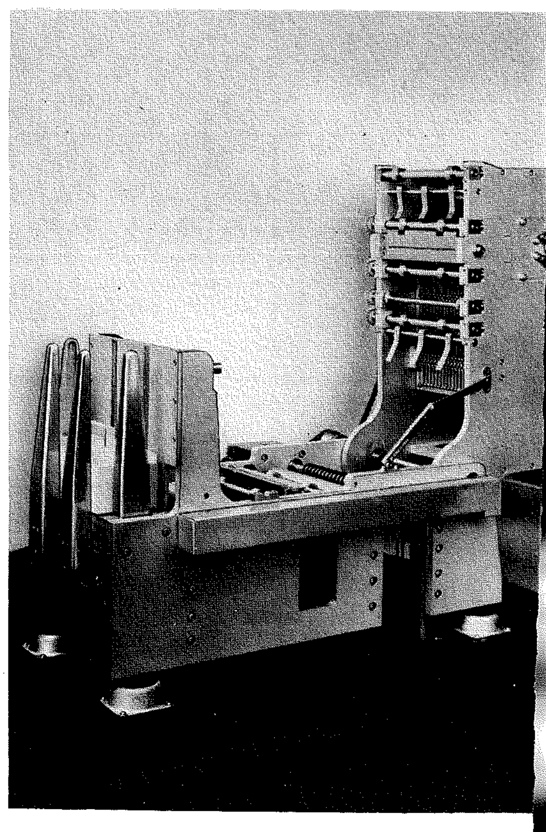
A DEVELOPMENTAL SUPER-POWER UHF TRIODE . . . By M. V. Hoover, Tube Division, Lancaster, Pa. Presented at Microwave Tube Symposium at Lincoln Laboratories of M.I.T., December 12-13, 1956. This paper describes a developmental super-power uhf triode intended to deliver a power output of 5 megawatts in long-pulse applications and 10 megawatts of short-pulse power at frequencies below 500 megacycles. The circuit-design philosophy of the double-ended configuration is explained, and salient design features are shown. Objective operational performance parameters are discussed.

DERIVATIVE MANIFOLDS IN L^2 AND THE HAMBURGER MOMENT PROBLEM . . . By D. S. Greenstein, DEP, Camden, N. J. Presented on December 29, 1956 at the 63rd Annual Meeting of the American Mathematical Society, Rochester, New York. Given $f(x) \in C\infty(-\infty,\infty)$ such that $f^{(n)}(x) = L^2(-\infty,\infty)$ $(n \gg 0)$, it can be shown that the closed linear manifold D_f spanned by $f(x)$, $f'(x)$, $f''(x)$, . . . is contained in the closed linear manifold T_f spanned by the translates $f(x+h)$. It is of interest to determine when $D_f = T_f$. This is so when and only when the absolutely continuous mass distribution whose derivative is almost everywhere equal to the square of the modulus of the Fourier transform of $f(x)$ is uniquely determined by its moments. It is further shown that if $D_f = T_f$, then $D_f(n) = T_f$ $(n \gg 0)$, which implies, via the Hamburger moment problem, a new result on L^2 completeness of polynomials.

A TRANSISTORIZED TRANSCRIBING CARD PUNCH . . . By C. T. Cole, K. L. Chien, and C. H. Propster, CEP, Camden, N. J. Presented by Mr. Propster at the Eastern Joint Computer Conference, New York City on December 10-11-12, 1956. The necessity to reduce large volumes of information stored on magnetic tape to punch cards instigated the design of a high-speed equipment to convert this data into IBM cards. The Transcribing Card Punch provides a means for converting data stored on magnetic tape in the Bizmac code into electronic machine cards using the IBM code. Anticipated conversion capability is up to 150 cards per minute, with the accuracy control features. Studies were made to assure proper operation of the TCP with electronic machine card system requirements. Novel logical methods of message storage were developed. A review of punching methods guided the mechanical design of the transport mechanism and its associated punch. A simple transistor circuit element is described which will satisfy all logical functions.



Transistor-Operated Memory—Helbig, Warren, and Rumble.



Transistorized Transcribing Card Punch—Cole, Chien, and Propster.

RELIABILITY PROGRAM MANAGEMENT . . . By C. M. Ryerson, DEP, Camden, N. J. Presented at Ottawa Section of the IRE on November 15, 1956, Ottawa, Canada. Five factors basic to the management of a Reliability Program are reviewed. These are Orientation, Organization, Economics, Staffing and Education. Each of these points is discussed as it involves Reliability as a field and its relation to the product or product line of the parent company or organization.

ENGINEERING TRAINING . . . By D. J. Gardam, Tube Division, Harrison, N. J. Presented at American Management Association, New York City, December 4, 1956. This paper describes the RCA Training Program for new engineers. The way in which the need for this program was determined is discussed, and a description is given of the development of program content and the administration of the program. A report is given on the program to date, and its effectiveness is evaluated.

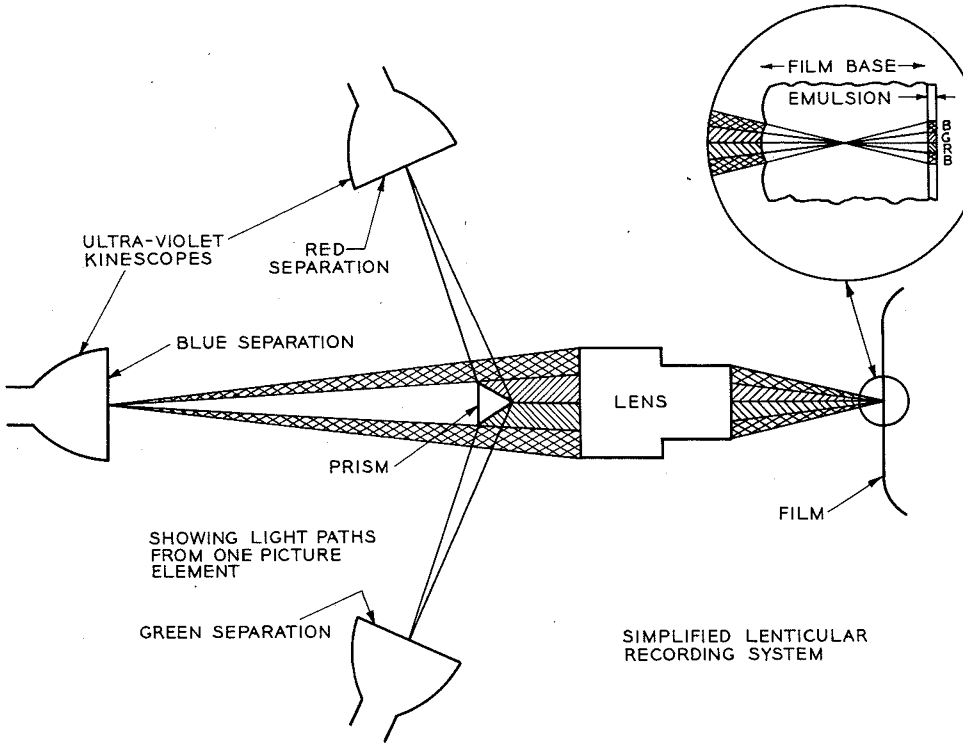
COMPUTER SIMULATION OF A COMPLEX COMMUNICATIONS SYSTEM . . . By L. Brotman and J. Minker, DEP, Camden, N. J. Presented by Mr. Minker on November 15, 1956 at the Operations Research Society of America, San Francisco, Calif. A new method of simulating on a digital computer the performance of a large complex communications system was presented. The computer has been programmed to simulate the performance of a human operator(s) at each of the switching centers. A method for simulating a completely automatic switch system was also given.

RADIO SYSTEM CONTROLS RAILROAD IN VENEZUELA . . . By B. Sheffield, RCA International Div., Clark, N. J. Published in the Dec. 1956 ELECTRONICS. Centralized-traffic-control system uses radio to enable a dispatcher at port end of 80-mile single-track railroad to control movements of ore cars at passing sidings. Technique is applicable to remote supervisory systems and telemetering.

PRINCIPLES OF COLOR TV FOR THE LAYMAN . . . By D. G. Garvin, Tube Division, Lancaster, Pa. Presented at the Optimist Club, Lancaster, Pa. on Oct. 23; Lions' Club, Landisville, Pa. on Nov. 5; YMCA, Lancaster, Pa. on November 20; and at the Cosmopolitan Club in Lancaster, Pa. on December 12, 1956. 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.

HANDBOOK ON SEMICONDUCTOR ELECTRONICS . . . Published in November, 1956. H. J. Woll, DEP, Camden, N. J. is a contributing author. A thorough guide and reference about the design and application of semiconductor devices, the book covers the entire field by 13 specialists. It includes a physical explanation of the principles of operation of semiconductor devices; a survey of the technology of the art in their fabrication; circuit applications of semiconductor devices, primarily of transistors; and a reference section.

Color TV Program Recording Employing Lenticular Film—Kell, Brumbaugh and Goodale.



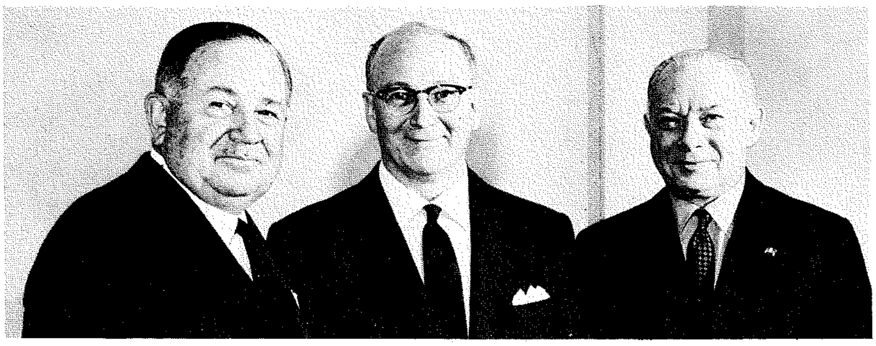
COLOR TV PROGRAM RECORDING EMPLOYING LENTICULAR FILM . . . By R. D. Kell, John Brumbaugh, DEP, Camden, N. J. and D. Goodale, NBC, N. Y. Presented on October 11, 1956 at the SMPTE Convention, Hollywood, Calif. Nationwide broadcasting of feature programs requires a three-hour "storage" medium. Of several being investigated, this is the first to be used commercially. A black-and-white emulsion, requiring only normal processing, is used on a 35-mm film base; the opposite of which is embossed into tiny horizontal cylindrical lenses. R, G and B "separation images," each coming from a different lens segment and consisting of ultraviolet light only, are focused in registry, in the base. The R, G and B information thus appears as separate emulsion strips behind each lenticule, and can be recovered by projection through similar optics.

CAMERA TUBES FOR COLOR TELEVISION BROADCAST SERVICE . . . By R. G. Neuhauser, Tube Division, Lancaster, Pa. Published in JOURNAL OF THE SOCIETY OF MOTION PICTURE AND TELEVISION ENGINEERS, December 1956. This paper describes requirements of camera tubes for use in color-television broadcast service, and evaluates the performance of existing camera tubes. Important characteristics for such service include sensitivity, light-transfer characteristics; black-level reproduction, spectral response, resolution and ability to register images, and signal-to-noise ratio. Problems encountered in three-tube simultaneous camera systems are discussed in detail.

INTERVIEWING AND TESTING FOR CREATIVITY . . . By C. M. Sinnett, RCA Victor Television Div., Cherry Hill, N. J. Presented on Oct. 18, 1956 at the Joint IRE/AIEE Sponsored Symposium in Creativity, Phila, Pa. This talk covered many factors which are found in non-creative and creative people. Among the static factors are: knowledge, observation, memory, persistence, concentration, judgment, reasoning, reflection, sincerity, and ability to communicate. The highly creative person possesses many dynamic characteristics in addition. They are: sensitivity to problems, skepticism, curiosity, optimism, vision, originality, mobility in thinking, imagination, willingness to gamble, self-confidence, enthusiasm, inspiration, and intuition. The latter part of the talk summarized the results of a series of psychological tests given to a group of RCA engineers.

Engineering NEWS *and* HIGHLIGHTS

RCA ELECTS TWO TOP EXECUTIVES



David Sarnoff, Chairman of the Board and chief executive officer of RCA (right, photo above) recently announced the election of Frank M. Folsom (left) as Chairman of the Executive Committee of the Board and John L. Burns (center) as President and a Director of RCA. General Sarnoff continues in his present capacity as Chairman of the Board and chief executive officer of the Corporation.

Mr. Folsom has served as President of RCA since 1949. Mr. Burns has been a senior partner and Vice-Chairman of the Executive Committee of the management consultant firm of Booz, Allen and Hamilton.

DR. D. H. EWING APPOINTED VICE-PRESIDENT RCA RESEARCH AND ENGINEERING

Dr. D. H. Ewing

Dr. J. Hillier

Dr. G. H. Brown

Dr. Douglas H. Ewing, Vice-President, RCA Laboratories, has been named Vice-President, Research and Engineering, RCA, in a recent announcement by Dr. E. W. Engstrom, Senior Executive Vice-President of RCA.

The new appointment was one of several announced in RCA's research and engineering organizations. The others included:

Dr. James Hillier, who has been Chief Engineer, RCA Commercial Electronic Products, appointed General Manager, RCA Laboratories;

Dr. George H. Brown, who has been Director of the Systems Research Laboratory, RCA Laboratories, appointed Chief Engineer, RCA Commercial Electronic Products.

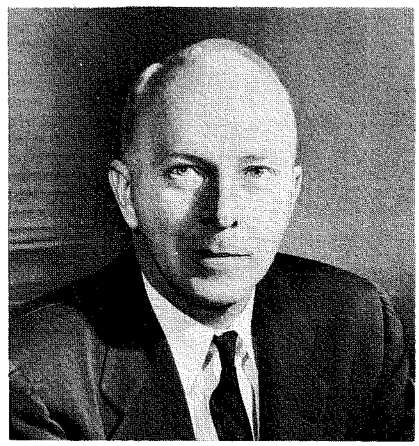
Dr. Ewing will be responsible in his new position for RCA Laboratories and RCA's Engineering Services, reporting to Dr. Engstrom.

DR. EWING has been the head of RCA Laboratories since November, 1955. He was graduated from Butler University, and received his Ph.D. degree in Physics from the University of Rochester in 1939. Following two years of teaching at Smith College, and wartime association with the MIT Radiation Laboratory, Dr. Ewing joined RCA in 1945 as Manager of the Teleran Engineering Section of the RCA Victor Division. From 1949 to 1951, he was granted a leave of absence from the company to serve on the Air Navigation Development Board in Washington. Returning in 1951, he became Director of Research Services of the RCA Laboratories in Princeton, N. J. Subsequently he served as Director of the Physical and Chemical Research Laboratory and as Administrative Director, RCA Laboratories, until his appointment as Vice-President, RCA Laboratories, in 1955.

DR. HILLIER, a pioneer in the development of the electron microscope, has been associated with RCA since 1940 as a research physicist and engineer. He received the degrees of B.A. in Mathematics and Physics in 1937, M.A. in Physics in 1938, and Ph.D. in Physics in 1941 from the University of Toronto, Canada. Joining RCA Laboratories as a research physicist in 1940, Dr. Hillier designed the first commercial electron microscope to be made available in the U.S. and subsequently made many basic contributions to improved design. In 1953, he became Director of the Research Department of Melpar, Inc., returning to RCA in 1954. He was named Chief Engineer, CEP, in November, 1955.

DR. BROWN, who joined RCA in 1933 as a research engineer, has made major contributions to radio and television broadcast communications. He studied at the University of Wisconsin, where he received the degrees of B.S.E.E. 1930, M.S. in E.E. in 1931, Ph.D. in 1933, and the E.E. professional degree in 1942. After two years as Regent Fellow at the University of Wisconsin, Dr. Brown became a research engineer with the RCA Manufacturing Company in Camden, N. J., where he developed the turnstile and other antennas used in television transmission. In 1942, he was transferred to RCA Laboratories, where he undertook wartime research and development of radio and radar antennas. He was appointed Director of the Systems Research Laboratory, RCA Laboratories, in 1951.

HEAD OF RCA TUBE DIVISION HONORED BY COOPER UNION



D. Y. Smith

Douglas Y. Smith, Vice President and General Manager, RCA Tube Division, has received a citation from Cooper Union for his attainments after graduation from the school. The citation was presented by Dr. Edwin S. Burdell, President of the institution at a recent convocation of alumni.

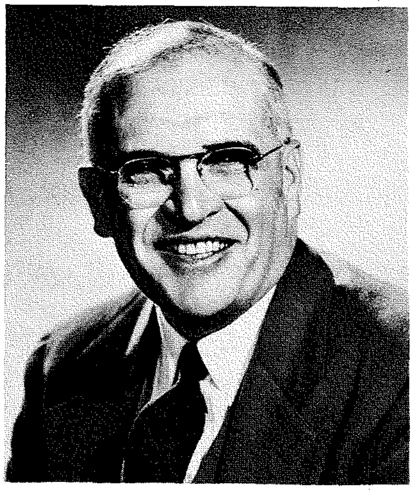
Mr. Smith's citation read:

"A graduate of Cooper Union with a degree of Bachelor of Science in Electrical Engineering, you have served the profession of Electrical Engineering and the electrical industry for more than 25 years with scientific resourcefulness, with uncommon good sense, and with attractive modesty.

"Holder of design patents on tube structure, recipient of the RCA Award of Merit, Member of the Industry Committee of the U. S. Government, your career is an inspiring example to the young engineers of today in industry.

"For your well-deserved attainments in American industrial life, the Cooper Union has chosen you for this citation."

SPECIAL SYSTEMS AND DEVELOPMENT DEPARTMENT ESTABLISHED IN DEP



Dr. C. B. Jolliffe

Establishment of a Special Systems and Development Department devoted to the planning and development of broad electronic systems for future military needs was announced recently by Theodore A. Smith, Executive Vice President, RCA Defense Electronic Products.

Dr. C. B. Jolliffe, Vice President and Technical Director of RCA, has been appointed Manager of the new department.

Also appointed to executive posts in the department are: A. W. Vance, Chief Systems Engineer; G. L. Dimmick, Chief Development Engineer; A. C. Gay, Manager, Projects Engineering; and Dr. E. W. Pritchard, Administrative Engineer.

The Special Systems and Development Department will embrace systems engineering groups of the David Sarnoff Research Center, the general engineering development section of DEP, and an RCA advanced development engineering group which for more than a decade has concentrated on new electronic techniques and on mechanical and optical devices associated with electronics.

DR. JOLLIFFE, *Manager of the new department,* has been active in electronics engineering for many years. Earlier in his career, he was Acting Chief, Radio Section, U. S. Bureau of Standards, and later became Chief Engineer of the Federal Communications Commission. He joined RCA in 1935 and advanced through executive engineering posts of increasing responsibility, including Chief Engineer of the RCA Laboratories. In 1951, after six years as Executive Vice President in Charge of the RCA Laboratories Division, he was advanced to his present position of Vice President and Technical Director of RCA. Dr. Jolliffe also is a member of the Board of Directors of the Radio Corporation of America, the National Broadcasting Company, and RCA Communications, Inc.

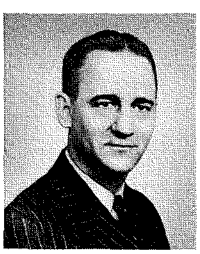
MR. VANCE, *Chief Systems Engineer,* has had considerable experience in the analysis of guided missile systems and has been responsible for a number of important developments in the analogue computer field. Mr. Vance formerly was Director of Special Projects Research Laboratory at the David Sarnoff Research Center.

MR. DIMMICK, *Chief Development Engineer,* has been engaged in development work since 1930. Prior to his new appointment, he was Manager of the Optics, Sound and Special Engineering section at RCA's Camden, N. J., plant (1953), then Manager of General Development Engineering (1955).

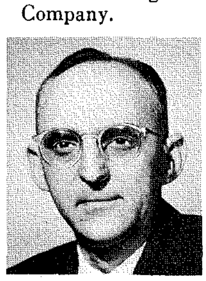
MR. GAY, *Manager, Projects Engineering,* has had extensive experience in research and development, including three years in the planning and development of the Air Force missile test range. Mr. Gay became Staff Engineer for RCA in 1955 and since that time has been engaged in highly classified projects.

DR. PRITCHARD, *Administrative Engineer* of the new department, has had broad experience with fire-control systems, automatic radar tracking and navigation systems. Prior to joining RCA as Technical Administrator in 1953, Dr. Pritchard was Chief Electrical Engineer of Control Engineering Company.

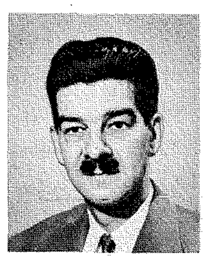
A. W. Vance



G. L. Dimmick



A. C. Gay



Dr. E. W. Pritchard

H. R. GREENE, MECHANICAL ENGINEER, RETIRES

On November 13, 1956, a retirement dinner was held in honor of Mr. H. R. Greene, a Mechanical Engineer with the DEP Missile & Surface Radar Design Activity, who retired after twenty-two years of service with RCA. The principal address was given by Mr. H. R. Wege, Operations Manager, Moorestown Plant, who was closely associated with Mr. Greene for some years when both of them were in the design activity. Mr. Dave Simonton, an Engineering Supervisor, acted as M.C. for the occasion.

Mr. T. G. Greene, an Engineering Supervisor at Moorestown and son of the retiring engineer, presented his father with a framed certificate designating recognition above and beyond the call of duty as a father and grandfather.

Although officially retiring at this time, Mr. Greene has agreed to work part time under contract as an engineering consultant and liaison engineer with RCA to aid in relieving the present engineering shortage of manpower.—*H. A. Brelsford.*

PRODUCT ENGINEERS RECEIVE IRE FELLOW AWARDS

Seventy-five leading radio engineers and scientists from the U. S., Canada, and Europe were named Fellows of the IRE by the Board of Directors at its November 14 meeting held in New York City.

Dr. James Hillier, former Chief Engineer, Engineering Department, CEP, and Leland E. Thompson, CEP Communication Engineering were the two RCA product engineers honored in this year's awards.

Dr. Hillier was cited "For contributions in the field of electron optics, particularly electron microscopy." Dr. Hillier has recently been appointed General Manager, RCA Laboratories, Princeton. (For biographical information, see P. 60).

Mr. Thompson, veteran RCA engineer, received the award at the January 14, 1957 meeting of the IRE Philadelphia Section. Mr. Thompson's citation reads: "For contributions to microwave communication systems and development of special purpose radio receivers". Mr. Thompson is a member of CEP Communication Engineering where, for the last thirteen years, he has been intimately associated with the development of RCA's microwave communication systems and equipment and in the investigation of propagation characteristics related to the application of such systems. He holds numerous patents in the microwave communication and radio receiver fields.

Other RCA Engineers cited were Jack Avins, RCA Laboratories, Ltd., of Zurich, Switzerland; A. A. Barco and L. E. Flory, RCA Laboratories, Princeton and C. D. Tuska, Director, RCA Patent Operations, Princeton.

HAROLD M. EMLEIN APPOINTED MANAGER, THEATRE AND INDUSTRIAL PRODUCT DEPARTMENT

Appointment of Harold M. Emlein as Manager, Theatre and Industrial Products Department, CEP, was announced recently by Arthur L. Malcarney, Vice-President and General Manager, CEP.

Mr. Emlein, for the past 10 years Manager of RCA's Indianapolis, Indiana, manufacturing plant, assumed his new post January 1, with headquarters at Camden.

Mr. Emlein joined RCA in 1930 as a student engineer after his graduation from the University of Minnesota with a degree in electrical engineering. During the following 14 years, he was advanced through various engineering and production assignments of increasing responsibility.

In 1944, he was transferred to RCA's Indianapolis plant as Manufacturing Manager for special apparatus and radio equipment for Government use. Two years later he was advanced to Plant Manager.

Mr. Emlein, in 1949, was cited with the RCA Victor Award of Merit, for outstanding achievement of production of RCA television receivers at Indianapolis.

A. P. VERMETTE DIES SUDDENLY

Members of RCA were saddened to learn of the untimely death of Albert P. Vermette, manager of the Marion Parts Plant Engineering. Mr. Vermette died of a heart attack on December 17, 1956, while visiting friends in Chicago. He was 49 years old.

Mr. Vermette was widely recognized throughout the industry for his knowledge and application of machine tooling. Mr. Vermette became associated with RCA in 1933 as a set up man and tool maker in the Harrison Plant. In order to combine the know-how of tool building with the theoretical knowledge of design, Mr. Vermette attended the Newark College of Engineering at night studying mechanical engineering from 1935 to 1938, and New Jersey State Teachers College 1938-1939 studying machine design. He was transferred in September of 1942 to the Indianapolis Plant as manager of Manufacturing Development Engineering which he held until 1944. After two years with the Navy, Mr. Vermette returned to the Record Engineering Department at Indianapolis for six months, and then joined Western Electric as a manufacturing engineer. In 1948 he took a position as Superintendent of the Midwest Tool & Engineering Company.

The Kinescope and Parts Plant operation began in 1950 at Marion. Mr. Vermette was invited to help organize the parts plant group and joined RCA as Manager of Parts Plant engineering.

Along with his organizational ability, Mr. Vermette developed tooling that was unique and several were adapted by other manufacturers for high speed parts production.

—*J. deGraad*

ITV NOW PART OF BROADCAST STUDIO ENGINEERING

Effective January 1, 1957, the Industrial Television activity, formerly of Theater and Industrial Engineering, became a part of Broadcast Studio Engineering, CEP.

Several benefits are expected to accrue from this transfer of activity. It will integrate engineering work on all types of closed circuit television equipment and systems, and will help to improve RCA's position in this field through better overall coordination and utilization of talent and facilities. In addition, ITV equipment will benefit from the comprehensive sales coverage afforded by the Sales organization in the Broadcast and Television Department.

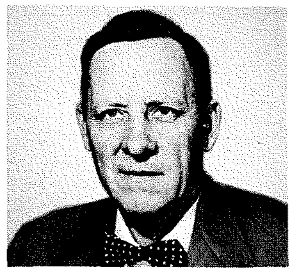
Mr. J. E. Dilley, Leader, Design and Development, reporting to V. E. Trouant, will be responsible for design work carried on by the following engineers:

B. L. Brady
H. R. Hay
J. G. Lee
G. A. Senior

Mr. J. F. Eckert will join the Broadcast Systems group under A. F. Inglis, where ITV Systems activity will be coordinated with other closed circuit systems work.

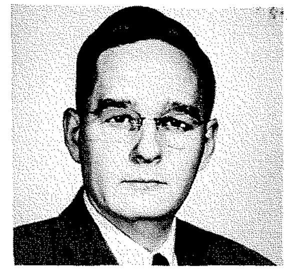
—*J. H. Roe*

NEW EDITORIAL REPRESENTATIVES APPOINTED



H. R. Dyson

R. W. Jevon



H. E. Haynes

HORACE R. DYSON, DEP Technical Administration, has been appointed to represent that activity as a representative for the RCA ENGINEER. He completed his undergraduate work in Communication Engineering at MIT. Mr. Dyson started his career with Westinghouse in 1920, joining RCA in 1930 to form the Special Apparatus design group, which fulfilled RCA's first government contract. Since then he has been responsible for design and production of a long list of military and civilian communication equipments.

In 1945 Mr. Dyson was appointed Manager of Government Radiation Engineering, and in 1951 became Technical Administrator of Custom Products, EPD until receiving his present assignment.

He is a member of Alpha Sigma Delta and the Institute of Naval Engineers, and is a registered Professional Engineer in N. J.

ROBERT W. JEVON has been appointed to supersede Dr. H. J. Wetzstein, representing the Airborne Systems Laboratory, Waltham, Massachusetts.

Mr. Jevon joined RCA in May, 1956 as Staff Engineer. He is presently involved in Technical Program and Manpower planning, Cost Estimating and space allocation.

He was instructor in the USAF, 1944-45; 1946-1950, he was employed by Grumman Aircraft in Aerodynamics and Flight Test Department; and 1951-1956, Technical Liaison for Government Defense Agencies.

Mr. Jevon received his B.S. degree in Aeronautical Engineering, MIT, 1946; his M.S. degree in Aeronautical Engineering, MIT, 1951.

HAROLD E. HAYNES has been appointed to represent CEP Advance Development Engineering as an Editorial Representative for the RCA ENGINEER.

A native of Nebraska, he received a B.S. degree in Electrical Engineering from the University of Nebraska in 1939. After a period as instructor in Electrical Engineering at South Dakota School of Mines, he joined RCA in 1941. He has since participated in the development of a number of equipments involving optical systems. The RCA Color Correction Equipment for the graphic arts is one. He is now engaged on a program of Industrial Inspection for CEP Advance Development.

Mr. Haynes is a member of the Institute of Radio Engineers, and of the Optical Society of America. He has fourteen U.S. patents granted.

SPECIALISTS JOIN DEP

COLONEL SKINNER JOINS RCA . . . Colonel Leslie A. Skinner, military expert on guided missiles, recently joined RCA Missile and Surface Radar Engineering as Manager of RCA Missile Technical Operation, White Sands Proving Grounds.

Colonel Skinner is a graduate of the U. S. Military Academy at West Point, with a B.S. degree. He received his M.S. degree from the Massachusetts Institute of Technology.

Colonel Skinner initiated modern rocket development in the Armed Services in 1932 and carried it on alone until organized rocket work for military purposes began in 1940 under Dr. Hickman of the N. D. R. C. at the Indian Head Rocket Laboratory. Colonel Skinner became Director of the Army Projects.

Since 1945 he has been awarded for his weapons work: The Legion of Merit, U. S. A. for the "Bazooka"; Military Engineering Award of the Engineers and Architects Society of Southern California; The Hickman Award of the American Rocket Society for 1950.

M. M. TALL, RELIABILITY SPECIALIST, JOINS RCA M&SR DEPARTMENT . . . The Missile and Surface Radar Department, DEP, Moorestown, N. J., has appointed Max M. Tall, widely known specialist in military electronics, to head its expanding reliability program for missile control projects, in a recent announcement by R. C. Willman, Chief Engineer of the department.

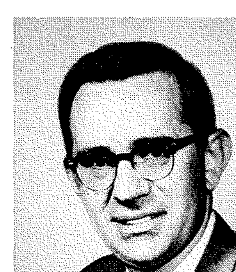
The reliability program is associated with missile control systems projects under the management of Jesse B. Cecil.

Mr. Tall, formerly associated with Vitro Laboratories and the National Radio Institute of Washington, D. C., is a recognized authority in the field of equipment reliability for military electronics. He was General Chairman of the recent Third National Symposium on Reliability and Quality Control in Electronics, and is a member of the Systems Reliability Committee of the Radio-Electronics-Television Manufacturers Association.

Mr. Tall is a graduate electrical engineer of City College of New York.

L. A. Skinner

M. M. Tall



MEETINGS, COURSES AND SEMINARS

AFTER HOUR PROGRAM CONDUCTED FOR CAMDEN ENGINEERS

The 10-12 session courses were completed in January and February and a new series will begin the last week of February. These will include (as planned at this time) the following:

Course	*Instructor*
Cooling of Electronic Equipment (new course)	G. Auth
Engineering Accounting and Finance	J. Idema
Engineering Management and Organization	L. R. Grimme
Engineering Writing,	Monro & Wentworth
Transistor Circuit Fundamentals	F. Putzrath

Other, longer courses will continue into the spring.

The fact that close to 600 (599 actual) engineers enrolled for the courses (16) gives some indication of the importance of such a program.

The objective of the program is to supplement the local college programs with courses of a practical nature that will help the engineer to become more effective in his job.

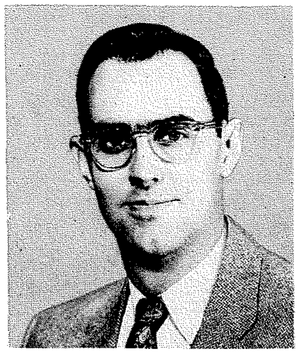
Since no credit is offered, except the recognition given individuals who successfully complete a course (a record is filed in his personal folder), the aim is not to duplicate, locally, the offerings of colleges or the Tuition Loan and Refund plan.

The program is administered by the Engineering Training and Personnel Studies activity, Building 10-1 and any requests for information concerning After Hours study should be directed to this group.

BERNARD SWEDLOFF, Computer Systems field engineer, RCA Service Company Technical Products Service Department, has just returned from a three months training course given at the West Coast Plant of the J. B. Rea Company. He is now maintaining the Readix Computer installed at the du Pont Plant in Wilmington, Delaware. —*E. Stanko*

RCA PROMINENT IN THIRD NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL IN ELECTRONICS . . . The Third National Symposium on Reliability and Quality Control was held January 14 through 16 at the Hotel Statler, Washington, D. C. This affair jointly sponsored by IRE, RETMA, ASQC, AIEE, and AIA was well attended and received national recognition by the press. Over twelve hundred engineers and managers including nearly forty from RCA attended the twelve sessions which included three discussion panel sessions. Tours to the Naval Ordnance Lab, Andrews Airforce Base and the David Taylor Model Basin occupied the last day. The featured speakers included: James M. Bridges, Director of Electronics, Office of the Assistant Secretary of Defense who gave the keynote address; Mr. D. E. Noble who spoke at the banquet and some forty other leading specialists in various aspects of Reliability Control and Quality Control.

RCA was well represented with Mr. M. C. Batsel on the Advisory Committee, Mr. C. M. Ryerson as Program Chairman, Mr. M. M. Tall as General Symposium Chairman, Mr. R. M. Jacobs, Publicity Chairman and Mr. W. W. Kauffman, I. K. Munson, R. M. Jacobs, and G. T. Ross presenting papers. The Fourth National Symposium is planned for the same location next January 6, 7, & 8.



J. W. Wentworth

J. W. WENTWORTH, Broadcast Studio Engineering, CEP, was the guest speaker at the first meeting of the newly-formed Hampton Roads Subsection of the IRE, held at Norfolk, Virginia, on January 11, 1957. His subject was "Compatible Color Television"—a review of the technical principles upon which the color television broadcast service is based.—*J. H. Roe*

1957 TRANSISTOR CONFERENCE

The 1957 Transistor and Solid State Circuit Conference was held February 14 and 15, 1957, at the University of Pennsylvania. Sponsored jointly by IRE, and AIEE and the University of Pennsylvania, G. H. Kunstadt, Airborne Fire Control Engineering, RCA, is Chairman of Publicity for the Conference. K. E. Palm, DEP General Engineering Development is coordinating papers for the Conference.

DEP MANAGEMENT TRAINING PROGRAM

The "middle management group" of Airborne Systems Equipment Engineering is participating in a Management Training Program based upon their development needs.

The group originally met with John Woodward, Chief Engineer, ASEE, and members of Camden Engineering Training to discuss their present and future needs and develop a program to meet those requirements.

The emphasis of the program is on practice of managerial skills. Toward this end, the program was built around four all-day Workshops that provide opportunity to practice various techniques used in Dealing with People, Problem Solving, Organizing Ability and Communicating.

The Workshops are held once each month and are preceded by weekly two hour seminars that provide information beneficial to practicing the skills.

The first all day Workshop was held at the Cherry Hill Inn October 9, the topic was "Dealing With People". The participants analyzed cases involving problems in human relations. Group discussion of the cases and demonstrations was aimed at increasing skills in motivating personnel, assessing and maintaining morale, generating enthusiasm, and utilizing personnel effectively.

Mr. N. J. Cappello, Manager, Personnel, DEP, spoke of the Principles of Good Human Relations at the luncheon. Mr. Cappello participated in the morning sessions of the Workshop, and drew examples from the group's discussion to illustrate the basic principles of effectively dealing with people.

IRE STANDARDS ON TRANSMITTER TERMS . . . At its last meeting in New York on January 11th, the IRE Technical Committee on Radio Transmitters initiated effort to bring up to date the standard definitions of terms relating to radio transmitters. No change has been made since the issuance of the original standards in 1948.

The committee is considering the deletion of obsolete or confusing terms, the revision of terms which have acquired a different meaning and the addition of terms which have been generated since the original compilation.

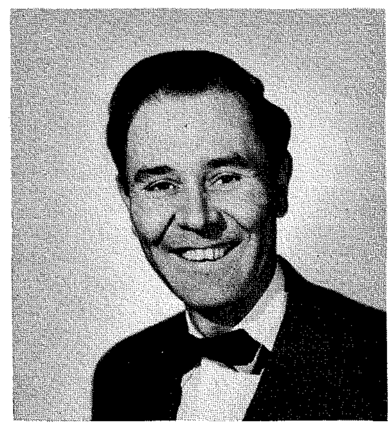
In general, terms which are in general use in all branches of the profession, and are cited in other standards, will be deleted.

Comments and suggestions may be addressed to the Definitions Coordinator of the Committee:

H. R. Butler, Division Head
Radio Transmitters
Federal Telecommunications Labs.
492 River Road
Nutley, N. J.

or to the Definitions Standard Editor of the Committee:

P. J. Herbst
DEP Technical Administration
Bldg. 10-7
Radio Corporation of America
Camden, N. J.

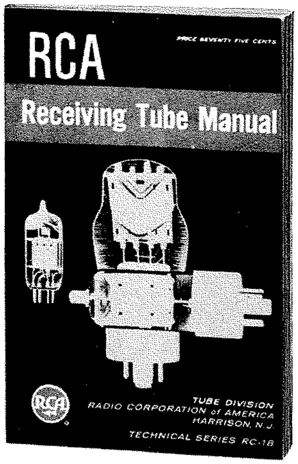


G. E. Poorte

BIZMAC ENGINEERS ON IRE COMPUTER SUBCOMMITTEE . . . The Institute of Radio Engineers has undertaken the task of recommending standards for digital computer block diagram symbols. The IRE Technical Committee has established a Subcommittee on Digital Computer Logical and Block Diagram Symbols.

At present a wide variety of computer block diagram symbols are in use by the several manufacturers and users. In many cases these symbols conflict with each other, or with symbols used for analog computers and other electrical equipment. These conflicts are impeding the progress of the whole computer field. They present a difficulty to customers and to training functions which must provide training on more than one type of equipment. The conflict is particularly noticeable in large computing systems built for the government by a number of different manufacturers.

Among the members of the committee are Glenn E. Poorte, BIZMAC Engineering and James G. Smith, alternate, BIZMAC Engineering.—*T. T. Patterson*



NEW RCA RECEIVING TUBE MANUAL ANNOUNCED . . . The new RCA RECEIVING TUBE MANUAL, RC-18, is revised, expanded, and brought up to date. The Manual contains technical data on more than 575 receiving tubes, including types for black-and-white and color television and series-string applications, and more than 75 picture tubes including color types.

The section on Electron Tube Applications has been expanded to include a description of television applications such as tuner circuits, video amplifiers, sync circuits, agc circuits, and deflection systems. Other sections include information on generic tube types, interpretation of tube data, and electron-tube installation.

The Receiving-Tube Classification Chart is arranged to facilitate rapid selection of RCA types according to their family class, functions, and filament or heater voltages.

The section on Circuits covers such typical applications as superheterodyne, superregenerative, and short-wave receivers, AM and FM tuners, various types of amplifiers, a code-practice oscillator, a 6-station intercom, and high-fidelity audio amplifier circuits including a low-distortion input amplifier stage, a two-stage input amplifier using cathode-follower (low-impedance) output, a bass and treble tone-control amplifier stage, and a complete 10-watt hi-fi amplifier.

COMMITTEE APPOINTMENTS

Three members of CEP Communications Engineering have been appointed chairman of three committees of the joint Professional Groups on Microwave Theory and Techniques, and Antennas and Propagation, of the Philadelphia Chapter of IRE.

R. H. FRICK is Chairman of the Membership Committee; **E. J. FORBES** is Chairman of the Meetings and Papers Committee; and **O. E. JOHNSON** is Chairman of the Publicity and Arrangements Committee.
—*B. F. Wheeler*

H. G. REUTER has been appointed RCA representative on the AIEE Committee on Electrostatic Charge Standards.
—*T. T. Patterson*

CORRECTION

N. C. Colby, CEP Communication Engineering, was announced erroneously in this column in the last issue as a member of DEP Surface Communications Engineering.

NEW GRADUATE STUDY PROGRAM

A part-work, part-study program has just been announced. Selected engineers and scientists may earn the Master's Degree in two years or less, in the fields of Electrical Engineering, Mechanical Engineering, and closely allied sciences. The main objective is to attract superior graduates from colleges and universities throughout the country, to meet the recruitment needs of certain engineering operations. Graduates hired for the Harrison and Somerville locations will attend Rutgers University, while those in the Camden-Moorestown vicinity will study at the University of Pennsylvania. Additional schools may be brought into the program as need and opportunity arise.

A number of openings in the Graduate Study Program will be reserved for qualified engineers and scientists already employed by the Company at the aforementioned locations. Selections for these openings will be made competitively, on the basis of professional promise and scholastic ability, and will be distributed in engineering operations approximately in proportion to the number of newly hired engineers each will require through the program.

Participants will work 20 or more hours a week, depending upon academic load, and will receive pay for hours worked. To the extent that suitable projects can be arranged, company-sponsored thesis research time will be counted as time worked, and paid accordingly.

If you are in an operation covered by the program and wish to apply, see your supervisor.

RELOCATION OF RCA SERVICE COMPANY'S TECHNICAL PRODUCTS ENGINEERING LABORATORY

On December 7, 1956, the RCA Service Company, Technical Products Laboratory was moved to its new location at Westfield Avenue at Norwood, Pennsauken, N. J. In addition to regular laboratory activities, facilities are available for limited electronic and mechanical operations and testing of various equipments and instruments used in the field. A class room for training of field personnel is also incorporated in the building.—*E. Stanko*

NEW AGC AMPLIFIER AND STAB AMP

The TA-21 Video Automatic Gain Control Amplifier and the TA-9 Universal Stabilizing Amplifier have been completed by TV Terminal Engineering. These specialized amplifiers will play important roles in simplifying television studio operation and in improving picture quality. The former device is based on pioneering work done at NBC (see article in next issue by J. Schroeder) and product development and design work accomplished by F. L. Bechly, A. H. Turner, and R. T. Ross. The TA-9A was developed and designed by R. C. Dennison and C. P. Corey under the direction of C. R. Monro.—*J. H. Roe*

ENGINEERING MEETINGS AND CONVENTIONS

February - April, 1957

FEBRUARY 26-28:
Western Joint Computer Conference, Statler Hotel, Los Angeles, Calif.

FEBRUARY 26-28:
Joint Military-Industrial Guided Missile Electronic Test Instrument Symposium, Redstone Arsenal, Huntsville, Ala.

MARCH 4-6:
National Biophysics Conference, Columbus, Ohio.

MARCH 11-14:
EJC Second Annual Nuclear Science and Engineering Congress, Philadelphia, Pa.

MARCH 18-21:
IRE National Convention, Waldorf Astoria and New York Coliseum, New York City.

MARCH 18-21:
Annual National Conference and Pacific Coast Plastics Exposition.

APRIL 8-11:
British Radio and Electronic Component Show, Grosvernor House and Park Lake House, London, England.

APRIL 9-10:
Annual Industrial Electronics Educational Conf., IRE. Armour Research. Institute of Technology, Chicago, Ill.

APRIL 11-13:
Ninth Southwestern Regional Conference & Show, Shamrock-Hilton Hotel, Houston, Tex.

APRIL 11-13:
National Simulation Conference, Shamrock-Hilton Hotel, Houston, Tex.

APRIL 14-16:
IRE PGTRC National Telemetering Symposium, Philadelphia, Pa.

APRIL 15-17:
Tenth Annual Conference for Protective Relay Engineers, A&M College of Texas, College Station, Tex.

APRIL 23-25:
Symposium on Role of Solid State Devices in Electric Circuits Engrg. Society Bldg., New York City.

APRIL 24-26:
Region Seven Technical Conference & Trade Show, San Diego, Calif.

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