OBJECTIVES

To disseminate to RCA engineers technical information of professional value.

•

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

•

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

•

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

•

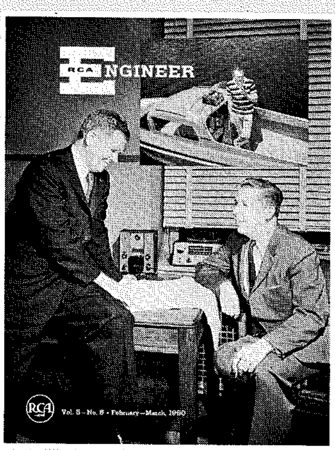
To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.

•

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

•

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



OUR COVER

The modern mariner need not rely on "ancient-mariner" techniques if he avails himself of the low-cost, compact RCA Radiomarine equipment shown. At left, Gordon Rogers, Communications Products Dept., IEP, is shown with his *Radio-Phone Deluxe* transceiver for the 27-mc Citizens Radio band (more on this on Page 6); at right, Karl Neumann, Mgr., Fixed Communications, IEP, and his *Portaguide* transistorized, portable, radio direction finder. Inset: Vaughn Monroe—no ancient mariner—makes use of such gear.

INTEGRITY

Being of sound moral principle; honesty; sincerity—WEBSTER

ENGINEERS ARE THE life blood of all progressive electronics companies. An effort is always made to establish an engineering team that has a variety of capabilities and interests so that new fields can be entered with the same confidence as is evident in the pursuit of well-established lines.

It is not difficult to acquire a collection of technical people; to turn them into an effective team that can operate successfully and efficiently requires conscientious cooperative effort on the part of both the company and each engineer. *Integrity* is one of the essential requirements for both the engineers and their employer.

Engineers are fortunate in their choice of a profession. They emerge from colleges and universities resplendent in a cloak of integrity. They have been trained in the exact laws of science and mathematics; they deal with materials and tangibles which are capable of proof. These are the easy things of which integrity is made. *Effective teamwork* requires much more.

Engineers, in their contacts with other engineers, almost universally assume sincerity and honesty in the use of the tools of their profession. Consequently, integrity means much more than this. It is the task-master that requires the best engineering possible within the limitations imposed on a project; the willingness to accept responsibility for one's own errors and the desire to give the extra effort that often is required to make the team project a success. It also requires respect for the ability of one's teammates and loyalty to the company.

The company, on the other hand, has a similar responsibility. It can be so patronizing toward the engineers that they react with resentment, or it can be so paternalistic that they are lulled into a state of self-satisfaction. Either state is undesirable. The company must provide challenging problems so that the energy of reaction is applied to a complicated task. When a goal is reached, the engineer must be shown that his skill is needed and appreciated but this must be followed by another new and interesting problem.

Integrity places other requirements on the company. One obligation is to maintain a line of well-engineered equipment that enjoys widespread customer acceptance. Every well-established company creates an image of itself in the minds of its customers. For example, one company may strive to supply the lowest-priced equipment, another may supply the finest equipment, while other competitors may be recognized for various characteristics between these extremes. RCA has established a reputation for dealing with honesty and sincerity. This has created an enviable image. It is the obligation of each of us to remember that along with every product, RCA sells integrity.

Wendell C. Morrison, Mgr.
Engineering Plans & Services,
Industrial Electronic Products
Radio Corporation of America

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The Engineer and the Corporation

RCA GRADUATE STUDY PROGRAM

by H. G. MATZ, Administrator

Graduate Study Programs, College Relations, RCA Staff, Camden, N. J.

ELECTRONIC DEVICES, COMPONENTS, AND SYSTEMS continue to grow more sophisticated. They are requiring an ever higher level of professional engineering to conceive, develop, and produce them. To maintain a position of leadership in today's electronics technology demands that any company —particularly when expanding its engineering activities to meet the competitive demands of the industry—must supply itself with engineering talent having the benefit of advanced training in many fields. RCA has recognized this problem. Since 1957, the Corporation has fostered a growing Graduate Study Program for outstanding young engineers who are desirous and capable of continuing their education and ultimately obtaining Masters Degrees.

PHILOSOPHY OF THE PROGRAM

The engineer receiving his Bachelors Degree is today faced with the decision of whether to accept the immediate salary returns available to him, or perhaps to delay this and continue with higher-level education that might, in the long run, benefit him more professionally. The cost of a graduate degree, both in tuition and income foregone, can be a determining factor. In addition, immediate professional application of his engineering training may appear more interesting. However, both from the individual's and from the Corporation's standpoint, it is important that those engineering and science graduates who possess outstanding long-range potential be encouraged and materially aided to complete graduate degrees.

To accomplish this, the Graduate Study Program is designed to offer the advantages of an academic fellowship, the benefit of immediate professional work for the Corporation, and the financial return normally available to an engineering graduate. Selections for the program may be made directly from college campuses, the military services, employment referrals, and present employees, such that all potential sources of engineering talent can be considered. The basic requirements are the same in all cases—demonstrated engineering aptitude and long-range potential.

HOW THE PROGRAM WORKS

The program combines academic graduate studies at a University for two days a week with practical engineering work within the Corporation for three days. During school recesses and summer vacations, participants work full time on RCA engineering projects. During the school term, no more than 24 hours of work is permitted each week, with a strict prohibition against overtime. The basic program leads, normally to a Masters Degree in a two-year period.

During the first school semester, participants receive 80 percent of their regular monthly salary; in successive terms participants receive full salary. During summer recess, full salary is paid and any available overtime work is permitted. The salary levels involved in this program are determined under the same criteria used for any RCA engineer with comparable background. Raises and promotions both during and after completion of the program are also determined by regular methods. All academic tuition, fees, textbooks, and materials are paid for by the Corporation.

Arrangements exist with appropriately located schools to allow efficient course scheduling: the University of Pennsylvania, Rutgers—The State University, Princeton University, and the University of California at Los Angeles. Arrangements are now being made to extend the program to include the Brooklyn Polytechnic Institute in 1960.

Since 1957, over 250 men have started the program. They have been screened from over 125 Colleges and Universities, with about 10 per cent of the number being drawn from Corporation ranks.

Each major operating unit throughout RCA determines, each year, the number of participants it desires in the program and the particular professional disciplines needed. All salaries and costs of the program are paid directly by the operating unit involved.

SELECTION OF PARTICIPANTS

The College Relations activity, Corporate Staff, Camden, N. J., makes a preliminary selection of candidates for the program who have been obtained either by recruiting or by recommendation of their operating unit. Candidates must possess a recent Bachelors Degree in Electrical Engineering, Mechanical Engineering, or Physics.

The RCA Graduate Study Selection Committee is responsible for final selection of candidates. It consists of representatives of engineering management from the major operating units and from the College Relations Activity. The Selection Committee competitively chooses a number sufficient to satisfy the requirements previously established by the operating units by applying the following criteria: 1) academic achievement of a level to qualify for a recognized engineering honor society; 2) future potential for significant engineering or related management contributions to RCA, determined by

HENRY G. MATZ received his BS degree in Education from Temple University in 1949. After graduation, he taught General Science in the Camden School System from 1949 to 1953. He joined RCA in 1953 and has worked in the Camden Personnel activity as an Interviewer and Training Specialist. As an RCA employee, Mr. Matz earned his Master's degree from Temple University in 1957, majoring in Industrial Management and minoring in Guidance and Counseling. He also worked in the Industrial Electronic Products Division Personnel Staff in Management Development. Since September, 1958, he has been a member of the Corporate Staff College Relations activity as Administrator, Graduate Study Programs. In this capacity, he is responsible for recruiting of advanced-degree candidates as well as initially screening, placing, and counseling Graduate Study Program candidates.

personality, technical interests, and extra-curricular activities; and 3) professional accomplishments and honors.

A participant in the program has the same employment status that any other engineer in the Corporation has—i.e., he does not contract to work for RCA for any special period, and his salary and advancement after completing the program are determined by the regular policies of the unit by which he is employed. Thus, a program participant is offered the opportunity of pursuing advanced work for which his background indicates he is well-fitted, while at the same time his professional future remains his to determine.

To illustrate the kind of men who have been chosen for the Graduate Study Program, brief biographical sketches of five who have completed the program are presented at the right.

RELATION TO OTHER RCA EDUCATION PROGRAMS

The Graduate Study Program forms a logical complement to the other educational programs that RCA sponsors. These include the Tuition Loan Refund Program (available to all employees for study outside working hours at company expense); a Scholarship Program for undergraduate students in Engineering, Science, Industrial Relations, Dramatic Arts, and Music; a Fellowship Program for postgraduate students; a separate Scholarship Program for students preparing for the Science Teaching Profession; and an Educational Television Workshop at New York University to create and disseminate to educational groups effective aural and visual techniques for classroom television.

CONTINUING EDUCATION—A PROFESSIONAL TOOL

RCA management attaches great importance to continuing professional education as a means of equipping engineers and scientists with the tools needed to meet the heavy demands of today's complex, competitive electronics technology. The Graduate Study program—along with the Corporation's other educational programs—illustrates well the responsibilities that a progressive management has assumed towards providing opportunities for professional development to those able and willing to take advantage of them.

CARL CLASEN received his AB in Physics from Washington University, where he was a member of three honorary societies. He initially joined RCA in June, 1953, but was shortly called into the military service. After discharge in 1955, he rejoined RCA and entered the Graduate Study Program in September, 1957. He completed his M.S. in Physics in June, 1959. Mr. Clasen has written the antenna portions of several proposals including the MADRE, and MPQ-32 and has coordinated the microwave and antenna portions of the Advanced weapons system proposal. He was associated in the development of the AN/FPS-16 and is presently working on electronic scanning. He is author of several technical reports, a member of the IRE, and is presently in the Missile and Surface Radar Division, in Moorestown, New Jersey.

MARVIN CROUTHAMEL received his BS in Mechanical Engineering from Pennsylvania State University. While an undergraduate at Penn State, he was a member of the Pi Tau Sigma, Sigma Tau, and Tau Beta Pi honor societies. He was also Vice President of the Student ASME. He started the RCA Graduate Study Program in September, 1957, and attended graduate classes at the University of Pennsylvania Graduate School, receiving his Master's Degree June 10, 1959. He has worked on the Electrofax Automatic Library Card Copier and is presently doing work on the Thermoelectric Cooling and Power Generation in the Development Engineering activity of Defense Electronic Products.

DAVID FRIED received his BA in Physics from Rutgers—the State University. He began the RCA Graduate Study Program in September, 1957, and attended Rutgers, receiving his Master's Degree in Physics in January, 1959. Mr. Fried spent two years in military service as a radar operator. He began his employment with RCA in June, 1957, and has been working on project Acsi-Matic. He is presently working in the Special Systems and Development activity of Astro-Electronic Products.

GERALD HERSKOWITZ received his BEE degree from Brooklyn Polytechnic Institute. He was a member of Tau Beta Pi and Eta Kappa Nu honor societies as well as President of the Student Council. He came to RCA in June, 1957, started his graduate studies at Rutgers in September, 1957, and received his Master's Degree in Electrical Engineering in June, 1959. He has done work on Projects Acsi-Matic, Tiros I, and Pangloss, and has applied for a patent for a Satellite Picture Rectifier. He is presently in the Special Systems and Development Engineering activity of the Astro-Electronic Products Division.

VLADIMIR HORVAT received his Electrical Engineering degree from the University of Zagreb. He began his employment with RCA in 1955 and became a participant on the RCA Graduate Study Program in June, 1957, attending the University of Pennsylvania. He received his Master's Degree in Electrical Engineering in June, 1959. He has designed various magnetic components (transformers, reactors, saturable reactors). He was in charge of the Magnetic Amplifiers Design and Magnetic Amplifier Research project and has applied for a patent on the Magnetic Amplifier as Frequency Multiplier. He is presently a member of the Low Frequency Inductive Component activity of Defense Electronic Products.

IEP—ITS SCOPE AND FUTURE

by **J. J. GRAHAM, General Manager**
Communications and Operations Division
IEP, Camden, N. J.

EVERY ECONOMIC unit must fulfill a specific human need in order to exist and prosper. This rather obvious statement is often forgotten in the routine of business. In this day of work subdivision and specialization, we sometimes even tend to think of our own particular job specialty as an end in itself. Planning the future course of a business, however, must always be governed by the stark consideration of customer reaction.

RCA is a large company set up to satisfy a widely diverse set of human needs. It is segmented in a manner devised to permit discrete groups to concentrate on meeting specific customer requirements in the most effective way. Governed as they are by different end requirements, it follows that each of the many divisions must have an underlying philosophy of operation attuned to the parameters of its own market situation. Thus, Industrial Electronic Products has a basic, central mission: It is the capital-goods producer of RCA. Most of its products are simply tools, enabling other people to conduct profitable businesses.

A broadcast station is a good example. Along with buildings and services, the transmitter, antenna, and studio gear make up the station operator's manufacturing plant. This is his income-generating equipment. Of course, he also needs a license, capital, talent, and program material, but his basic tool is the equipment.

It is axiomatic that a businessman buys a tool only if he can liquidate the cost in a reasonable period of time and realize a satisfactory profit on the investment. Thus, the task of IEP boils down to supplying the best tool, from an economic standpoint, to do a specific job of income production.

When the customer looks at what RCA has to offer in the way of tools to do a specific job, he evaluates them versus competition on several broad grounds. These are: ability to do the job, reliability, first cost, operation cost, maintenance cost, special features, versatility, and expansibility. Assuming satisfaction on these points vis-à-vis competition, features such as styling and availability may become determining factors.

ENGINEER FOR MAXIMUM VALUE

RCA has always been blessed with a large group of highly qualified engineers, who keep up-to-date with latest developments in their field. IEP is no exception in this. It is within the abilities of these engineers to design equipment to more than meet these all-inclusive customer requirements, if cost were no object. The commercial world, however, is a fiercely competitive one which places no premium on over-design. Bearing in mind that we are in the tool business, the salable design is that design below the theoretical ultimate which represents the best value for customer's dollar invested.

Because of this necessity for exactly meeting the customer's requirements, our planning and development must always be customer-oriented. It must seek to satisfy either present needs or future needs. The farther out into the future we project new needs, the greater becomes the worth of the marketing man, planner, or engineer who can accurately target areas of customer needs which RCA can fill.

IEP IS CUSTOMER ORIENTED

We have spoken of the division of RCA to meet broad categories of human needs. The planning set forth above explains the breakdown of IEP into the Broadcast, Communications, Electronic Data Processing, Industrial & Automation Divisions, and RCA Communications Inc.

The criticism is often leveled at large companies that they are over-organized, in the sense that there are too many small, identifiable product activities, leading to large numbers of lower- and middle-management personnel and multi-layering of higher management for control. This charge is not always without foundation, but it is important to understand that the reason for organizing in this manner is the highly appealing one of bringing the specialist manager, salesman, and engineer face to face with his particular customer.

In IEP, the organization is designed to maximize the opportunity for this intimate association with the customer, consistent with the economics of the particular situation. Let us look at some of the major divisions of IEP and their future plans.

BROADCAST AND TV DIVISION

This Division is engaged in supplying FM, AM and TV transmitters and studio gear to broadcasters, closed-circuit TV equipment to a wide range of customers, and high-power r-f equipment for military radar use, and nuclear-fusion–reactor prototype equipment.

Another important area of future business for RCA lies in the automation of broadcast and TV operations; substantial progress has been made with such items as the TS-40 Switching Equipment, and heavy emphasis is being placed in this potentially profitable area.

With the advent of production models of the Video Tape Recorder, RCA is now in a position to actively compete in this rapidly expanding field, not only for sale of tape recording equipment but also for a wide variety of auxiliary equipment.

Efforts on the C-Stellerator by the IEP group have materially assisted RCA progress on this important project. Plans are being made to further capitalize on the IEP know-how in high-power r-f. Numerous possible applications in industry are being studied and some of these appear to be promising.

RCA already holds a strong position in the closed-circuit TV field, secured by the use of high-performance TV cameras in such blue-chip installations as the Strategic Air Command, Walter Reed Hospital, and Redstone Arsenal. Commercial installations, such as the Southern Railways installation at Atlanta, Georgia, have spread the reputation of RCA in the market. Comprehensive programs aimed at furthering our interests in closed-circuit TV are in process.

COMMUNICATIONS DIVISION

A revitalized two-way radio group has started to recapture the traditional

RCA position in the field of private radio communications. The new line of mobile radio equipment is a concrete expression of the IEP policy of meeting a need with the lowest-cost equipment consistent with performance. Today's two-way radio customer is, in the main, buying a service, not a radio set. The new line gives him the lowest-cost transistorized equipment in the market, plusses in serviceability and reliability, and a practical level of battery drain.

The future large market in personal communications is being pried open by the RCA *Personalfone*, first in the field. Its use in such glamour situations as the Madison Square Garden Horse Show and air terminals, as well as for such mundane work as laying underground cables, promises much.

RCA broke open the Citizens' Radio field with the super-regenerative Radio Phone, followed by the super-heterodyne Radio Phone and now offers the ultimate in the sleek Mark VII, which gives crystal control of four *receive* and four *transmit* channels, as well as offering a tunable receiver. This unit is part of a long-range program to provide two-way radio in all price and use classifications.

A budding, but potentially large market for Small Craft Electronics is being given much attention by IEP. At the New York Boat Show RCA introduced a whole line of new items—Radio Telephones, Direction Finders, Depth Meters, an Inverter—crowned by the finest compact Small Craft Radar in the business.

RCA continues its pre-eminence in Fleet Electronic equipment with the successful CR-108 Radar, shortly to be followed by the True-Motion Radar, which will put the radio operator in the picture and will provide greater safety and less chance for misinterpretation than conventional radar.

Recent actions by FCC herald the approach of a large-scale microwave market. Plans are being made to capitalize on the expected heavy demand. RCA has recently received a large contract for a coast-to-coast microwave system — a high-capacity, 6000-mc system that will probably find other applications.

INDUSTRIAL & AUTOMATION DIVISION

This Division is engaged in the rather complex operation of 1) capitalizing on present markets for such well-accepted items as the RCA Electron Microscope and beverage-inspection machinery, 2) establishing programs in such new fields as newspaper automation and industrial devices, and 3) integrating the old with the new.

The RCA Electron Microscope continues as the standard of the industry. The next generation of beverage-inspection equipment, the continuous-motion Type S machine is in the field, offering twice the inspection speed plus advanced control features. X-Ray diffraction equipment for industry, a new entry, is moving well.

Such newcomers as the Electronic Typesetter, the Electronic Lectern, and the Language Laboratory (a teaching device) have received immediate acceptance.

Much planning and great effort will be required to capitalize on today's technology and prepare for the ultimate job of completely automating industry.

ELECTRONIC DATA PROCESSING DIVISION

The reception of the RCA 501 has been unprecedented in the field of data processing. This success has established RCA as a leading figure in this industry. This came about as a result of our ten-year program which included the development of Typhoon and Bizmac.

Progress continues with the announcement of the 502, 503, and 504 series computers. IEP is currently engaged in work on a very large contract for electronic-data-switching equipment, using 501 techniques. New, transistorized MUX/ARQ-2 equipment is on the market. Numerous other devices and systems are in prospect. RCA has also done much work on advanced computer techniques.

RCA will keep pace with the ever-growing need for swifter, less-costly means of handling the ever-mounting masses of information necessary to keep our complex society in motion.

RCA COMMUNICATIONS, INC.

This activity is conducting the oldest business of RCA, overseas radio communication. Paradoxically, this old-line business is conducting its business in a manner so modern, so efficient that many of the newer businesses of RCA could well copy its philosophies.

It is well-known in the industry as the most forward thinking, most efficient of the overseas carriers. It now serves 68 countries of the world with circuits for message, voice, telex, and data transmissions.

Ever-diligent search for new markets has led to the development of the highly successful TEX service and leased channels. Other areas are constantly being examined for new outlets for RCA Communications, Inc.

THE FUTURE

This, then, is a montage of today's IEP planning for the future. IEP is operating in that sector of the American economy where possibilities of large growth are greatest. It can properly be termed a growth operation. With growth of any kind, human or business, come many problems, but also many opportunities. IEP represents a many-pronged, integrated offensive by RCA on the problem of supplying human needs. We have discussed the underlying philosophy of that offensive. Given the dedicated efforts of many people, IEP and RCA will grow with the American economy and become an even more important part of the business community.

JOHN J. GRAHAM is a business-administration graduate of the University of Pennsylvania, where he was elected to Sigma Kappa Phi, honorary business fraternity. Later, he completed Harvard's Advanced Management Program. After design and industrial engineering experience with several Philadelphia companies, he joined RCA in 1947 as a specialist in production cost analysis. In 1950, he was placed in charge of Manufacturing Engineering for the government plant of the old Engineering Products Division and, in 1954, became manager of Manufacturing Engineering for the Division (whch included all of the present DEP and IEP operations). He organized and directed the RCA Automation Laboratory and has written and spoken widely on that subject. In 1955, he was named Controller of the Commercial Electronic Products Division. His achievements there won him the RCA Victor Award of Merit in 1956. When IEP was formed in 1957, he was named Manager, Operations; and in 1958, General Manager, Communications and IEP Operations Division.

RCA EQUIPMENT FOR THE NEW CITIZENS RADIO BAND

by **G. F. ROGERS**
Communications Products Department
IEP, Camden, N. J.

Fig. 1—RCA Radio Phone, Type CRM-P2A-5.

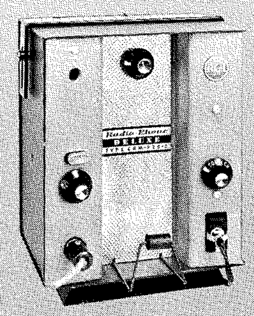


Fig. 2—RCA Radio Phone Deluxe, Type CRM-P2B-5.

Fig. 3—RCA Mark VII Radio Phone, Type CRM-P3A-5.

IN THE FALL OF 1958 the Federal Communications Commission allocated a new frequency band for *Citizens Radio* voice communications. This new 27-mc band permits communication over greater distances with less-expensive equipment than required for the 465-mc band previously allocated for Citizens Radio. The 465-mc band was allocated in 1947 for Citizens Radio, but with the limitations of line-of-sight transmission and expensive equipment requirements, there has been no large Citizens market for the band. In this new band, twenty-seven channels with 10-kc spacing were allocated between 26.965 mc and 27.225 mc with twenty-two of these channels for voice communication and four for radio control of airplane and boat models, paging, and similar uses. In addition, a 27.255-mc channel was allocated for both voice and radio control stations.

Opposite page: The author, Gordon Rogers (at left) and Karl Neumann, Mgr. Fixed Communications. (See inside front cover.)

GORDON F. ROGERS graduated from Clemson College with a BS in EE, and has since had 22 years of experience in electronics. The first nine years were with the PAMSCO Branch of Pan American Airways in Coral Gables, Fla., where most of the radio equipment for the PAA system was designed and built. There, he became Chief of the Radio Receiver Laboratory. Equipment developed included a combination Communication and Automatic Direction Finder Receiver, the first Isolation Amplifier used on aircraft, a simulator for training Radio Navigation, and an Alarm Monitor Receiver. When the PAMSCO Branch was closed in 1946, Mr. Rogers took a position with the Industry Service Laboratory of RCA Laboratories in New York City as a member of the Technical Staff, doing research on AM Receiving Systems. In 1949, he became Section Head, Technical Staff, with responsibility for development work on TV receiver circuits and a consulting engineering service to the patent licensees of RCA. In 1950, Mr. Rogers was sent to Hollywood, California as Engineer-in-Charge to open up a branch of the Industry Service Laboratory (ISL). In 1953, he was made Engineer-in-Charge of the Chicago branch of the ISL. In 1958 he transferred to the Communications Products Dept. of RCA in Camden where he has been responsible for the development of Citizens Radio transceivers. Other work has been on small-craft Radiomarine products. Mr. Rogers has 12 issued patents and several pending. The most widely used patent is on the circuit currently used for keyed AGC in TV receivers.

At the same time, the FCC also liberalized its requirements for obtaining a station license; no operator's license is required.

Unfortunately, this new frequency band is subject to interference from some powerful commercial stations outside the United States, and from industrial, scientific and medical devices operating in the frequency band. The most common type of interference is from diathermy machines.

NEW MARKET

RCA felt that the FCC action opened up a large new market for low-cost communications equipment for use by individuals, with the largest segment of the market being the small-boat owner. Since the FCC permits licensees to use any of the new voice channels, RCA reasoned that the receiver should be a broadband type to receive all transmissions from other boats without retuning. With this in mind, the Communications Products Department formulated plans to produce its first Citizens Radio equipment.

NEW PRODUCTS

The RCA Radio Phone, Type CRM-P2A-5 was the first product designed for this market. It is a complete transceiver in a two-tone blue cabinet (Fig. 1). Because it weighs only 8 pounds, the instrument is readily portable to a source of 115 volt a-c power or a storage battery. A collapsible built-in antenna was provided as well as provision for connection to an external antenna. A 2½-inch dynamic loudspeaker serves both as microphone and loudspeaker. The speaker case includes the *push-to-talk* button. With the requirement for a broadband receiver the superregenerative type offered the most performance for the least cost. The CRM-P2A-5 came off the production line in March 1959. Accessories included: external antennas for fixed station, automotive and marine use, external speakers for greater acoustic output; and a wall-mounting bracket. To quiet the receiver when not receiving transmissions, an accessory squelch control unit was provided. This unit operated from the receiver noise between 10- and 12-kc to cut off the first audio-amplifier.

The RCA Radio Phone De Luxe, Type CRM-P2B-5, was designed when market and field experience indicated the need for a narrow-band receiver. The market requirement for a broadband receiver was less than had been anticipated and the previous broadband receiver received more external random noise, diathermy and foreign station interference than narrow-band receivers, thus reducing the range. The CRM-P2B-5 shown in Fig. 2 uses a crystal-controlled superheterodyne receiver which may be made tunable by merely unplugging the crystal from the front panel. The De Luxe Radio Phone uses the same cabinet and microphone speaker combination as the earlier Radio Phone. The squelch control is on the right-hand side and the tuning control on the left. Market experience with the earlier transceiver had brought complaints of very short range, which upon investigation usually proved to be due to the limitations of a built-in antenna. Accordingly, the built-in antenna was omitted from the De Luxe Radio Phone so that it could be operated only with an external antenna. This unit was first produced in October 1959.

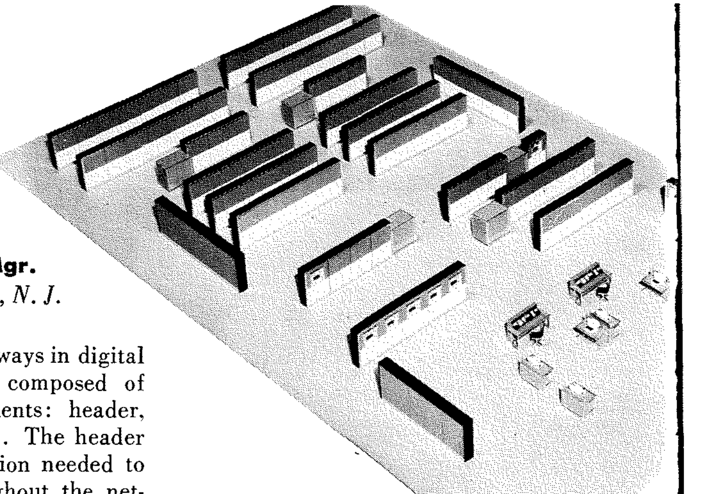
The Mark VII Radio Phone Type CRM-P3A-5 provides four crystal-controlled transmit and receive channels, and also a tunable receiver (see Fig. 3). This model, only 5 inches high, is easy to mount under the instrument panel of a car. A separate ceramic microphone with *push-to-talk* switch permits use of a larger speaker to give more acoustic output.

APPLICATIONS

The above equipment supplies the need for low-cost communications by the citizen between homes and car or boat, on farms between tractors and the farm house, and in many industrial uses. In the first year after the new band was opened to the public, approximately 50,000 licenses were issued by the FCC. Counter to the intent of the FCC, many of the licensees use their equipment for amateur-type communications, rather than for strictly personal or business communications. There has been considerable long-distance communications of the amateur type, but this has been curtailed by citations from the FCC.

AUTODATA—RCA'S AUTOMATIC MESSAGE SWITCHING SYSTEM

by **T. L. GENETTA, J. F. PAGE, and J. L. OWINGS, Mgr.**
Special Data Processing Equipment Engineering, IEP, Camden, N. J.



AUTODATA IS AN automatic, fully transistorized store-and-forward message switching center. It is designed to handle messages which are digital in form and to provide a very flexible facility for relaying them throughout a worldwide communication network. The AutoData message-switching system was conceived to achieve the following, when installed in a communication network:

1) minimum rental charges for communication lines
2) automatic transfer of data over the communication network
3) transfer of data between dissimilar equipments using different data rates, different codes, or different formats
4) flexibility in the choice of data transfer rates on all trunk and tributary circuits in the network
5) high degree of message protection, including automatic error detection and correction on closed loop circuits
6) flexibility in the choice of message-handling procedures
7) building block expansibility of equipment to increase service as required
8) compatibility with a variety of common-carrier terminal facilities.

How the AutoData system is being designed to provide these advantages will be presented by first describing the configuration of an AutoData communication network, pointing out the basic switching center functions, outlining the principal system design considerations which make AutoData outstanding, and finally reviewing the flow of messages through a typical AutoData switching center.

AUTODATA COMMUNICATION NETWORK

Fig. 1 shows the elements of a communication network using AutoData message switching centers, along with a scale model of an AutoData layout. Messages are originated and terminated at tributary stations ($T_1 \ldots T_n$) or Electronic Data Processing Equipments (EDPE) stations. The stations are connected to the switching centers via tributary lines. To complete the network, the switching centers are interconnected via trunk lines. All communication lines and their associated terminal equipments, including technical control, are rented from a common carrier.

The message traffic is always in digital form. Each message is composed of three characteristic elements: header, text, and ending (Fig. 2). The header contains all the information needed to route the message throughout the network as well as other information needed for message protection. The text contains the data to be transferred. The ending uniquely marks the end of the message.

Messages are interchanged throughout the network by sending them first to the nearest switching center. They are then relayed among switching centers and finally distributed to addressees. In the process of doing this, each switching center may interchange messages among many types of communication terminal equipments such as teletype, punched-card transceiver signalling units, and high-speed digital data-transmission devices. These devices may have a number of incompatible characteristics which the AutoData system must cope with to provide the required relaying of message traffic.

Data-transfer rates may vary from about 30 to 3000 bauds and higher depending upon the type of subscriber terminal device used. [ED. NOTE: The *baud* speed of a system is the reciprocal of the length, in time, of one character element.] Data characters may be transferred in a variety of codes, ranging from 5 to 8 elements in length. A variety of redundancy features may be employed to permit automatic error detection and correction, i.e. constant ratio codes such as the 4-out-of-8 or 3-out-of-7 code, parity-checkable codes where each character has an extra bit added to make the sum of the bits in each character an even or odd number, or block-checkable codes where an extra bit is added to each column of a group of characters to produce the odd or even checkable characteristic. Also, the coordination signalling characteristics of subscriber terminal devices may be dissimilar. Some devices may be

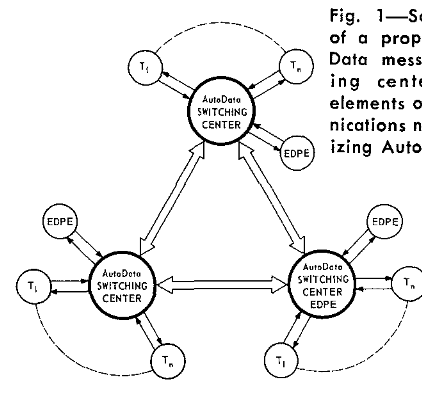


Fig. 1—Scale mod of a proposed Auto Data message-switch ing center. Below elements of a commu nications network uti izing AutoData.

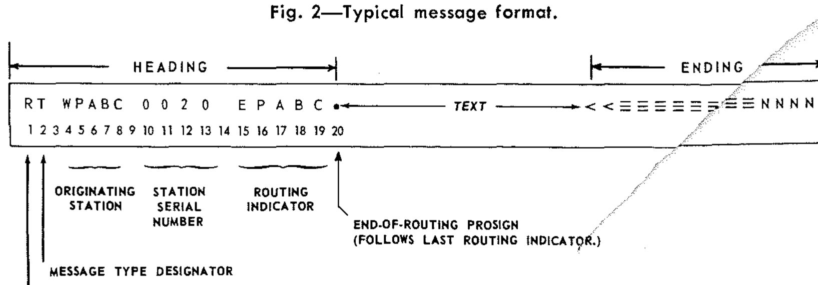
synchronous, others asynchronous. Some may operate with closed loop control; others provide one-way transmission only. Some are fully automatic; others are manual. Finally, the type of transmission may vary among subscriber terminal devices, for example, d-c keying, tone keying, frequency-shift keying, and phase-shift keying.

The AutoData system takes maximum advantage of the many different characteristics of communication terminal equipments, thus providing the traffic engineer with added flexibility to optimize the design of any particular communication network. The following outline of the basic Switching Center functions will provide a foundation upon which to base a more detailed description of the AutoData system.

BASIC MESSAGE SWITCHING CENTER FUNCTIONS

Fig. 3 is a simplified block diagram of an AutoData store-and-forward message switching center. It illustrates the basic

Fig. 2—Typical message format.



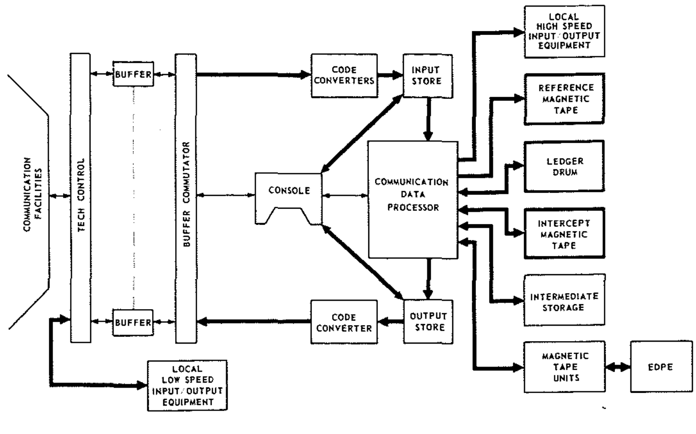


Fig. 4—Functional diagram.

functions associated with the relaying of traffic in any Switching Center.

The common carrier facilities are shown terminating in a switching complex. Here the individual incoming and outgoing communication channels are made separately available to the switching center. Facilities are provided for assigning each incoming and each outgoing channel to the appropriate switching-center incoming or outgoing channel. In some installations, this provision is manual; in others semiautomatic; and in still others, a combination of the two. A further refinement of some installations is to provide "cut-through" patching facilities within the switching complex. This provision permits the semi-permanent by-passing of a Switching Center. This is usually done to permit the interconnection of two subscriber facilities. It can be done only if the two channels are compatible.

The *input function* coordinates the transfer of inbound traffic on each tributary and trunk channel. This function usually provides some form of storage for each incoming channel where messages are accumulated and made ready for routing. Channel-sequence number checks, coordination signalling checks, and other controls may be exercised at this point to improve the effectiveness of the overall system.

The *cross office function* receives messages from the input function, interprets the message header, and directs the message. The complexity of this varies widely among different systems. The implementation in some systems is manual, in others semiautomatic; in AutoData, it is completely automatic. The AutoData system uses a specially designed, stored-program data processor for this function. This provides great logical power. a high degree of flexibility, and very fast data-handling speeds.

The *intransit storage function* provides a reservoir for traffic when outgoing lines are occupied. This feature is one of the most important economic and good-service features of the system. It permits any subscriber to send messages whenever he wants to. He does not have to get a through connection to the addressee. He may address one message to any number of addressees and not concern himself with the need for a conference call. The addressee equipment may be shut down for the moment. By queuing messages for long-line transmission, a fewer number of long lines are needed to provide the required service. Messages are usually queued for outgoing lines on a first-in-first-out (FIFO) basis. In more-sophisticated systems, priority handling categories are superimposed over the regular handling procedures. This permits certain classes of messages to pre-empt facilities by circumventing queues and interrupting transmissions in progress.

The *output function* coordinates the transfer of outbound traffic on each tributary and trunk channel. This function usually provides some form of storage for each outgoing channel. Messages are transferred to this storage via the cross office function. Channel sequence numbering, coordination signalling checks, and other controls may be exercised at this point to improve the effectiveness of the overall system.

Electronic data processing equipments (EDPE) usually gain access to the switching center via incoming and outgoing communication channels. However, AutoData has provision for distributing messages directly to EDPE at high speed via the cross office function.

The AutoData system conforms to these broad functional characteristics of a store-and-forward message switching center. However, the implementation used provides a number of important advantages. Therefore, before describing the flow of messages through the equipment, a brief description will be given of the principal design features which make up the AutoData system.

SYSTEM DESIGN FEATURES

AutoData has been designed to make all of the features listed below fully automatic wherever the subscriber terminal device permits. The AutoData system begins at the *buffer units* shown in Fig. 4.

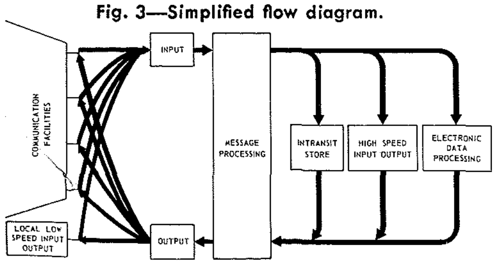
Input Function

Each incoming trunk and tributary channel is independently terminated to suit the type of communication terminal equipment used. This permits different data-transfer rates, different character coding, and different coordination signalling on all channels. The present system is designed to handle data rates from about 30 to 3000 bauds on each channel for up to 50 incoming channels. Higher data rates may be handled when the communication terminal equipments become available. Up to 100 incoming channels may be handled by a single system if the data-transfer rates do not exceed a short-term average of 15,000 characters per second.

All the commonly used 5- to 8-element codes are provided for in the system by means of a family of code converters which are time-shared among all incoming lines. These code converters convert the code of the incoming channel to the common code of the switching center.

Coordination signalling is done on a closed loop basis to assure accurate, automatic, and controlled transfer of all messages. Where closed-loop control is not possible, message numbering may be added to the system in one of several ways. The coordination procedure may be different for each circuit. The principles of closed-loop control include the following important rules: During periods of no message transmission, idle line signals are sent by all transmitters and alarms registered if they are interrupted by anything other than a message. To send a message, the transmitter requests permission and is directed to proceed by the receiver. During the transmission, the receiver checks the accuracy of the message and requests reruns if errors are detected. At the completion of transmission, the transmitting station must receive an acknowledgment signal from the receiving station before it can

Fig. 3—Simplified flow diagram.



assume that the transmission has been correctly received.

Cross-Office Function and In-Transit Store

The AutoData system uses a specially designed stored-program computer for these two functions. A magnetic-core high-speed memory is used for the main working storage. This unit provides the following important functions:

1) single, multiple and group address routing
2) FIFO traffic handling
3) up to 6 levels of traffic handling priorities
4) direct cross office for high priority traffic
5) overdue alarms for messages not relayed fast enough
6) magnetic-tape intercept for selected traffic
7) message editing for transfer among different types of machines
8) collection and display of traffic statistics
9) collection on magnetic tape of all traffic.

Output Function

This function is quite symmetrical with the input function. One of the few functions peculiar to this section is the capability of assigning two alternate destination codes to each outgoing channel. This permits automatic alternate routing under program control.

Electronic Data Processing Equipment

EDPE is integrated with the Switching Center via a family of control units. These perform the necessary code conversions, format changes, etc., to permit the automatic interchange of traffic.

MESSAGE FLOW

To solidify the picture of the AutoData system, the entire system now will be reviewed from the point of view of how messages flow through a switching center. The various subsystem components will be named and briefly described so that it will be clear where the various system functions are performed.

Input Function

Input buffers provide compatibility between the different channel data rates and the drum data rate. The *sampling unit* interrogates the various buffers for the characters of an incoming message. The characters are decoded from the language of the communication channel to the common language of the system and are then accumulated in an *input store* assigned to the input buffer. The equipment provides as many stores as there are communication channels. Individual characters are collected in the input store until a complete message is accumulated. In Fig. 5, the *low-data-rate input section* of AutoData is brought out in more detail. The heavy lines show the message flow, while the lighter lines show the control functions.

The contents of each buffer are sampled by the *buffer sampler unit* every 3 milliseconds. If a complete character is present, it is transferred to a *buffer collector* which can store one character from each buffer. The buffer stops the characters until they can be transferred to the input message store associated with the particular input buffers. As characters are read from the buffer, one at a time, they are checked for validity if the transmission code permits (such as the 4-out-of-8 code). The characters are then converted into parallel form and translated into the common language of the center, so that various control functions in the equipment can interpret characters directly and make the necessary decisions. Under direction of the proper control signals, the gates associated with the input message store control the transfer of each character at the proper time. A bookkeeping *tally sector* associated with each input message store sends the proper signals to the data processor so that characters may be accumulated in the input message store in proper sequence. Characters are collected until a complete message is assembled. At this point, the character count is checked. If incorrect, control signals initiate a retransmission request.

Cross Office Function

The data processor function (see Fig. 6) provides the means for extracting the character blocks from the input message store; processing the header according to established routing and priority procedures; sending the blocks to the *intermediate store* or to the *intercept magnetic tape;* and, retrieving the message for subsequent distribution to the *output message store.* Overall control of the procedure for sequential operation of the

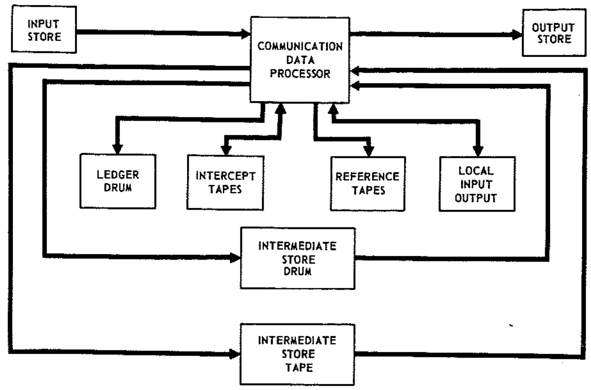


Fig. 6—Cross-office function.

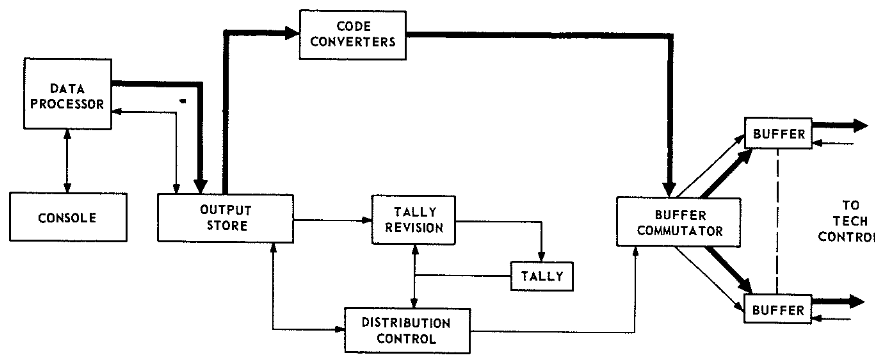
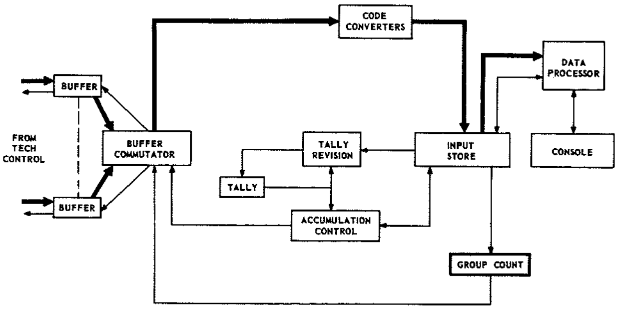


Fig. 7—Output implementation.

Fig. 5—Input implementation.



cross office function is maintained by a stored program.

Messages are also shown originating from the various sources mentioned above and proceeding out of the system. Group and multiple address messages are handled in the data processor; a segregated copy of the message is transmitted to the tributaries.

Output Function

Once messages from various sources have been accumulated in the output message store, they are transmitted character by character through the code conversion function to make them compatible with whatever language is used for communication. After conversion, the characters are distributed to the various buffer units and are then transmitted to the designated communication channel at the correct transmission rate.

Fig. 7 details the output function. Proceeding from the output message store under supervision of the *output bookkeeping tally sector*, characters of a message are transferred out one at a time and translated into the language of the receiving equipment.

Each character is then converted from parallel to serial form and transferred to the *buffer distributor*, where the character is stored until such time as it is in time agreement with the proper output buffer. It is then transferred into the output buffer and out to the communication channel at a speed compatible with that channel. The transmitted message is retained in the output message store until an acknowledgment of correct transmission is received. The output bookkeeping tally sector keeps an account of all internal transactions required during the transfer of a message out of the output message store.

FUNCTIONAL DUALITY

The system provides paralleling of some of the common equipment, including the input-output message stores, intermediate stores and data processors.

In normal operation, the system fully utilizes all the equipments. However, when one data processor is down, the other can process the normal flow of messages from both input-output message stores. If traffic is at its peak, low-priority messages will be sent to intermediate storage, and high-priority messages will be processed first.

The *accumulation and distribution unit* is also able to operate with only one input-output message store; the functioning unit can handle its own traffic plus all messages from the down unit which can be alternately routed through its output channels. The functional-duality feature, then, means providing a second normal operating unit rather than a full-peak-capacity standby equipment which does not operate except during an emergency.

MESSAGE PROTECTION

A *message journal* in magnetic-tape form is provided to record the header of each incoming and each outgoing message. This information is recorded so that the tape may be used to determine the in-station time of each message by priority, message length, and circuit utilization vs. circuit availability by date and time of day. Provision is made for the read-out of these journals upon demand.

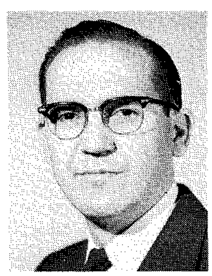
The *ledger balance* function provides complete message protection within each AutoData Center. The ledger balance provides the means whereby each message may be quickly identified, traced and rerun from the switching center when necessary. Means for rerunning messages is provided in case of receipt of a request from a tributary station or internal equipment failure resulting in possible loss of messages. Means for the prevention of duplicate message transmission are provided.

EQUIPMENT LAYOUT

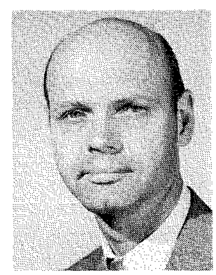
The AutoData equipment shown in Fig. 1 is a scale model of a proposed 50-line message switching center now being developed in the RCA Electronic Data Processing Engineering Department. AutoData closely resembles the RCA 501 equipment and will take advantage of the proven reliability of the plug-in modules and physical construction of the RCA-501 Computer. The equipment is completely transistorized.

(Acknowledgment is given to personnel of the Western Union Telegraph Company who assisted in the development of this system.)

J. L. OWINGS graduated from Lehigh University with a B.S.E.E. in 1948. In 1953, he received his M.S.E.E. degree from the University of Pennsylvania. In 1948, Mr. Owings joined the Advanced Development section of RCA, where he worked on military airborne automatic air navigation and bombing systems. In 1954, he joined the System Central development and design group in RCA's commercial digital computer section. He assisted in developing the centralized control concept for the early RCA Computer systems and in designing the equipment for integrating the product line into a complete system of equipments. In 1956 Mr. Owings joined the Special Projects group of Electronic Data Processing Engineering where he supervised the design of digital data-processing equipment for a missile program and a military ground-to-air data-link system. Mr. Owings was promoted to Mgr., Special Data Processing Equipment Engineering in 1959, and now heads the RCA AutoData Project and is coordinating Project Lightning.



T. L. GENETTA graduated from the University of Delaware in 1952 with a B.S. degree in Electrical Engineering. With RCA since 1952, he has participated in packaging and standardization of the BIZMAC system, design of a tape inspecting machine, coordination of all the power supplies in the BIZMAC system, work on various input-output devices. He was responsible for all of the timing and program control of part of the GCI equipment and also was project engineer of two units of the Data-Link System. During the past year he has been participating in the systems and logic design of equipment in the Special Data Processing Equipment Engineering Group. Mr. Genetta is now actively engaged as project engineer on a laboratory model of the AutoData System and is Leader of the group on development of accumulation and distribution equipment for this system. He belongs to the IRE and is currently attending the Moore School of Electrical Engineering, working towards a Master's degree.



J. F. PAGE graduated from Northeastern University in 1943 with the degree of B.S. in Mechanical Engineering. As a member of the Systems and Logic Group of Electronic Data Processing Engineering, Mr. Page is involved in the study and evaluation of proposed new systems, and with overall system coordination. He has done much of the early logical design for integral portions of RCA's original Electronic Data Processing Systems. He joined RCA in December 1951 as a design engineer responsible for logical design and system engineering for digital computing and data-handling systems. Prior to joining RCA, Mr. Page was employed as production engineer by Anderson Nichols Company, Inc. He was responsible for planning the production methods and tools to be used in manufacturing small, intricate mechanisms. He also has experience as an industrial appraiser and as a design engineer while associated with the Federal Telephone and Radio Corporation. Mr. Page is a registered professional engineer in the State of New Jersey.

Editor's Note: The IEP Electronic Data Processing Engineering Department has been able to apply digital computer circuits and techniques to the design of communications switching equipment for RCA Communications, Inc. Design of this MUX/ARQ-2 equipment is described in this article. For applications of this equipment, see the next article in this issue, "MUX/ARQ Facilities in the RCA Communications, Inc., System" by E. D. Becken. Successful completion of this project represents a mutually beneficial customer-producer relationship within IEP. Thus, several groups have contributed, including early work by the Radio Research Laboratory.

TRANSISTORIZED MUX/ARQ-2

by **J. E. PALMER**
Electronic Data Processing Division
IEP, Camden, N. J.

IN TRANSOCEANIC radio-teleprinter communication systems, the problem of error-free transmission of traffic has long been of major concern. Periodic deterioration of radio-path quality is characterized by fading, noise, and multiple transmission paths, all of which serve to produce frequent and drastic mutilations of the transmitted information. By careful selection of carrier frequencies—considering time of day, direction and destination of transmission, sun-spot cycles and many other factors—the situation can be improved. The result, however, is generally unacceptable for transmission of commercial traffic and falls far short of the reliability of land line networks.

ERROR-INDICATING CODE

To alleviate these difficulties, an error-indicating code was adopted in the 1930's for long-haul radio-teleprinter service. This code, invented by J. B. Moore of RCA Communications Inc., represents 32 different alphabetic or numeric characters by seven signal elements, of which three are always marks (or *ones*) and four are always spaces (or *zeroes*). As long as this 3-to-4 ratio is preserved, the information received can be considered correct, since the probability of permuting the elements of a character without destroying the 3-to-4 ratio is extremely remote. This error-indicating code gave teleprinter operators a means of locating and manually requesting the retransmission of those characters mutilated by poor radio path conditions. The procedure was quite time consuming and inefficient, however, and made it quite difficult to correct printed copy to the level of commercial acceptability.

AUTOMATIC ERROR-CORRECTING EQUIPMENT

In the early 1940's, a fully automatic system called ARQ was developed by Van Duuren of the Netherlands Post Telephone and Telegraph Administration. This system used Moore's error-indicating code and automatically initiated the request for retransmission when a mutilation was received. It also prevented printing of the mutilated character by stopping the printer. When reliable transmission was restored, the printer resumed nomal operation, printing first the corrected character and then those following.

This ARQ system was placed in service soon after World War II. The original versions were electromechanical, and many such units are still in use today. While Van Duuren's system is basically unchanged, advancements in electronics have led to many improvements. The RCA MUX/ARQ-1 used magnetic cores and vacuum tubes. In addition to ARQ, it provided for multiplexing up to four separate teleprinter channels on a single radio channel. With the advent of transistors, the next logical step was a transistorized ARQ. The high level of reliability, small size, low power consumption, and simplicity that can be achieved with transistors made their application to MUX/ARQ extremely attractive.

TRANSISTORIZED MUX/ARQ-2

In the MUX/ARQ-2, the basic unit is the *diplex*. Each diplex simultaneously combines two inputs from paper tape into a single outgoing aggregate and separates an incoming aggregate into two components, which are routed to separate page printers (Fig. 1). Each diplex is divided into a transmitting section and a receiving section called the *diplex transmitter* and the *diplex receiver* to distinguish them from the radio receivers and transmitters. In Fig. 1, traffic flow is indicated by solid lines and control paths by dotted lines.

If we were to trace the signals on Channel A from left to right, operation begins when a new character is requested from the paper-tape reader by the diplex transmitter in Terminal 1. In the diplex transmitter, that character is converted from the 5-unit teleprinter code to the 7-unit error-indicating code and transmitted serially to modulate the radio transmitter. When it arrives at the diplex receiver in Terminal 2, it is inspected for the proper 3-to-4 ratio and printed by the page printer. Characters on Channel B are processed in the same fashion, but are interleaved with Channel A characters, as shown in Fig. 2 (A and B). The result is *character-sequential time-division multiplex.*

In many cases, when conditions permit, it is desirable to provide further multiplexing to combine four teleprinter channels into a single aggregate. This can be done by using diplexes and combining their outputs on a *bit-sequential*

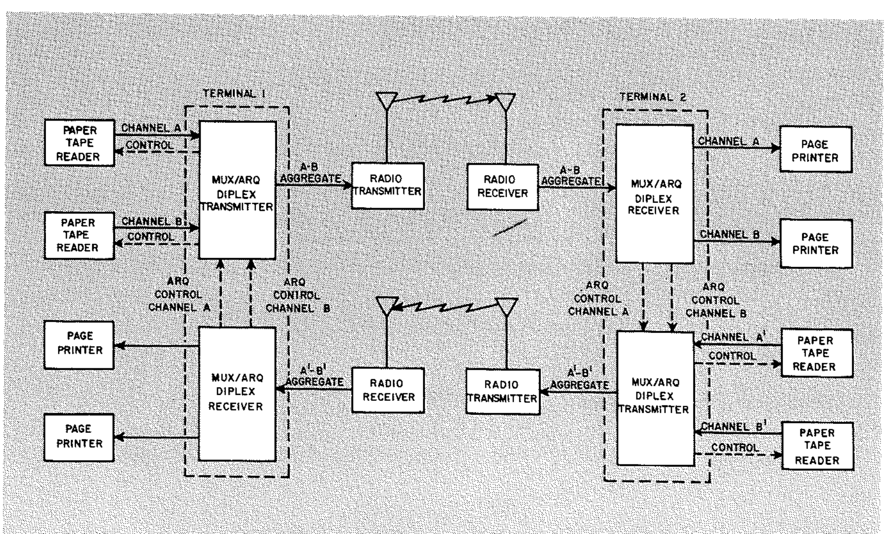


Fig. 1—MUX/ARQ-2 system.

		ARQ STORE							
RQLA	RQLB	8	7	6	5	4	3	2	ASSY REG.
							I		A_1
		A_1					I	I	B_1
		B_1	A_1				I	I	A_2
		A_2	B_1	A_1			I	I	B_2
		B_2	A_2	B_1	A_1		I	I	A_3
		A_3	B_2	A_2	B_1	A_1	I	I	B_3
		B_3	A_3	B_2	A_2	B_1	I	I	A_4
		A_4	B_3	A_3	B_2	A_2	I	I	B_4
		B_4	A_4	B_3	A_3	B_2	I	I	A_5
		A_5	B_4	A_4	B_3	A_3	I	I	B_5
		B_5	A_5	B_4	A_4	B_3	A_3	I	I
		I	B_5	A_5	B_4	A_4	I	A_3	B_6
		B_6	I	B_5	A_5	B_4	A_4	I	A_3
		A_3	B_6	I	B_5	A_5	I	A_4	B_7
		B_7	A_3	B_6	I	B_5	A_5	I	A_4
		A_4	B_7	A_3	B_6	I	I	A_5	B_8
		B_8	A_4	B_7	A_3	B_6	I	I	A_5
		A_5	B_8	A_4	B_7	A_3	I	I	B_9
		B_9	A_5	B_8	A_4	B_7	I	I	A_6
		A_6	B_9	A_5	B_8	A_4	I	I	B_{10}
		B_{10}	A_6	B_9	A_5	B_8	I	I	A_7
		A_7	B_{10}	A_6	B_9	A_5	I	I	B_{11}
		B_{11}	A_7	B_{10}	A_6	B_9		I	
			B_{11}	A_7	B_{10}	A_6			
				B_{11}	A_7	B_{10}			
					B_{11}	A_7			
						B_{11}			

Fig. 6—MUX/ARQ-2 standard circuit.

into Position 8 of the *ARQ store* and is then advanced toward the assembly register as new characters enter Position 8.

Measured from the XTPA which inserted A_1 into the assembly register, three full cycles of XCL are required for A_1 to progress to Position 3 of the ARQ store. If no ARQ cycle is called for, then the next XTPA, in addition to its other functions, causes A_1 to be destroyed and replaced with *I* in Position 3. Shifting of the ARQ store continues with *I* eventually arriving in the assembly register where it too is destroyed and replaced with a new character at XTPA time. Thus, the assembly register is constantly receiving *I*'s from the ARQ store; and, as new characters are gated into the assembly register, the *I*'s are destroyed. If, however, an ARQ cycle is called for on Channel A by the receiver, XTPA is inhibited by RQLA (RQ level *A*), and both the insertion of new information and of *I*'s is discontinued on Channel A. Note that discontinuance of XTPA also stops the destruction of *A* characters at Position 3 of the ARQ store. A *I* which was previously inserted but not destroyed is transmitted, followed by the three characters contained in the ARQ store. As long as the ARQ action continues, the *I*, followed by three characters, will be circulated in the ARQ store and continuously retransmitted. As soon as XTPA resumes, normal operation is restored and new information enters the assembly register, destroying what was there.

The action for Channel B is identical to and independent of Channel A. Fig. 6 shows the contents of the ARQ store and the assembly register at Terminal 1 just after XTP time for the ARQ cycle shown in Fig. 3.

DIPLEX RECEIVER

In the diplex receiver, the action is just reversed. Incoming information is collected in an assembly register and then gated through the 7-to-5 code converter by RTPA and RTPB (receiver transfer pulses for Channels A′ and B′, respectively). As in the transmitter, Channel A′ is received during the positive portion of RCL (receiver character level) and Channel B′ during the negative portion. After code conversion, the signal is demultiplexed by the channel selector under the control of RCL. Next, the conversion from parallel to serial is made, and the information is sent to the printers. The receiver performs the additional function of inspecting characters for the proper space-to-mark ratio and, in the event of a mutilation or *I*, generates the RQL's. In the receiver, the RQL's prevent the transfer of information into the parallel-to-serial converters by inhibiting the RTP's. This stops the printers during ARQ. The ARQ control section also contains the logic that implements the ARQ cycle rules listed above. As in the transmitter, ARQ action on the two channels is independent.

An additional function performed in the receiver is that of frequency (more precisely, *phase*) correction. To achieve close synchronism between the two ends of the communication path, the incoming aggregate signal is used to correct the phase of the basic diplex clock pulse, which is generated by a frequency standard accurate to one part in 10^6. This correction assures that each bit of the aggregate signal is shifted into the assembly register exactly at its mid point (see Fig. 5). When a terminal is providing the time reference for both ends of the communication path, it is called the *master*. In this mode, the transmitter derives its timing directly from the frequency standard. In *slave*, the transmitter is timed by the frequency corrector, as is the receiver in both master and slave. The reason for such precision in the frequency standard is as follows: The seven bits bracketed by each half of RCL are inspected by the receiver as one character. Thus, in a diplex, there is one proper phase position for RCL and thirteen improper ones. Once the proper phase is achieved, it is desirable to maintain it, even though contact with the far end of the communication path may be lost for a considerable period. If the shift pulses to the receiver's assembly register are allowed to drift more than one-half baud with respect to the incoming signal, this proper phase relationship will be lost. Frequency correction alone will maintain synchronism in the face of high noise and will prevent the receiver shift pulses from drifting, but it cannot take the place of precision and stability when no signal at all is present.

Before leaving the subject of phasing, it should be noted that MUX/ARQ-2 has provision for automatic selection of the one proper phase position out of fourteen. This is accomplished by inspecting for proper receipt of *I* on both Channels A and B. If *I* is not received after a reasonable period on both channels, then the phase is auto-

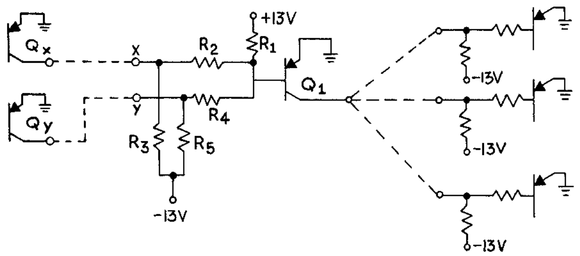
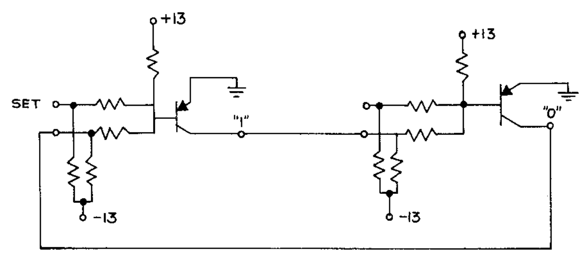


Fig. 7—Top: Basic transistor circuit. Bottom: flip-flop transistor circuit.



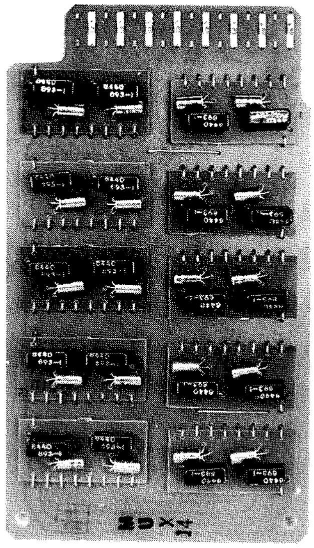


Fig. 8—Printed circuit plug-in.

matically shifted by one baud, and the signal is again inspected for *I*. This process continues until *I* is properly received on both channels. Note that *I* will always be present in the received signal when two diplexes are out of phase, since they must be in an ARQ cycle, because of the receipt of garbled information.

TRANSISTOR CIRCUITS

The logic of MUX/ARQ-2 is implemented with one basic transistor circuit. This circuit, shown in Fig. 7, requires two d-c voltages, has a logical gain of five, and exhibits all necessary logical properties. Note that if either driving transistor (Q_x or Q_y) is cut off, Q_1 will conduct due to base current in R_2-R_3 or in R_4-R_5. Thus, the *or* function is provided. Conversely, Q_1 will be cut off only if Q_x and Q_y both conduct and raise inputs x and y to ground level. This achieves the *and* function. Use of only one input provides the *not* function (inversion) and cross connection of two similar circuits, as shown in Fig. 7, produces a flip-flop.

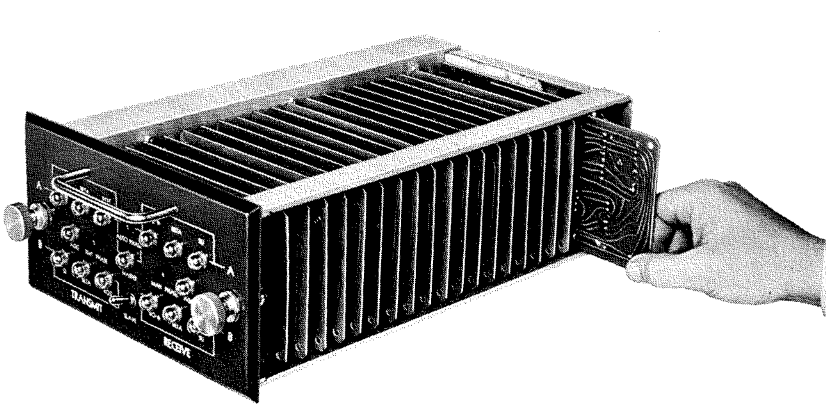


Fig. 9—Drawer capable of housing 20 of the printed circuit plug-ins of Fig. 9.

The salient advantages of this circuit over conventional resistor-coupled transistor logic (RCTL) NOR circuits are the elimination of the collector clamp diode and clamp voltage, and a significant reduction in power dissipation by the elimination of the collector load resistor. In conventional RCTL circuits, the collector resistor is selected to permit driving a maximum number of loads and thus dissipates constant power regardless of the number of loads actually connected. By moving the collector load resistor from the collector circuit of the driving transistor to the base circuit of the driven transistor, its value may be increased. Thus each logic element requires only enough power for its own operation, and no power is wasted in those stages that are not fully loaded.

PACKAGING

Two such circuits are packaged on one submodule with provision for up to ten sub-modules on one printed circuit plug-in (Fig. 8). Twenty plug-ins can be housed in one drawer (Fig. 9), and the drawers mount in a standard 84-inch rack, as shown in Fig. 10. The lower portion of the rack contains the power supply, and the upper portion can accept up to 20 drawers. With this arrangement, 400 plug-ins with a maximum of 8,000 transistors can be housed in one rack, and a drawer or the power supply can quickly be replaced. Forced-air cooling is provided by a fan in the top of the rack, and air is blown downward to avoid drawing dust from the floor into the equipment. The high transistor density provided by this configuration permits four diplexes to be mounted in one rack, a two-to-one improvement over previous MUX/ARQ equipment. These four diplexes may be operated either independently or in conjunction to form two complete quadruplex terminals.

Thus, the advantages of standardized circuitry, modular plug-in construction, high transistor density, and considerable operational flexibility—combined with such features as fully automatic phasing and visual presentation of radio path quality through analysis of the ARQ rate—should serve to earn for the RCA MUX/ARQ-2 a strong and enviable position in the field of world-wide radio-teleprinter communications.

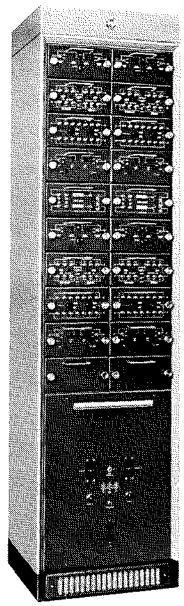
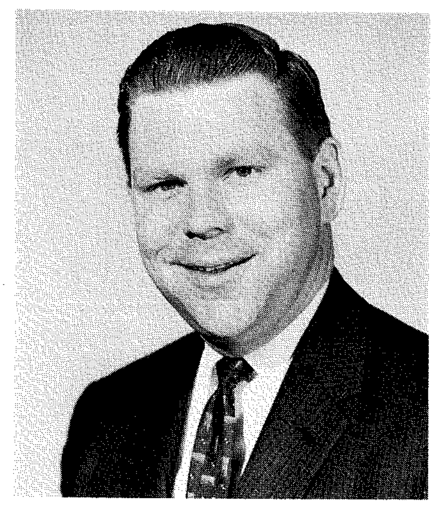


Fig. 10—Standard 84-inch rack with the drawers of Fig. 9 mounted.



J. E. PALMER was graduated from the University of Pennsylvania in 1953 with a BSEE degree. He joined RCA in June 1953 in the EDP Engineering Activity and was engaged in the development of punched card processing equipment. In August, 1954, Mr. Palmer entered the Army and rejoined RCA in June 1956. Mr. Palmer returned to EDP Engineering to continue work on input and output devices in the systems design of card-reading and card-punching equipment for use in the RCA 501 System. Mr. Palmer was promoted to Leader, Design and Development Engineers, in 1959, with responsibility for advanced circuit development and the design of a digital communications multiplexing system.

basis. Fig. 2 (C) shows organization of the aggregate for this mode of operation. Multiplexing beyond four channels is not practical for long-distance radio communications because the reduced bit lengths required render the system extremely susceptible to variations in the radio path length.

No further discussion of the four-channel, or *quadruplex,* system is undertaken here. Suffice it to say that the quadruplex can be described completely by considering it as two separate and independent diplexes with their aggregates interleaved.

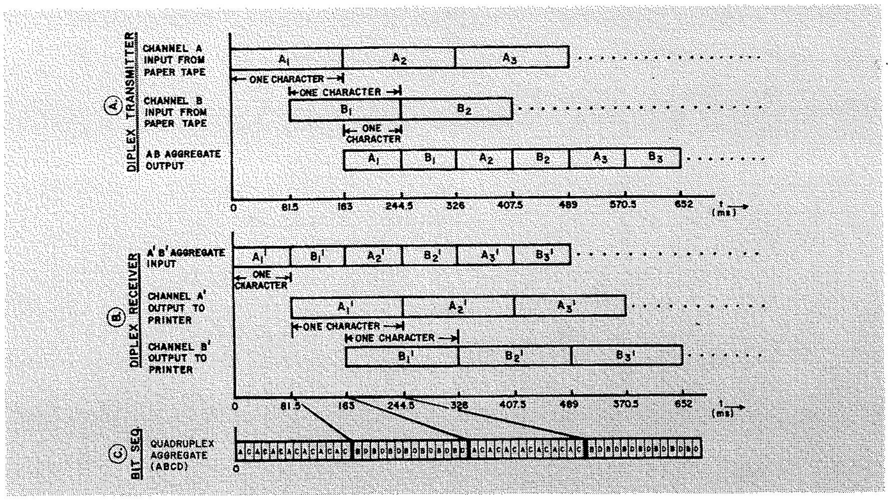


Fig. 2—Multiplex timing.

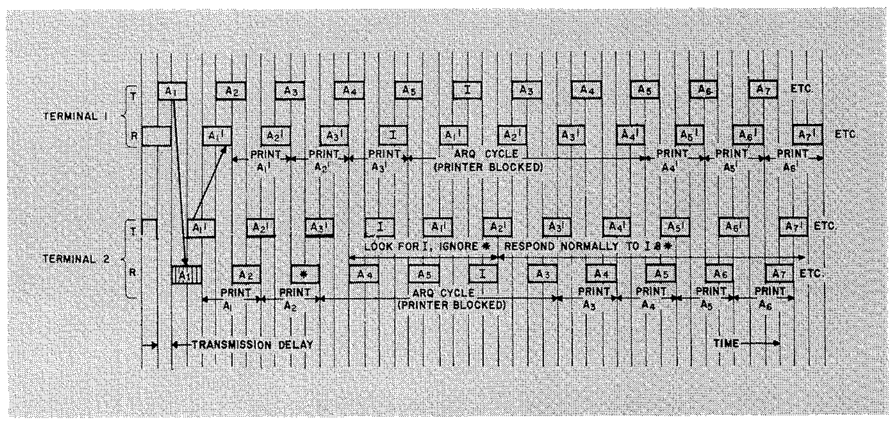


Fig. 3—ARQ cycle timing.

ERROR CORRECTION

Returning to Fig. 1, Channels A′ and B′ operate like A and B. Consider now the effect of a mutilation on Channel A. When the diplex receiver in Terminal 2 notes an improper mark-to-space ratio in the received signal on Channel A, it immediately prevents printing of the suspect character and alerts the associated diplex transmitter via ARQ Control-Channel A. The diplex transmitter completes the processing of the character in progress and then interrupts transmission on Channel A′. It transmits a special character, identified for convenience as *I*, followed by the last three characters transmitted over Channel A′. During this process, Channel B′ continues in the normal fashion. When *I* is received by the diplex receiver in Terminal 1, it responds by interrupting transmission on Channel A (via ARQ Control-Channel A) and inserting *I* followed by the last three *A* characters. Thus, the repetition of the mutilated character has been achieved. When the diplex receiver in Terminal 2 receives the repetition correctly, normal operation is restored. Three characters must be repeated to prevent the loss of those characters in process or in transit at the time a mutilation is detected.

A typical ARQ cycle is shown in more detail in Fig. 3. Terminal 1 is transmitting the series of characters A_1, A_2, A_3, etc. to Terminal 2, and Terminal 2 is responding with A'_1, A'_2, A'_3. Time is plotted horizontally, and a space is left between successive characters to allow for Channel B, which for simplicity is not shown. Approximately half a character is devoted to propagation time between Terminals 1 and 2. Note that a character begins to print upon receipt of its seventh bit at Terminal 2. Because of the time compression, due to multiplexing, printing takes twice the character-transmission time. Thus, the printing of A_1 begins just as its last bit arrives and is completed just as the last bit of A_2 arrives (see Fig. 2, C).

Consider now the effect of mutilating A_3 (shown as * in Fig. 3). The diplex receiver senses this mutilation and instructs the associated transmitter channel to respond with *I*, followed by the last three characters transmitted. However, at the time the mutilation is sensed, A_3' is being transmitted. To avoid destruction of A_3', the transmitter waits for the next *A* character time and then responds with *I*, A_1', A_2', A_3'. Meanwhile, the mutilation has stopped the printer at Terminal 2 and has initiated an ARQ cycle which lasts for at least four character times. Note that the last character printed at Terminal 2 was A_2.

At Terminal 1, *I* was received during the printing of A_3'. Its effect is the same as that of a mutilation. That is, it causes interruption of traffic and the transmission of *I* followed by the last three characters transmitted; in this case A_3, A_4, A_5. It also initiates a four-character ARQ cycle during which printing is stopped. Note that A_4 and A_5 had already been transmitted by Terminal 1 prior to the receipt of *I*. Hence, A_4 and A_5 are received at Terminal 2, followed by *I*, A_3, A_4, A_5. Note that the mutilated character, A_3, has now been repeated.

Since Terminal 2 initiated the ARQ action, it must be assured that Terminal 1 has responded properly and that transmission conditions are satisfactory before resuming normal processing of traffic. This assurance is given by the receipt of *I* at Terminal 2 during the first three character counts of the ARQ cycle. If Terminal 2 does not receive *I* during the ARQ cycle, it will continue in ARQ until a *I* is properly received. In the example chosen, *I* was properly received, indicating to Terminal 2 that it should return to normal operation at the end of the current ARQ cycle. Thus, printing begins with the previously mutilated character A_3, and the printed copy shows no interruptions or incorrect characters. Obviously, if A_3 again arrives mutilated, a new ARQ cycle must be initiated.

Terminal 1, on the other hand, received no mutilations, but rather was forced into ARQ by the receipt of *I*.

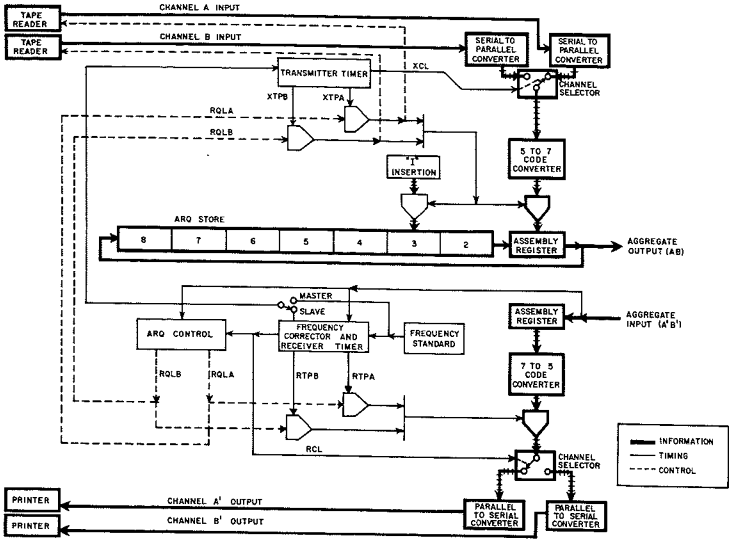


Fig. 4—MUX/ARQ-2 terminal.

It cannot expect another *I* during the first three character counts of its ARQ cycle, and therefore, it must resume normal operation automatically. If Terminal 2 had continued in ARQ, then Terminal 1 would have received *I* in place of A_4' and would have entered a new ARQ cycle.

From this example a simple set of rules may be stated.

1. Upon receipt of * or *I*, respond as soon as possible with *I* followed by the last three characters transmitted.
2. If ARQ is initiated by *I*, stop printing for four character counts and then return to normal.
3. If ARQ is initiated by *, stop printing for four character counts and return to normal only if *I* is received during the first three character counts of the cycle. Otherwise, enter another ARQ cycle.
4. Respond normally to *I* or * if either occurs during the fourth character count of an ARQ cycle. Ignore additional * at other times during ARQ.

More-complex ARQ actions involving multiple errors and mutilations at both terminals can be plotted in like manner; and, in every case, perfect printed copy will result. A common question in discussions of ARQ is: *Why must the terminal that receives a mutilation repeat the last three characters it transmitted? Why not simply let it transmit* I *and then return to normal traffic?* The answer to this is that in certain situations involving multiple mutilations, information will be lost if only one terminal transmits a repetition. For those interested in plotting this case, assume the *I* transmitted by Terminal 2 to be mutilated when it arrives at Terminal 1.

DIPLEX LOGIC

Consider now the multiplexing and ARQ functions accomplished in MUX/ARQ-2. In the diplex transmitter, four basic operations must be performed: The first is multiplexing, which can be thought of as a single-pole–double-throw switch alternately selecting signals from Channel A and Channel B. The second is the conversion from 5- to 7-unit code. The third is storage of the last three characters transmitted in case a repeat is required. The fourth is a control and timing function which determines whether the transmitted intelligence is to be taken from paper tape or from the internal storage.

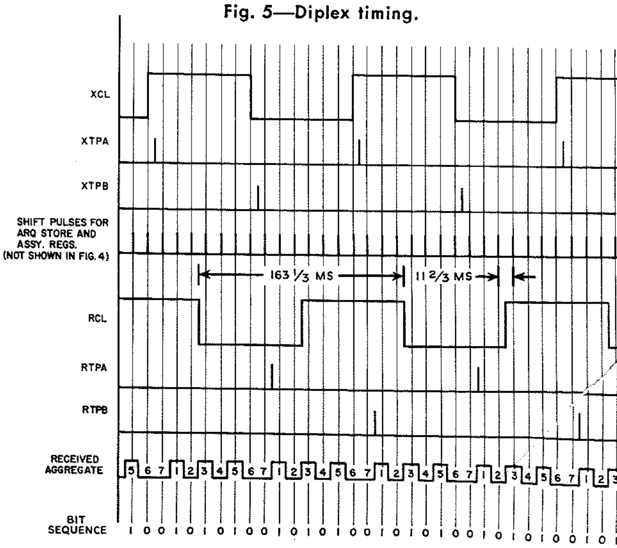
All of these functions except storage have counterparts in the diplex receiver, where incoming information is first demultiplexed and then reconverted to 5-unit code for transmission to the printers. The control function in the receiver is somewhat more complex than in the transmitter, because the receiver must test the validity of the incoming information and initiate the ARQ action. The additional functions of serial-to-parallel conversion in the diplex transmitter and parallel-to-serial conversion in the receiver achieve compatibility with serial communications links.

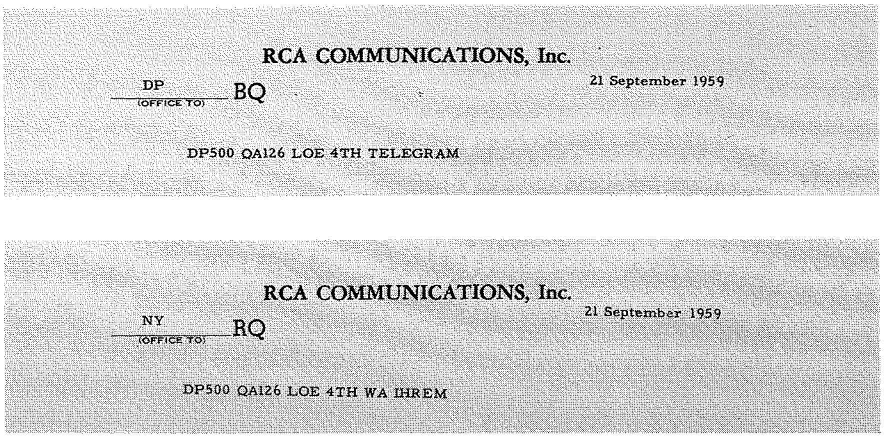
Fig. 4 shows the block diagram of a diplex. To distinguish the several functions, heavy lines indicate traffic flow, lighter lines indicate timing, and broken lines indicate control functions. Heavy lines with cross strokes denote parallel transmission of information, while heavy lines without strokes denote serial information. Brief reference to Fig. 5 will help to clarify the time relationship between the various timing signals.

DIPLEX TRANSMITTER

When XTPA (transmitter transfer pulse *A*) occurs, it activates the tape reader associated with Channel A, which sends a single character (A_1) serially to the diplex. The time required for completion of this character is 163 milliseconds, or one period of XCL (transmitter character level). At the end of this time, the channel selector selects Channel A in response to XCL and another XTPA occurs. As before, the tape reader is activated, and the first *A* character, which is now in the serial-to-parallel converter, is gated through the 5-to-7 code converter and into the *assembly register*. From there it is shifted serially out to the radio transmitter and at the same time into Position 8 of the ARQ Store. During this time, the second *A* character (A_2) is arriving in the serial-to-parallel converter. This same sequence occurs on Channel B, but 180° out of phase with Channel A. Thus, at XTPB, the *B* tape reader is activated and a *B* character is gated through the 5-to-7 code converter into the assembly register. In other words, *A* characters are transmitted during the positive portions of XCL, and *B* characters are transmitted during the negative portions. Note that each character transmitted is fed back

Fig. 5—Diplex timing.




RCA COMMUNICATIONS, Inc.

DP (OFFICE TO) BQ — 21 September 1959

DP500 QA126 LOE 4TH TELEGRAM

RCA COMMUNICATIONS, Inc.

NY (OFFICE TO) RQ — 21 September 1959

DP500 QA126 LOE 4TH WA IHREM

Fig. 1—Typical RQ and BQ telegraph messages.

MUX/ARQ FACILITIES IN THE RCA COMMUNICATIONS, INC., SYSTEM

by **E. D. BECKEN, Vice President**
Operations Engineering
RCA Communications, Inc.
New York, N. Y.

THE APPLICATION of automatic error-correction equipment in the world-wide international communication system operated by RCA Communications, Inc., has contributed very materially to the improvement in accuracy and reliability of the communication service furnished.

Since the early days of telegraphy, it has been necessary at times for the central telegraph office to prepare messages of inquiry regarding the accuracy of certain received messages. These messages of inquiry or requests, sent internally in the telegraph system to the sending point, are called RQ messages or, more simply, RQ's. A reply to such an RQ is called a BQ. An example of an RQ and a BQ message is shown in Fig. 1. Fast handling of these RQ's and BQ's is essential, since the correction and final delivery of the important message may depend upon completion of the RQ-BQ exchange.

The fact that intercontinental communication on high-frequency radio channels could be subject to the vagaries of the transoceanic path led in 1934 to the development of the Moore constant ratio (7-unit or 8-unit) code and a little later to the associated 7-unit printer system. This 7-unit code, employing 3 marking and 4 spacing bits for each character, made it possible at the receiving point to detect mutilations of the signal caused by the transoceanic path. If the signal were mutilated and the 3-to-4 ratio of mark-to-space elements were disturbed, it was possible with a simple ratio bridge to sense the presence of this mutilation. The 7-unit printer and associated equipment would print a maltese cross upon receipt of such a mutilation; then, the traffic operator would have to manually break in on the circuit and request a repetition of the mutilated character by an RQ type of message. A BQ message of reply would follow. This costly and slow manual process suggested investigation of automatic means for correcting errors introduced by the transmission path.

AUTOMATIC ERROR CORRECTION

Once the technique for sensing the presence of this type of error was developed, consideration was given to the possibility of an automatic error-correction facility. The credit for this long step forward in communication automation goes to Dr. van Duuren of the Postal and Telecommunication Services (PTT) of The Netherlands, who developed this equipment which, in conjunction with the then-available time-division multiplex, made it possible to automatically correct errors, character by character, as they occurred on the transmission path. This function was known as *automatic request for repetition*, or automatic error correction, or simply ARQ.

Operation of the first installation began in 1947 between New York and Amsterdam. The results were very encouraging, and much additional equipment was installed on commercial transoceanic radio telegraph circuits in the next few years. The first of these installations consisted of separate time-division-multiplex equipment associated with ARQ facilities, but later developments combined the two functions into one terminal. The time-division-multiplex functions assigned the radio circuit time sequentially between two or four local 60-word-per-minute teleprinter channels, each of which then had the benefit of the automatic error-correction features. The four-channel aggregate keying speed is about 240 words per minute.

Fig. 2 shows one of the first send-receive systems in use in the United States and consists of an RCA four-channel time-division multiplex mounted in the two racks (shown on the left) and The Netherlands PTT's four-channel ARQ facilities mounted in the third rack (shown on the right). This was followed by the development and manufacture of functionally similar terminals by several others as well, and in 1956 RCA manufactured the one-rack terminal shown in Fig. 3. This terminal, known as MUX/ARQ-1, was designed by the RCA Laboratories and employed many advanced techniques, including magnetic cores. Further improvement in design resulted in the present RCA MUX/ARQ-2 terminal. [ED. NOTE: See J. E. Palmer's article in this issue, *Transistorized MUX/ARQ-2* for detailed description.] It is a fully transistorized unit, and the one rack contains two four-channel send-receive multiplex-ARQ systems. This advanced design is more reliable, requires less space and power, has better control and monitoring functions, and is easier to maintain than previous designs.

It has been mentioned that the ARQ equipment will sense an error when the mark-space ratio is upset, but what happens when two offsetting mutilations occur within the seven signal elements or bits of the same character? This type of transpositional error will certainly reduce the improvement factor, but by how much? A theoretical analysis of the ionospheric propagation path is only of limited value, since multipath and impulse noise of highly variable characteristic may be present. Tests and commercial operation disclose that the improvement with ARQ is substantial and varies with the rate of mutilation of the received signal. Approximate improvement ratios and net channel speeds are given in Table I; even when the radio path is very poor, the improvement ratio is substantial.

TABLE I—Improvement Ratio and Net Channel Speed with ARQ

Net Channel Speed WPM	Signal Mutilation Rate (Characters)	Divide by Improvement Factor of	*Probability of Transpositions (Characters)
60 Nom.	1/1000	10,000	1/10,000,000
55	25/1000	400	1/16,000
50	50/1000	200	1/4,000
40	150/1000	70	2/1,000
30	240/1000	40	6/1,000
20	350/1000	30	12/1,000

*Tabulated values are indicative only.

TELEX AND LEASED CHANNEL SERVICE

Customer-to-customer teleprinter service such as that furnished by the RCA Communications, Inc., world-wide communication system would not have been practical without ARQ. The Telex service, akin to the American Telephone and Telegraph Company's TWX service, is available on demand for two-way nonsimultaneous communication between page printers in the customer's office, with a three-minute chargeable time minimum. Leased Channel service for private customers is available on a continuous monthly basis. With both services, the customer operates the terminal teleprinter equipment on his premises and therefore handles the traffic. It is essential that this traffic be as free from mutilations as possible and ARQ equipment goes a long way to ensure receipt of only correct copy.

The growth of RCA's Telex service and Leased Channel service is shown in Figs. 4 and 5. The present rate of growth of these services averages about 30 percent per year and demonstrates again the vast potential growth of communication volume when the service is improved.

There are thirty-five possible combinations or permutations available with a 7-bit code with 3 marking and 4 spacing bits. There are thirty-two combinations available with the 5-bit start-stop code. However, shifting from lower case to upper case by striking the figure shift on the 5-unit code teleprinter expands the assignment possibilities, thus taking care of all of the characters involved. The three additional basic assignments available with the 7-bit code are called *Idle Alpha, Idle Beta,* and *Roman I* signals. The first two of these are utilized for indicating traffic operation status in the Telex service. The MUX/ARQ terminal will continuously transmit the Idle Alpha signal when the channel is available for use, but no call is being established by the operator. The local Telex operator at the originating end of the circuit indicates to the operator at the overseas terminal that a call is being initiated by converting to the Idle Beta signal. The Roman I signal is the error-indicating signal and is automatically transmitted back to the sending point upon receipt of a mutilated signal. These Idle Alpha, Idle Beta, and Roman I signals are also protected by the automatic-error-correction function.

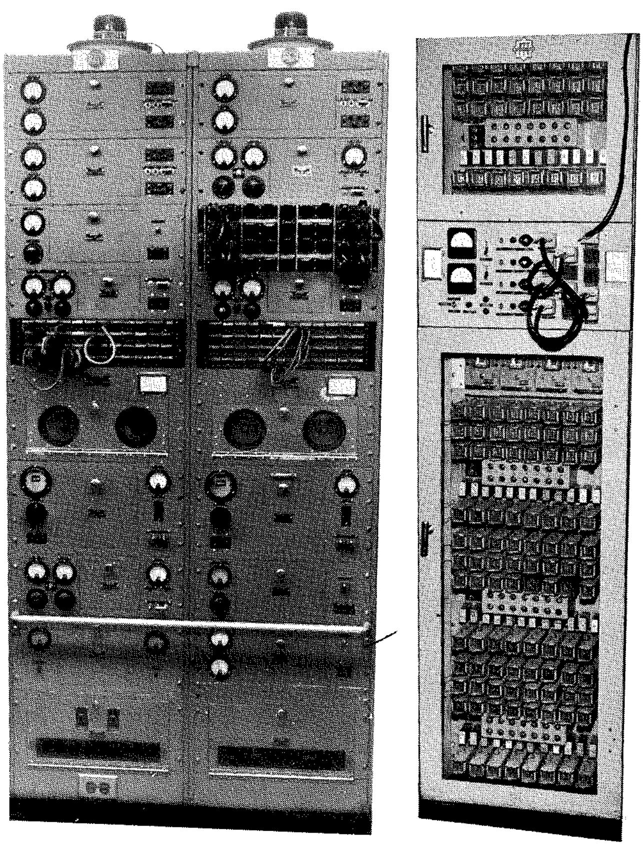


Fig. 2—Original four-channel RCA time-division multiplex (two racks on left) associated with original PTT automatic error-correction equipment (one rack on right).

RCA's world-wide international Telex service connects RCA's 1,800 private tie-line users in the gateway cities of New York, Washington, and San Francisco with about 40,000 Telex subscribers located in 43 foreign countries throughout the world. In addition, RCA's international Telex service is interconnected with the American Telephone and Telegraph Company's TWX system in the United States, which makes it possible for any of the AT & T Co.'s approximately 40,000 TWX subscribers anywhere in the United States to communicate directly with about 40,000 overseas Telex subscribers through RCA's Telex facilities.

The difference in keyboard assignments between the TWX system in the United States and the Overseas Telex subscribers is taken care of in both directions with converters provided and operated by RCA. All of these TWX and Telex subscribers have the advantage of MUX/ARQ operation on RCA's overseas facilities.

It is well to mention that in the Telex service the customer does not pay for the time lost from ARQ cycling on the radio path. The charge is based only on the opportunities presented to pass a correct character over the radio circuit.

In Leased Channel service, any one of two or four ARQ-protected 60-word-per-minute time-division channels can be further subdivided with suitable auxiliary equipment into as many as four 15-word-per-minute subchannels. Each of these subdivided channels retains the automatic error-correction features.

REGULAR MESSAGE SERVICE

The use of ARQ on regular message traffic channels has resulted in a significant reduction in clerical and operating costs because of the substantial decrease in need for sending manually processed RQ and BQ messages and reduction in the number of rerun requirements. It should be noted that RQ and BQ messages are still required for errors introduced in other parts of the circuit than that protected by the ARQ function, but these are relatively few. Message traffic flows more quickly and accurately

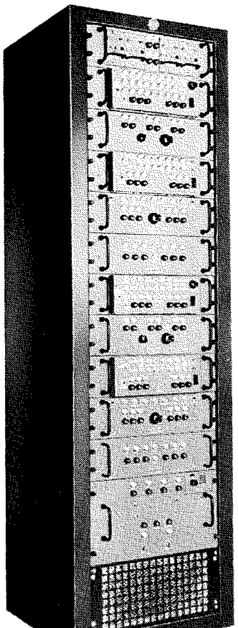


Fig. 3 — RCA four-channel time-division-multiplex ARQ-1 Terminal.

through the system. It is felt that ARQ is a prerequisite on high-frequency circuits for use with automatic message-handling facilities in a central telegraph office. ARQ contributes substantially to ensure the correct receipt of the destination code in messages flowing through an automatic switching system and thus practically eliminates the possibility of a misroute of a message.

OPERATIONS

The extent of MUX/ARQ application to RCA circuits is shown in Table II. Similar ARQ application has been made to radio circuits operated by most other important operating agencies in the world. These systems are operated on either a four-channel or on a two-channel basis. The MUX/ARQ signals are carried on standard frequency-shift-keyed transmitters with a shift of 400 cycles, or on single-sideband transmitters with subcarriers spaced at 680 cycles with shift of 340 cycles for four-channel keying, or 340 cycles with shift of 170 cycles for two-channel keying.

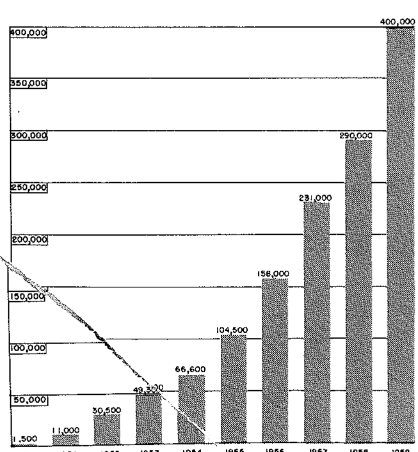


Fig. 4—Number of RCA international Telex calls.

TABLE II—Extent of MUX/ARQ Application within RCA's System

Circuits	No. of 60-Word-Per-Minute Channels
New York—Europe	116
New York—Central & South America	27
New York—Africa	6
San Francisco—Pacific	37
Other	6
TOTAL:	192

It is often necessary to operate ARQ-protected channels in tandem, and this is handled in two different ways, depending on the circumstances. For example, with a Telex call originating in Buenos Aires, Argentina, and transiting New York for London, England, the Telex channels would be interconnected in New York on a single two-way 60-word-per-minute basis. Then the Buenos Aires–New York link would ARQ-cycle independently of the ARQ cycling on the New York–London link. The customers in Buenos Aires and London would receive correct copy at the rate permitted by each radio link, in turn.

The second method of interconnection involves regeneration and relaying of the four- or two-channel aggregate signal at the relay point without separating out any individual 60-word-per-minute channel. This is possible only when channels are terminated at the same points. The Stockholm–New York Telex service with four-channel relay at Tangier is an example of the latter operation. The high-speed 240-word-per-minute aggregate signal is electronically regenerated at Tangier, and the ARQ cycling signals automatically pass through Tangier, resulting in one ARQ cycling link for the entire distance.

Under this arrangement, a correct character is not passed over the circuit unless both radio links will support a proper signal at that moment. None of these four channels can be individually dropped off or used for originating traffic in Tangier.

The rate of ARQ cycling is an indication of the quality of the radio circuit and provides a means for automatically alerting the technicians to retune the radio receiver, adjust other equipment, or change frequencies on the radio circuit. Auxiliary equipment to constantly monitor and integrate the cycling rate is being developed for use with existing ARQ terminals and is incorporated in the new MUX/ARQ-2 terminals.

All current applications of ARQ involve 5-unit-code teleprinter terminal operation, and the MUX/ARQ terminal converts from this 5-unit to 7-unit code signal for transmission on the radio path.

However, the ARQ principle is also applicable with other constant-ratio codes and can be used in single- as well as multiple-channel operation. Data-communication circuits using the 8-unit constant-ratio code would benefit by the use of ARQ equipment designed specifically for that purpose.

In summary, ARQ has substantially improved the accuracy and speed of the international radio-telegraph service and is certain to find wider and more diverse application on the communication circuits of the future.

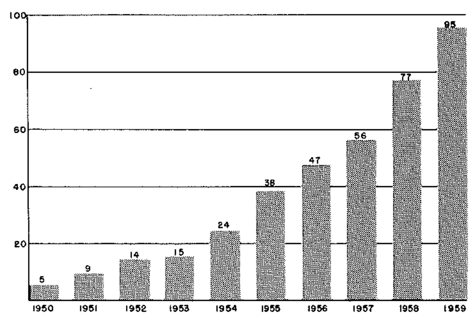
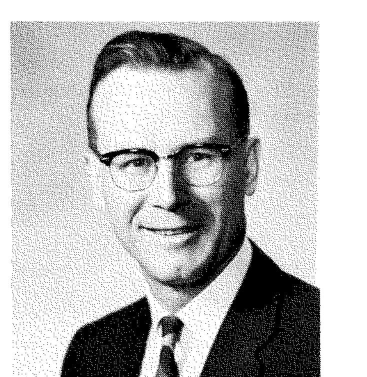
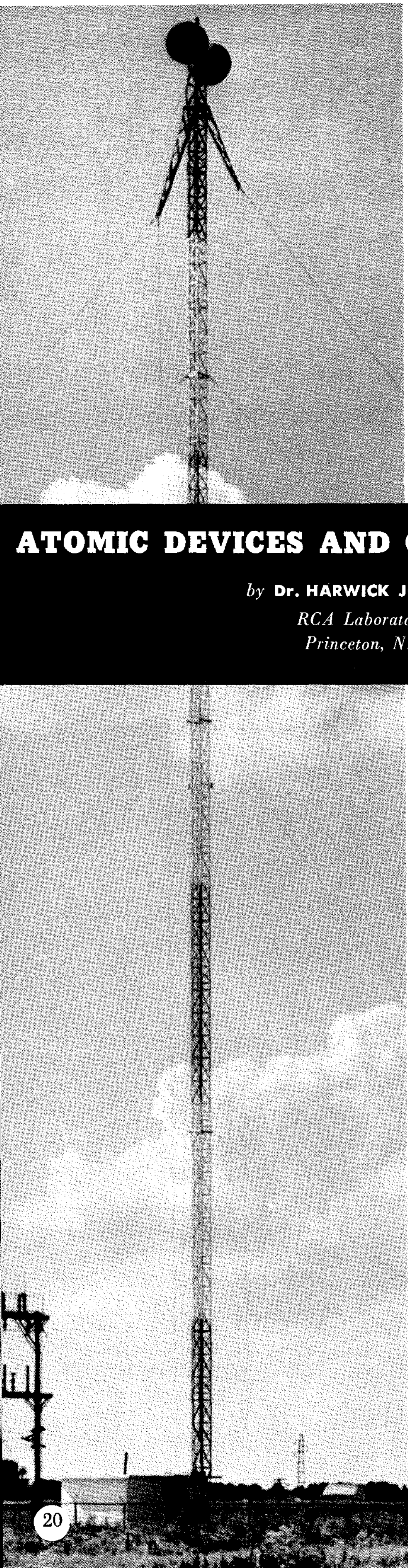


Fig. 5 — Number of leased radio-telegraph channels provided by RCA.

EUGENE D. BECKEN received the degree of BSEE from the University of North Dakota in 1932 and the degree of MSEE from the University of Minnesota in 1933. He has been employed in various operating and engineering capacities by RCA Communications, Inc., both in the field and in New York Headquarters since 1935. He was awarded a Sloan Fellowship at the Massachusetts Institute of Technology in 1951 for a year's study of industrial management, which culminated in the degree of M.S. in Business and Engineering Administration. In his present position, he is responsible for communication equipment and system design and development, and for the technical operation and maintenance of the Company's worldwide international communication services. His present activities include developing automatic switching systems and data communications technique. Mr. Becken is a registered Professional Engineer in New York State and a member of the Institute of Radio Engineers and the American Institute of Electrical Engineers. He is also a member of Sigma Tau and an associate member of Sigma Xi.





ATOMIC DEVICES AND COMMUNICATIONS

by **Dr. HARWICK JOHNSON**

RCA Laboratories

Princeton, N. J.

THE IMPACT OF electron devices utilizing electromagnetic interaction with the internal energy of atomic or molecular systems is now beginning to be felt in the communications art. This raises another specialty of physics in which communications research and development engineers will be expected to develop an acquaintanceship if they are to utilize these new devices with proficiency in communication systems. Moreover, it is an area more entwined with quantum-mechanical considerations than were previous electron devices.

Taking *atomic* devices and communications in their broadest sense, devices employing atomic phenomena are not entirely new to the communications field. For example, termini of certain communication systems employ photocells (photoemission), television camera tubes (photoconductors and photoemission), kinescopes (cathodoluminescent phosphors), and light amplifiers (photoconductors and electroluminescent phosphors). While all of these devices employ atomic phenomena, many may be classified as hybrids. For example, the semiconductor solar battery employs the interaction of electromagnetic radiation with an atomic system to generate carriers in the semiconductor; however, the remainder of the considerations governing the characteristics of the device are those of transistor physics.

COMPARISON OF CLASSICAL AND ATOMIC DEVICES

The electron tube and the transistor function by changes in the kinetic or potential energy of electrons moving through space—in the case of the vacuum tube—or of the mobile electrons moving through the crystal lattice—in the case of the transistor. Thus, even though a solid-state device like the transistor may have called upon quantum physics for justification of some of the fundamental concepts, its operation could be analyzed and understood using primarily classical concepts. This is simply because its operation depends on the transport of free, or unbound, electrons.

However, in the new atomic devices now beginning to appear, macroscopic charge transport plays no part, and we deal primarily with energy transformations of the electrons bound to the atoms making up the crystal. These internal energy transformations in detail lie definitely within the province of quantum physics. There is also the added complexity of interaction with the crystal lattice in which the active atoms are embedded. Nevertheless, there are certain classical analogies and elementary principles that may be used to gain a feel for the basic phenomena involved in these new devices. Herein, we shall discuss these in a very general way for the broad communications field, without dwelling on the many details that additionally have to be satisfied for a successful particular device.

Before doing so, it may be of interest to see why these new devices are of interest to the communications field—certainly, the vacuum tube and the transistor have contributed much to communications. What is it that the atomic or molecular devices promise for communications that cannot (at least readily) be obtained with more-conventional devices?

PROMISES OF ATOMIC DEVICES

The first of these is in the area of generation and amplification of very-high-frequency electromagnetic waves. The difficulties encountered in extending conventional electron devices into this area can readily be seen by recalling the scaling relations. The critical dimensions of the device are proportional to the wavelength and generally can be no larger than $\lambda/2$, so that for millimeter-wave devices the critical dimensions are small, indeed (< 0.020 inch). Moreover, the current density required goes as $1/\lambda^2$ and the power density as $1/\lambda^3$. The latter indicates that even if sufficiently small structures could be made, the power density is so high that it is extremely difficult to conduct away the concentrated heat loss. In a way this comes about because in an electron tube we deal with relatively small electron densities, around 10^{12} per cubic centimeter, with changes of potential energy of 100 to 1000 electron volts (e.v.).

The opposite approach is utilized in atomic devices: energy changes are related to frequency (about 10^{-4} e.v. for millimeter waves), but densities could be of the order 10^{20} to 10^{21} per cubic centimeter in solids. Similarly, transistors occupy a middle ground with energy changes of 10 to 100 e.v. with electron densities of the order 10^{16}. In an electron tube or transistor, as mentioned above, limitations arise from the fact that the interaction region can be no larger than $\lambda/4$, while the electron must traverse this region in a time no longer than ½f or $\lambda/2c$. These considerations lead to the structural and high-field difficulties. On the other hand, the interaction in an atomic device may be a volume effect, and of course, since there is no charge transport, we are not concerned with transit time. We are concerned with other time intervals, however, such as relaxation or decay times from excited energy states.

Another important promise of the atomic or molecular devices is that of high-frequency amplification with extremely low noise. For one thing, since charge transport is absent, these new devices are free of such noise sources as shot noise and partition noise. Since some of these devices have so far had to be operated at very-low temperatures (4°K), thermal noise from the device itself is substantially eliminated.

With these promises of advances in the low-noise and high-frequency fields, let us turn to a consideration of various basic atomic phenomena and where they may fit in the communications field.

ENERGY AND MOMENTUM QUANTIZATION

In contrast to electrons in free space, which may be accelerated to any energy, electrons bound in such microscopic systems as atoms or molecules are allowed to take on only discrete energies. This is generally represented pictorially by an energy-level diagram (Fig. 1), where the levels simply indicate the allowed energies the system under consideration may assume. Changes in the energy state of the system are accompanied by the absorption or emission of a photon, the energy difference between the final and initial states. Thus,

$$E_2 - E_1 = \mathbf{h}\,\omega_{2\text{-}1}$$

and connects the changes in internal energy of the system with the frequency of the electromagnetic radiation. While such a diagram depicts allowed energy levels of a system, transitions between all allowed levels are not necessarily permitted. The internal energy of an atomic or molecular system exists in many forms, e.g. the orbital energy of an electron rotating around the nucleus, the magnetic moment of the orbiting electron, the configuration of the atoms in a molecule, and many others. Thus, energy-level diagrams seldom attempt to depict the totality of states allowed to the system, but generally show only a portion of the allowed states pertinent to the physical phenomena under discussion. Our concern is principally with changes in internal energy and not with the total energy of the system in the states under discussion.

In our illustrative material to follow we will need to employ one other principle of quantum physics, namely, the quantization of the momentum:

$$\int p\,dx = n\,h$$

That is to say, the momenta values of the various allowed energy states can only take on values that are multiples of Planck's constant, h.

The quantization principles were first introduced by Planck in his consideration of the radiation properties of a black body. The experimental behavior could not be accounted for by classical physics, but by introducing this principle, Planck was able to reconcile experiment and theory. Bohr extended the application of these principles to the atom much as we will use them but, of course, in a more general context. We will utilize these general principles as ones that must be accepted as part of the nature of the atomic world and not something that requires a classical explanation.

ENERGY QUANTA AND THE ELECTROMAGNETIC SPECTRUM

Having discussed above the correspondence between internal energy changes and the frequency of electromagnetic radiation, a broad view of the significance of atomic phenomena in communications may be obtained by looking at the electromagnetic spectrum and correlating various regions with certain primitive atomic phenomena. Fig. 2 shows the electromagnetic spectrum from low radio frequencies to the region of ultraviolet radiation. An energy quanta scale (in electron volts) is shown juxtaposed to the frequency scale, and the regions covered by certain atomic and molecular phenomena, which we will discuss below, are indicated.

In dealing with small internal energy transformations (10^{-4} e.v. in the millimeter-wave region) in atomic devices, consideration must also be given to the effect of thermal energies which at normal temperatures may be much greater than this (0.025 e.v. at room temperature). Thus, if the atomic energy phenomenon it is desired to employ in a device is coupled to the crystal lattice, transitions between the energy states

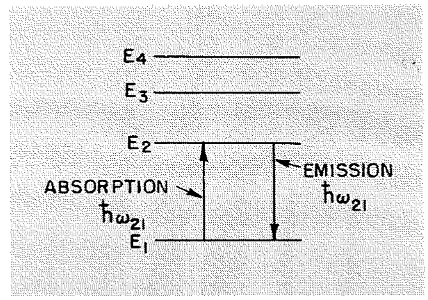


Fig. 1—Energy states of a system and relation of energy changes to absorption or emission of electromagnetic energy.

involved can be influenced by thermal energy as well as by interaction with an applied electromagnetic field. It is for this reason that devices such as a maser are operated at low temperature. Transistors fail to operate at high temperatures not because of the failure of the transistor action mechanism itself but because thermal energies excite unwanted electrons to a higher energy state. The energy quanta corresponding to the temperatures of two common cooling media, liquid nitrogen and liquid helium, as well as that of room temperature are shown in Fig. 2 for orientation.

We will next consider a number of the elemental physical phenomena. Order-of-magnitude calculations will be made to justify the correlation shown on Fig. 2. For numerical data, we will need but little more than the common physical constants listed in Table I to the degree of approximation we will use.

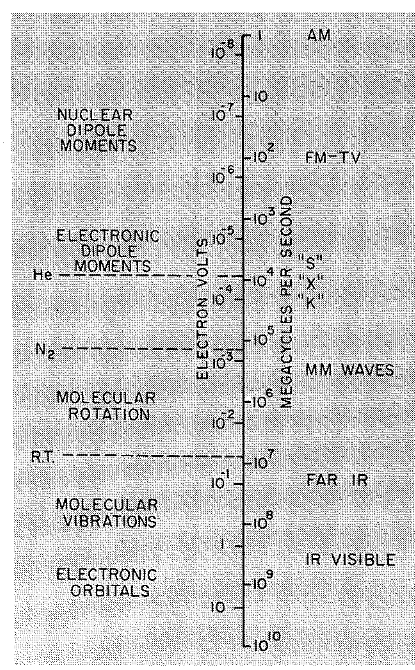


Fig. 2—Electromagnetic spectrum with energy-quanta scale juxtaposed to the frequency scale. Thermal energies at liquid-helium, liquid-nitrogen, and room temperature are also indicated.

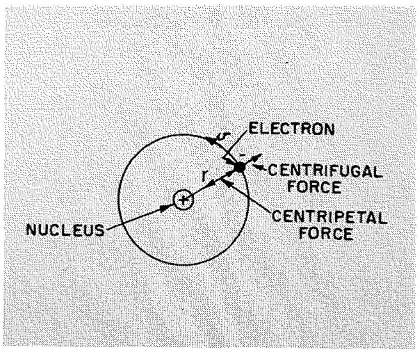


Fig. 3—Orbital motion of an electron around a nucleus.

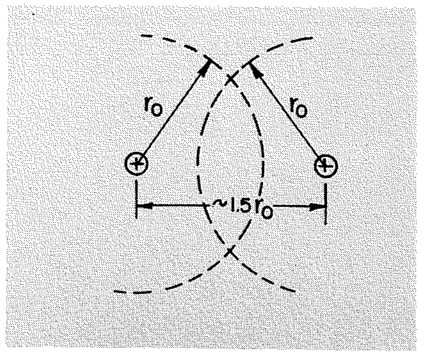


Fig. 4—Overlapping orbits of electrons in a hydrogen molecule.

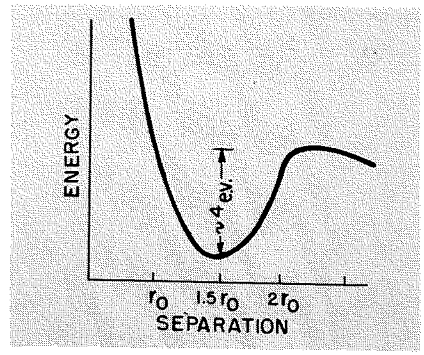


Fig. 5—Variation of energy with distance of separation.

TABLE 1. APPROXIMATE PHYSICAL CONSTANTS

Electronic charge	$e \approx 5 \times 10^{-10}$ e.s.u.
Electronic mass	$m \approx 9 \times 10^{-28}\ g$
Proton mass	$M \approx 2 \times 10^{-24}\ g$
Planck's constant (h/2π)	$\mathrm{h} \approx 1 \times 10^{-27}$ erg-sec
To express energy in electron volts	1 e.v. $\approx 2 \times 10^{-12}$ erg
Velocity of light	$c \approx 3 \times 10^{10}$ cm/sec

Electronic Orbital Energies

To exemplify the internal energy involved in the orbital motion of the electron around the nucleus of an atom, let us consider the simple case of the hydrogen atom (Fig. 3). For a stable circular orbit, the centrifugal force (mv^2/r) of the orbiting electron must be balanced by the Coulombic attraction (e^2/r^2) of the positively charged nucleus for the negatively charged electron. Thus,

$$\frac{mv^2}{r} = \frac{e^2}{r^2} \qquad (1)$$

Applying momentum quantization over the circular path gives

$$\frac{1}{2\pi}\int p\,dx = mvr = n\mathrm{h}. \qquad (2)$$

From these relations, the velocity is

$$v = e^2/n\mathrm{h}$$

So the kinetic energy stored in the orbital motion of the electron is

$$K.E. = \frac{1}{2}mv^2 = \frac{1}{2}\frac{me^4}{n^2\mathrm{h}^2}$$

$$= \frac{1}{2} \cdot \frac{(9\times10^{-28})\ (625\times10^{-40})}{(1\times10^{-54})} \cdot$$

$$\frac{1}{2\times10^{-12}} \cdot \frac{1}{n^2} = \frac{14}{n^2}\ e.v.$$

where n defines the particular Bohr orbit or energy level, and the last numerical factor is the transformation to electron volts. If we take $n = 1$, we see that the energy is 14 e.v. This corresponds to the ionization energy of the hydrogen atom (more accurately 13.5 e.v.) and, referring to our spectrum scale of Fig. 2, lies in the ultraviolet region of the spectrum. In a system such as this, the magnitudes of the kinetic and potential energies are equal. As n increases, the internal energy changes between levels is less, and so that we can roughly expect that atomic orbital energies will give rise to phenomena of interest in the infrared-visible-ultraviolet regions of the spectrum. For example, the photoelectronic devices mentioned in the introductory paragraph operate by transitions between orbital states and, in most cases, by freeing the electron entirely from its atomic orbit.

For subsequent use, we can also find the orbital radius by solving (1) and (2).

$$r_o = \frac{\mathrm{h}^2}{me^2} = \frac{10^{-54}}{(9\times10^{-28})\ (25\times10^{-20})}$$

$$\approx \frac{1}{2} \times 10^{-8}\ cm$$

Molecular Vibration Energies

Consider next the energies involved in the internal vibrational motion of a molecule; for our simple exposition, we consider the hydrogen molecule. The coupling or binding energy between the two atoms of a hydrogen molecule may be thought of as arising from the overlapping of the electron orbits or sharing of the electrons between the nuclei (Fig. 4). The energy acquired by the system as the two atoms are brought together to form a molecule may be visualized as follows: As the two atoms are brought together, the energy required increases to about the point where the electron orbits begin to overlap. This is at a distance $2r_o$ (see Fig. 5). Thereafter, as the electrons are shared, the energy decreases until the orbits overlap about half way (separation $1.5r_o$). The energy then increases until the orbits overlap the nuclei (separation $1r_o$) at which point the nuclei are no longer effectively shielded from one another, and the energy rises very steeply. As a particle in a potential well can oscillate, so the molecule can be visualized as vibrating with the separation between atoms oscillating about the minimum energy condition.

If the potential well is approximated by a parabola, the oscillation is that of the familiar harmonic oscillator whose frequency is given by

$$\nu = \frac{1}{2\pi}\sqrt{\frac{k}{M}}$$

where k is the restoring force proportional to the displacement. To obtain an approximate value for k, we will take as the depth of the potential well 4 e.v., a value typical of the dissociation energy of many simple molecules, and assume a parabolic energy relation for separations between $1r_o$ and $2r_o$ (Fig. 5). Then, since $V = kx^2$,

$$k = \frac{V}{x^2} = \frac{4}{\frac{1}{4}r_o^2}$$

$$= \left(\frac{4}{\frac{1}{4}\times\frac{1}{4}\times10^{-16}}\right) 2 \times 10^{-12}$$

$$= 128 \times 10^4$$

so that

$$\nu = \frac{1}{2\pi}\sqrt{\frac{128\times10^4}{2\times10^{-24}}}$$

$$= \frac{4}{\pi} \times 10^{14} \approx 10^8 \text{ megacycles/sec.}$$

Referring to Fig. 2 of the electromagnetic spectrum, this result together with extension to higher energy transitions and more-complex molecules with lower binding energies places us in the region of the far infrared and toward the millimeter-wave region.

Molecular Rotational Energies

In addition to vibration, a molecular system may contain energy in the rotation of the molecule (Fig. 6). The kinetic energy of a rotating system is

$$K.E. = \frac{1}{2}I\omega^2$$

where I is the moment of inertia and in this case of two masses (the nuclei)

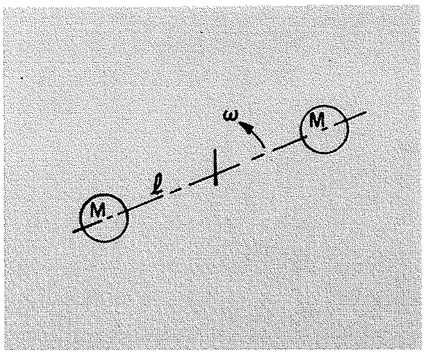


Fig. 6—Rotating diatomic molecule.

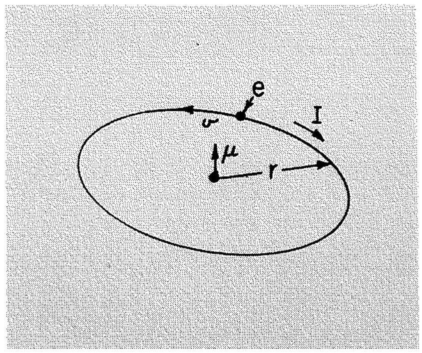


Fig. 7—Magnetic dipole arising from orbital electronic motion.

separated a distance l is Ml^2. Rewriting the kinetic energy so that the rotational momentum, $I\omega$, can be introduced and quantized we have

$$K.E. = \frac{1}{2} I\omega^2 = \frac{1}{2} \frac{I^2\omega^2}{I} = \frac{1}{2} \frac{p^2}{Ml^2}$$

$$= \frac{1}{2} \frac{n^2 h^2}{Ml^2}$$

$$= \left(\frac{n^2}{2} \cdot \frac{1 \times 10^{-54}}{2 \times 10^{-24} \times 10^{-16}}\right) \left(\frac{n^2}{2 \times 10^{-12}}\right)$$

$$\approx \frac{n^2}{8} 10^{-2} \approx n^2 10^{-3} \text{ e.v.}$$

Hence, the corresponding frequencies of the electromagnetic spectrum lie in the millimeter-wave and microwave region.

Dipole Moments

The forms of energy discussed above have been visualized in terms of mechanical motions of the system. In addition, internal energy may be distributed among various magnetic and electric dipole moments that arise from electron motion or spin or from the disposition of electrical charge within the system. To illustrate, we consider the magnetic moment arising from the orbital motion of an electron around the nucleus. Since the motion of the electron represents a moving charge, it may be viewed as a current giving rise to magnetic phenomena (Fig. 7). The magnetic dipole moment of a circulating current is proportional to the current and to the area enclosed by the current path, $\mu = IA$, so that for an electron in a circular orbit,

$$\mu = IA = \frac{\text{charge}}{\text{time}} \times \pi r^2$$

$$= \frac{e}{T} \times \pi r^2 = \frac{e}{2\pi r/v} \times \pi r^2$$

To introduce and quantize the momentum, this may be written as

$$\mu = \frac{e}{2m} \times mvr = \frac{e}{2m} \text{p} = \frac{e}{2mc} n\text{h}$$

where c is introduced to obtain e.s.u. If we consider an impressed field of 10^4 gauss, the energy due to the magnetic dipole is

$$\mu H = \frac{\text{eh}}{2mc} H$$

$$= \left(\frac{5 \times 10^{-10} \times 1 \times 10^{-27}}{2 \times 9 \times 10^{-28} \times 3 \times 10^{10}}\right) \times 10^4 \left(\frac{1}{2 \times 10^{-12}}\right)$$

$$= 5 \times 10^{-5} \text{ e.v.}$$

Thus, phenomena involving electron magnetic moments are expected to be found in and near the microwave region of the electromagnetic system. The dipole moment of electron spin differs from the above calculation only by a factor of two, which is unimportant for the broad view we are taking. Nuclear magnetic moments, partly because of the larger mass and more complex structure, are to be found at lower energies ($\approx 10^{-7}$ e.v.) in the radio-frequency portion of the spectrum. The proton moment, for example, would be about 1/2000 of that of an electron.

Since electron–magnetic-moment energies lie in the microwave region, this phenomenon is of great interest for solid-state masers, an important new tool for the communications art.

Electric dipole moments may arise from nonsymmetrical distribution of charge on molecules or ions in a crystal lattice. The order of magnitude can readily be found as the product of electron charge and a dipole length of molecular dimensions,

$$\mu = (5 \times 10^{-10}) \times 10^{-8}$$

$$= 5 \times 10^{-18} \text{ e.s.u.}$$

The splitting of spectral lines in an electric field will then be, for a field of 30,000 v/cm, (100 e.s.u./cm),

$$\Delta E = \mu\epsilon$$

$$= 5 \times 10^{-18} \times \frac{30{,}000}{300} \times \frac{1}{2 \times 10^{-12}}$$

$$= 2.5 \times 10^{-4} \text{ e.v.}$$

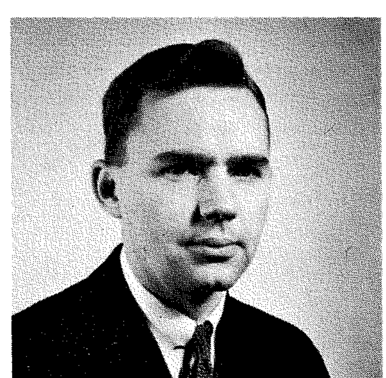
SUMMARY

We have related, through the internal energy change involved, a number of basic atomic and molecular phenomena with particular regions of the electromagnetic spectrum. At the same time, through elementary calculations we have developed the basic phenomena from the viewpoint of classical analogies. Rigorous calculations and device design concepts must be involved for successful devices based on extensions of these phenomena.

While our illustrations considered single atoms or molecules, practical devices, in order to handle the integrated energies required for practical signal strengths, must use aggregates of these simple systems, as in a solid or a dense gas. This modifies and brings into play interaction effects which have to be taken into account. Detailed considerations must be given to the choice of mateials, new materials must be synthesized, and a high order of device invention is called for to utilize these effects most advantageously and couple them to the outside world.

Nevertheless, present day examples of the atomic clock, magnetic field sensors, and masers presage the ever-increasing impact these phenomena and their more-complex derivatives will have on the communications art.

DR. HARWICK JOHNSON received his B.S. degree in electrical engineering from the Michigan College of Mining and Technology and his M.S. and Ph.D. degrees from the University of Wisconsin. From 1938 to 1942 he was a research fellow and teaching assistant in the Department of Electrical Engineering at the University of Wisconsin. Since 1942 he has been associated with RCA Laboratories Division at Princeton, N. J., where he has been associated with work on f-m radar, receiving tubes, noise phenomena, and transistors. Dr. Johnson is a member of the Institute of Radio Engineers, American Physical Society, and Sigma Xi.



THE FINISHING TOUCH—STYLING AND PROTECTIVE COATINGS

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Down through the ages, man has protected and decorated his prized possessions. Ancient Egyptian and Babylonian chariots were waterproofed and preserved with natural asphalts and with paints made of earth pigments ground with balsams, gum arabic, and egg whites. Noah "pitched" his ark of gopher-wood within and without. The American Indian liberally coated his face and body with war-paints made from chewed salmon eggs and fish oils.

Today, more than ever before, color and styling play a vitally important part in modern merchandising. The salability of even the most complex electronic equipment depends, to a large extent, on its appearance. Surface defects such as scratches, weld marks, and abrasive wheel marks, usually present in most metal fabrication, detract from appearance and must be removed or covered. When modern paints are formulated into a variety of pleasing colors and applied to such objects, minor surface defects are minimized or obliterated, and the object is simultaneously protected against corrosion.

RCA, in styling its technical products, must always consider the effect of styling on the probable customer. In the case of the RCA 501 electronic data processing system, for example, the customer is likely to be an executive of a department store or a vice president of an insurance company. Being accustomed to a generally fine business decor in his own office and often seeing advertisements of modern business furniture in periodicals aimed at the executive audience, he must be considered as already conditioned to certain forms and colors. This establishes preconceived notions that comprise one of the design elements to be considered.

VERSATILITY OF PAINTS

Paints today are extremely versatile and perform many functions in addition to decoration and protection. Among these applications are: increasing or decreasing visibility, electrical insulation or electrical conductivity, moisture and fungus proofing, increasing illumination, increasing or decreasing reflectivity, heat absorption or reflection, sanitation, and preventing ice formation. A few examples can be cited: Military and commercial airfields in close proximity create collision hazards that have resulted in several accidents and many more near-misses. Paint has played an important role in minimizing such accidents when the aircraft are striped with a high visibility, fluorescent, fire-orange paint visible to the naked eye for several miles.

Other interesting uses for paints on aircraft are ice-abherent coatings, camouflage coatings, thermal-resistance coatings for the bottom of aircraft delivering nuclear weapons, semiconductive coatings on radomes to bleed off precipitation static, and high-temperature coatings which must be operative at 1400 to 1600° F.

In the field of military electronics, thin coatings are applied on printed circuit boards to provide adequate protection for the printed wiring against degrading contaminants over operating and long-term-storage periods.

FORM AS A DESIGN ELEMENT

Electronic data processing equipment is a development of recent years and as an entire system has no precedent as to form and color. Certain business machines and mechanical office equipments have been in use over a long period of time and have thus established accepted forms and colors through continued progressive development. These equipments, however, were for the most part developed singly and independently of each other and wholly for a separate end use—with no consideration for use in concert to serve in a common system.

The latest comer into this office-business-machine field, of course, is the electronic computer, with its various types of data storage, handling, switching, and sorting—all for the most part mysteriously activated by an invisible force working at supersonic speed. This force is usually the sum total of tiny units which are subject to a great variety of physical arrangements to form the working package. This package, in the case of the 501, was determined by housing the greatest number of these small unit-circuit boards while retaining the most-efficient small size that offers maximum ease of service and maintenance with most-efficient performance. With this basic physical requirement, a further form consideration was also included; namely, an articulate expression of form fitness; that is, the package must be wholly acceptable as the dominating member of a system composed of office business machines. It must not be so large as to be overpowering, clumsy, or gross and thus cause a feeling of resentment for the very space it occupies. There being nothing more required, physically, than the storage of uniformly sized and arranged, uninteresting components (circuit boards for the most part), the form, color, and size of this package was a challenge to the industrial designer.

The inclusion of all the foregoing considerations and requirements are brought to full status of a modern concept of product design in the RCA 501.

The various input-output accessory units make possible the transition from humanly recognizable information to and through the electronic section, and finally by the output devices back again into recognizable, usable form.

These devices, for the most part, are the outgrowth of former wholly mechanical or electro-mechanical predecessors and have retained the best of the past, serving as a basis for the newly developed expanded version. Wherever possible, these mechanical functions are utilized as an animated design feature to add visual interest: magnetic and paper tape whirling by, cards being sorted or punched, the page being printed—all at terrific and unbelievable speeds.

The smaller units, together with the newer altogether-electronic computer console, are thoroughly integrated with the new large-rack storage units, the latter in such modules as to afford maximum expansion and greatest variety of arrangement.

The bringing together of all of the various units—large and small, and flexible enough to fulfill the greatest variety of requirements—forms a composite system in conformance with contemporary design with just the right emphasis placed on sheer, crisp, functionally efficient forms.

COLOR AS A DESIGN ELEMENT

When military electronic equipment is developed, the procuring activity often specifies the color and desired surface finish. A black wrinkle might be requested for a nonglare surface, or a brilliant aluminum paint for heat reflectance. Human engineering may play a key role as it has in designing the cockpit of jet aircraft. There, psychologists have ascertained that light pastel shades will not exercise the soporific effect of somber black cockpit finishes.

In the case of industrial electronic products, such as the RCA 501, the industrial designer creates the color motif and collaborates with the finishes engineer who determines the practicability of the selected scheme. The color selection as an aesthetic attribute is governed by several factors such as current color and pattern trends, environment of use, and an intangible factor known as design element.

The packaging of this RCA equipment is in the form of simple rectangular cabinets or module units, for flexibility in arrangement and for expandability. Some units are fixed and others are mobile. These cabinets, as sculptural units of design, need dynamic color patterns as a design element to augment their somewhat static forms. It was considered that a light gray-blue and soft yellow would lend dynamic interest, and a dark blue-black would tie the composite packages together.

With regard to the smaller mobile units, each with different functions, their movability was expressed in coral red. This was contrasted with the same light gray-blue and tied to the larger equipment with the dark blue-black.

The frame of all units was left unpainted because the use of natural satin aluminum is not only a strong accent, but the inorganic finish suggests strength and solidity.

Decorator tastes regarding the nature of the surface finish vary from

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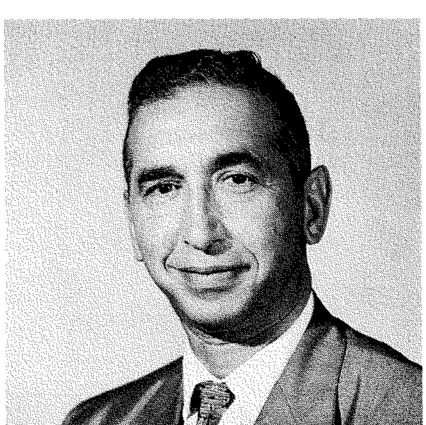
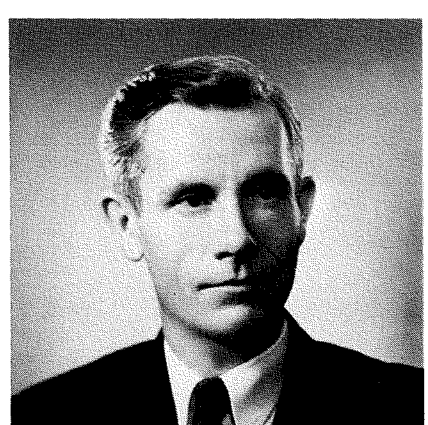


STEWART W. PIKE received the Bachelor of Fine Arts in Architecture from Pennsylvania in 1925. Mr. Pike was associated with a number of Philadelphia architects, and a few years before World War II entered private practice. After World War II, he joined the Industrial Design staff at RCA in Camden and is now Director of Functional Design for Industrial Electronic Products. He has been responsible for many of this Company's products, including TV cameras, the electron microscope, and the RCA 501. The electron microscope received an *Electrical Manufacturing* magazine annual Product Design award. He is a Fellow of the Industrial Designers Institute and has received the Portland Cement Association award for small-house design; the NAHB-Forum House Design Competition for plywood built-in features; and the Sterling Silversmith's Guild of America first prize award for a sterling silver bowl.



period to period. At the present time, a pebbly, leather-like finish is popular on fine office equipment and furniture. Its surface texture not only has eye appeal, but helps to break up the monotony of large, smooth areas, removes annoying reflections, and, in addition, covers up many minor surface defects such as scratches, welds, and power-wheel marks which commonly occur in production. The outward appearance of the leather texture is reassuring and familiar in spirit, though quite new as to material and method of attainment.

Textured plastic finishes resembling leather can be obtained by using nitrocellulose lacquer, vinyl, vinyl-organosol, vinyl-polyester, epoxy polyester, conventional enamel, and silicone-enamel variations. Obviously, each finish has its own peculiar advantages and disadvantages; and each finish must be applied according to the finish application program best suited for that finish and its end usage.

EVALUATION OF A FINISH FOR THE RCA 501

In the 501 program, samples of various plastic finishes resembling leather were obtained from paint manufacturers and subjected to a standardized series of evaluation tests.

The initial evaluation was concerned with the ability of the material to obliterate minor surface defects. Standard panels, prepared as they would be in normal production by degreasing, chemical treatment, and priming, had small scratches scribed into the metal in addition to spot-weld marks. The textured finish from each manufacturer was applied and cured. These samples were then examined to determine which finishes produced the most pleasing textured pattern and the greatest ability to cover the surface imperfections.

It was found that the vinyl-organosol finish rated at the top in both of these factors. Hence, the remaining series of tests was a complete evaluation of this type of finish under various environmental conditions.

Touch-up

No matter how durable a finish is, abnormal handling conditions occasionally damage the surface, and the coating system must be readily repairable. The manufacturer of the vinyl-organosol has available specially formulated air-dry touch up enamels in a variety of colors which blend in beautifully with the original finish.

Suitability of Curing Schedule for RCA Production

Vinyl-organosols are dispersions of discrete, colored vinyl and plasticizer particles in an organic solvent blend. Heat is needed to fuse these particles into a continuous, durable, decorative and wear resistant protective coating. It was found that at least 10 minutes within a temperature zone of 330° to 350°F was required. Below this range, the coatings were dull, and although hard, they lacked toughness. Above 350°F, the films were too glossy, and there was a perceptible change in color, particularly in the light pastel shades. Accordingly, a curing schedule of 20 minutes at 335°F was determined to be satisfactory for RCA production.

Wear Resistance

Outstanding wear resistance is a prerequisite for a business machine. Wear resistance is measured by testing the finish with a Taber abraser, in which a coated panel rotates horizontally on a turntable and two weighted abrasive wheels turn in opposite directions by friction against the painted panels. The end point of the test is taken as the number of revolutions required to wear through the coating to the metal panel. Three separated spots of bare metal in the abraded track is considered as the end-point. Using CS-10 wheels and a 500-gram weight on the wheel, over 5000 revolutions were required. The conventional baked alkyd enamel, used on most automobiles, will last about 100 cycles, under these conditions and a wrinkle enamel about 2500 cycles.

Scratch Resistance and Adhesion

To evaluate finish resistance to scrapes and scratches, a Hoffman Scratch-Hardness tester is used. This instrument consists of a blunt scratching tool attached to a carriage. A graduated-scale beam with sliding weights provides an adjustment in load from 0 to 2000 grams. The instrument is run over a painted surface and the load necessary to leave a perceptible mark on the painted surface is noted as is the load required to cut through the surface. No mark was made with the Hoffman on the textured vinyl surface within the load range of the tester, whereas in the case of conventional baked alkyd enamel, a 1000-gram load will mar, and approximately 1800 grams will cut through the surface.

Corrosion Resistance

An X was scored through the coating down to the bare steel surface on two sets of finished samples. One set was placed in a humidity chamber maintained at 95° and 95-percent relative humidity for 250 hours. The other set was exposed to a 20-percent salt spray for 100 hours. Although the exposed metal rusted in both environments, there were no signs of physical deterioration, such as blistering, film rupture, or lifting at the score marks, nor was there any corrosion of the steel panels associated with porosity of the paint film.

Conclusions

Although laboratory tests are recognized as limited indications of product durability in actual field usage, our field experience with the textured vinyl-organosol has been excellent. The finish has not changed in gloss, color, texture, or appearance; nor has it ever shown evidence of excessive wear. There have been no cases where the material has broken down from perspiration, chemicals, inks, or everyday handling. Apparently, we have achieved a toughness of the plasticized vinyl comparable to that used in upholstering furniture, automobile seat covers, and vinyl plastic floor tiles. Our experience has shown that dull wrinkle finishes often become shiny from continuous handling and do not have outstanding abrasion resistance. The lighter-color wrinkle finishes also trap dirt and cannot be cleaned easily. High-gloss enamels lose their high sheen on wear surfaces. The semigloss finishes, which are desirable from a light reflection point of view, polish badly and wear through at a high rate. The field reports on the performance of this textured vinyl-organosol fully justify the time and money expended on a complete product evaluation.

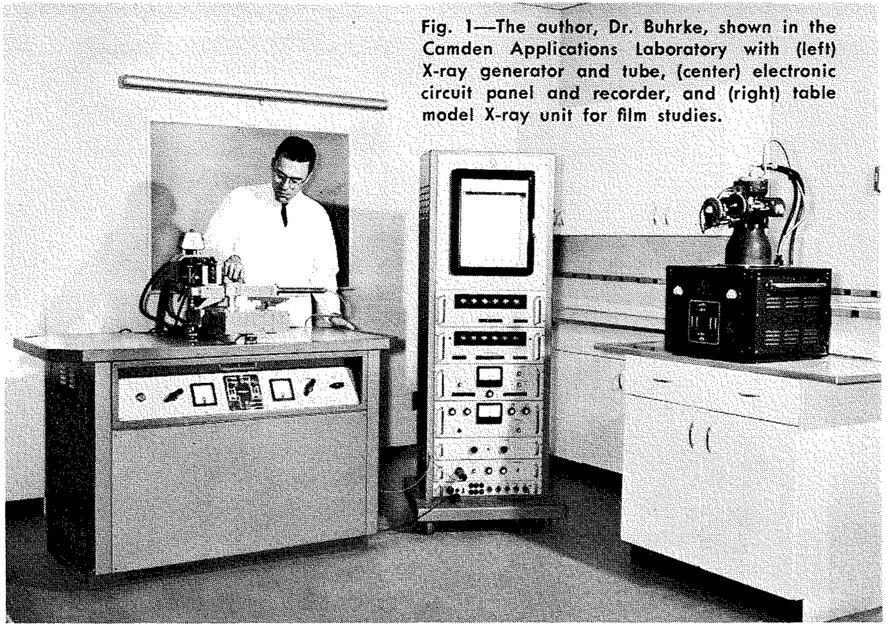


Fig. 1—The author, Dr. Buhrke, shown in the Camden Applications Laboratory with (left) X-ray generator and tube, (center) electronic circuit panel and recorder, and (right) table model X-ray unit for film studies.

DR. VICTOR E. BUHRKE majored in Physical and Analytical Chemistry at the University of Illinois. He received his doctorate in 1954 while serving as teaching assistant in the chemistry department and operating the Testing Laboratory. He entered the Army in 1954 and was stationed at the Army Chemical Center in Maryland for two years, after which he joined the Du Pont Polychemicals Department as an X-ray diffractionist studying polymers. He was later made group leader of the Chemical Service Section. In August 1958, he was put in charge of RCA's Application Laboratories for X-Ray Diffraction and Spectroscopy and Electron Microscopy. Dr. Buhrke is a member of the American Chemical Society, Sigma Xi, American Crystallographic Association, and the Electron Microscope Society of America.

WHY AN X-RAY LABORATORY IN CAMDEN?

by **Dr. V. E. BUHRKE, Director**
Applications Laboratory
Scientific Instrument Engineering
IEP, Camden, N. J.

Although many technical laboratories throughout the world use the electron microscope and the X-ray diffraction unit as companion research instruments, probably only few RCA engineers are aware of the new Applications Laboratory recently established in Camden for X-ray diffraction, spectroscopy, and electron microscopy activities. To complement the now-famous *RCA Electron Microscope*, the Scientific Instruments Section of IEP's Industrial and Automation Division began marketing X-ray equipment in the United States early in 1958. Such equipment, manufactured by the Siemens-Halske Corporation of Karlsruhe, Germany, was installed in the Camden laboratory in August of 1958. Until RCA entered the field, domestic laboratories were using equipment manufactured by either General Electric or Philips Electronics, an associate of Philips of Eindhoven, Holland. Since investigators here have little or no experience with RCA equipment, this new laboratory allows the new X-ray apparatus to be not only demonstrated but also tested and improved. Two complete instruments have been installed for these purposes.

An X-ray laboratory provides rapid and accurate data for a large variety of problems. Fundamental studies involving the determination of the distance between the atoms of a certain sample are conveniently performed by the RCA X-ray camera, which records the diffracted X-radiation on film.

In place of using cameras and films to measure inter-atomic distances, another RCA instrument is available which uses electronic detectors (geiger, proportional, and scintillation counters) in conjunction with an RCA diffractometer. The radiation diffracted by the sample is picked up by the electronic detectors, which in turn feed pulses to an electronic circuit panel. The panel provides a record on a strip of chart paper, which is a plot of the intensity of the diffracted radiation as a function of the angle at which the detector is located with respect to the undiffracted primary X-ray beam. It can also be converted to a spectrometer used for determining the identity of the atoms.

X-ray diffractionists and spectroscopists often must solve problems wide in scope which require complex, expensive instruments and, in turn, extensive training of the operators. The man entrusted with selecting the proper instruments must examine all existing commercial apparatus before making a selection; he also must satisfy himself that he can operate the equipment and produce significant data with a minimum of effort. The Camden Laboratory is thus important as a sales medium.

The laboratory is also a training center for RCA men associated with the sales, engineering, and servicing of the X-ray equipment. In addition, the Scientific Instruments engineering group has introduced significant modifications in the equipment to make it much safer to operate. The analysis of a vast array of samples submitted by outside laboratories interested in our equipment is another vital function of the X-ray laboratory. The data obtained from these analyses are often an important factor in demonstrating that RCA equipment can perform satisfactorily.

Thus, the new Applications Laboratory enables RCA to demonstrate, test, and improve its line of X-ray equipment to the chemists, physicists, metallurgists, and other men of science from industrial and university laboratories where X-ray diffraction and spectroscopy find application.

Fig. 2—RCA X-ray powder camera.

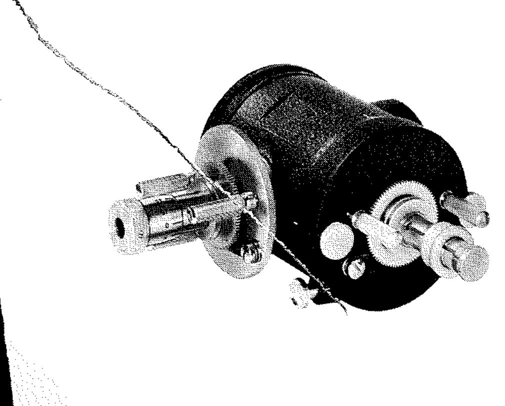


Fig. 3—RCA horizontal diffractometer.

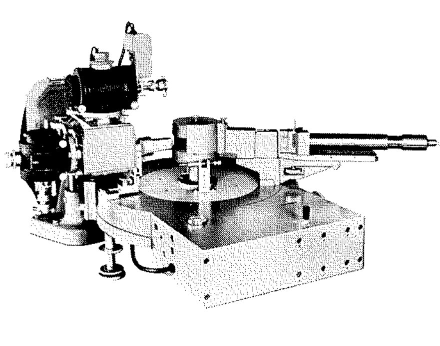
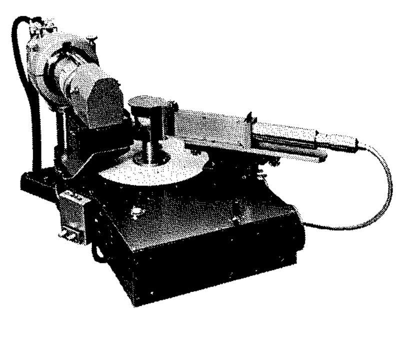
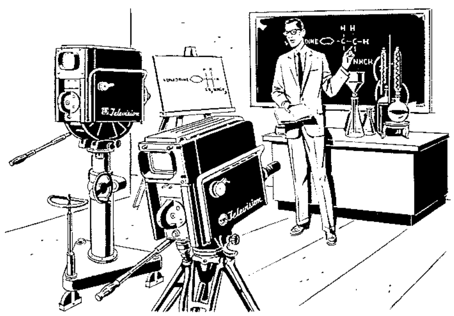


Fig. 4—RCA X-ray spectrometer.



ELECTRONICS IN EDUCATION

by **JOHN W. WENTWORTH, Staff Engineer**
Educational Electronics
IEP, Camden, New Jersey



EVERY WELL-INFORMED American is aware that our country's educational system is in a period of crisis. Public attention has been focused on the problems of education by the technological challenge of Communism, symbolized by Soviet successes with rockets and satellites, but the problems themselves are much broader in scope than our presumed weaknesses in training for the physical sciences. In addition to the Soviet challenge, the factors of population pressure, inadequate financial resources, and the growing complexity of our civilization all contribute.

Nearly all educational institutions, public and private alike, have been unable to increase their financial resources in proportion to rising costs and the increased loads thrust upon them. One inevitable result of America's economy-minded attitude toward education has been the development of an acute shortage of skilled teachers, since many of those competent to teach have been attracted to better-paying jobs in business or industry. In spite of these handicaps, our schools and colleges are being called upon to render an ever-increasing roster of services.

ELECTRONIC AIDS TO EDUCATION

There is no simple panacea to solve all the problems of American education. However, there is growing recognition that electronic devices can play a role in alleviating the present crisis.

Education, often still conducted in much the same manner as it was 300 years ago, must up-date its tools and techniques. Many pioneering educators are discovering that it is possible to improve both the quality of instruction and the efficiency of the educational process by adopting new techniques based on electronic aids.

RCA is already recognized as a major supplier of educational electronic devices, and there is substantial evidence that the portion of RCA's business devoted to education will increase significantly over the next decade. Some of the basic system concepts are described herein. For another important technique, see L. J. Anderson's article, *Language Laboratory,* in this issue.

EDUCATIONAL TELEVISION

Educational television systems represent one of the most effective applications of electronics to education. At the present time, there are 44 noncommercial television broadcasting stations in the United States used exclusively for educational programs. In addition, there are approximately 200 closed-circuit television systems operated by educational institutions, and some commercial stations and networks devote certain hours each week to educational programs. In spite of this activity, the surface has barely been scratched.

Television has many advantages for teaching. As a combined audio and visual medium, it has the ability to capture and hold attention for long periods. It permits a single teacher to reach a great many more students than would be possible on a traditional classroom basis. It makes reasonable the use of special visual aids that would be prohibitively expensive or cumbersome for use in every classroom. It can utilize the mobility of the camera to take the students to otherwise inaccessible places. It permits the integration of motion picture films and other photographic materials with live lectures on a smooth, convenient basis. Through television recording techniques, it is possible to save expensive instructional material for later re-use.

In general, educational television presentations are not intended to replace the traditional classroom teacher. In most cases where in-class televised instruction is used, only about one-half of the class period is used for the television presentation. The remaining time is used for recitation, for repetition by the classroom teacher of key points that might not have been absorbed by her students, for testing, or for exploration of somewhat more advanced material not directly covered by the televised lesson. The studio teacher and classroom teacher form a specialized team, each supplementing the efforts of the other. Freed from the burdens of keeping attendance records, grading papers, and counseling individual students, the studio teacher is able to concentrate on preparing lectures and visual aids. (The basic course outline is usually prepared well in advance, preferably at a seminar attended both by the studio teacher and all classroom teachers associated with the subject matter.) Likewise, the classroom teacher is freed from the burden of preparing daily lectures, and can devote more time to meeting the individual needs of students.

There are several schools of thought concerning production techniques for educational television programs. Some educators favor the simple use of one or more cameras in an ordinary classroom to view a teacher conducting a conventional class session, relying primarily on a chalk-board for visual illustrations. In this approach, the television system is regarded essentially as a means of extending the walls of a traditional classroom to enable larger numbers of students to witness the proceedings.

A more-professional approach, and one strongly favored by RCA, involves the use of a *teaching studio* instead of the traditional classroom as an origination point. In such a teaching studio, the teacher does not necessarily have an actual class present, but does have access to all the props and facilities needed to present smooth-flowing presentations. Specialized lighting is used to provide crisp, clear pictures, the floor layout is planned for efficient, effective camera movement, and specialized demonstration tables, chart holders, animated displays, and other visual devices are provided as needed. A film projection room adjacent to the studio permits the use of slides or short film clips at the push of a button. High-quality microphones and proper acoustical treatment of the studio assure good audio pickup without extraneous sounds.

RCA has supplied a significant fraction of the equipment currently in use for educational television. Excellent results have already been achieved with adaptations of broadcast or industrial-type equipment, but the market may soon expand to the point where television equipment designed specifically for educational use will be practical.

AUDIO-VISUAL EQUIPMENT

Motion-picture projectors, slide projectors, record players, radio receivers, public-address systems, and tape recorders have all been used for many years in educational institutions. For example, few teachers would dream of teaching music appreciation without the aid of records and a record player. In general, however, the potential benefits of audio-visual equipment have been exploited only to a mild degree because of conservatism, economic obstacles, or problems in the equipment itself.

In spite of the fact that projection equipment is readily available, the showing of slides or a motion-picture film is still considered something of a special event in most classrooms. The reasons for this limited use are not difficult to find. Photographic materials are relatively costly to produce, and the distribution channels which have evolved over the years are very cumbersome. Relatively few complete courses are available on film at reasonable cost, and it is difficult to locate, preview, and edit the many materials which might be used effectively as brief inserts in conventional presentations. The equipment itself leaves much to be desired. Most of the available projectors have inadequate light output to produce bright pictures in fully-lighted rooms, and the process of darkening a classroom to show a film or slides is sufficiently distracting and time-consuming that it is impractical to utilize photographic materials for only a few minutes at a time.

There are good opportunities for further engineering development in the audio-visual field. The introduction of educational television is certain to result in increased emphasis on visual teaching aids and to stimulate the flow of audio-visual program materials. Many of the present limitations of audio-visual equipment could be overcome by a fresh engineering approach, and there are new product possibilities that could be exploited. For example, an undeveloped opportunity exists in the field of *electronic library* equipment. Some of the more-enlightened librarians in our country's educational institutions are becoming aware that information in forms other than books and periodicals should be readily available to students, both for browsing and for serious study. There is need, however, for improved equipment designs that will permit the uniform storage and handling of audio and visual materials on essentially the same basis as books.

DATA-PROCESSING EQUIPMENT

Simplified, low-cost data-processing equipment could bring new efficiency to paperwork such as test scoring and attendance and grade records. The educational process itself might be streamlined by the introduction of specialized types of data-handling equipment. One can visualize, for example, a classroom in which a group of response buttons on each student's desk are wired up to a small data-processing unit in the teacher's desk. With such a system, a teacher could give instantaneous quizzes by asking questions and requesting immediate responses from all students simultaneously via the response buttons. It would be possible to record all responses simultaneously for grading purposes, and the students could be told almost immediately whether or not their responses were correct. The same system might also include buttons marked *slower, please*, which could be operated by students when they feel they are missing key points during a lecture. Such responses from an entire class could be integrated to operate a simple display device to indicate to the teacher whether or not his message is getting across. Feedback from one or more such systems into a TV teaching studio could help a television instructor pace his material at a realistic rate, even though he is unable to observe his students directly.

TEACHING MACHINES

One of the most-exciting and least-developed concepts is the so-called *teaching machine*. While any device capable of substituting for a teacher (such as a phonograph and a collection of language instruction records) might be regarded as a teaching machine, the term is used here in reference to a much more restricted class of devices in which some provision is made for feedback from the student. Such machines may assume a wide variety of forms, not necessarily electronic in nature. In fact, the types most widely publicized to date are primarily mechanical, designed to present purely visual information, usually in the form of printed text. The student responds to questions in the text either by pushing buttons or by writing on a built-in paper tape.

In general, teaching machines are designed for use by individual students, not by large classes. Their greatest virtue is the fact that they permit a student to make an immediate response to each new item of information and also give an immediate indication to the student whether or not his understanding of the subject matter is correct. Such active participation by the student provides a built-in incentive and greatly intensifies the learning process. Learning new material becomes an exciting game, and controlled experiments by psychologists indicate that the opportunity for rapid feedback makes new information both easier to absorb and easier to retain.

The relatively crude machines that have been developed to date could be greatly improved by the use of electronic devices to present both audio and visual information. Possible components for such teaching machines are cartridge-type tape recorders and automatically synchronized strip-film projectors. By the clever use of coding signals, it should be possible to devise machines in which a student's responses exercise direct control over the rate at which new information is presented. For example, a series of correct responses, indicating that the student is absorbing the material very rapidly, could cause the machine to skip ahead to the next major point, omitting repetitious material. On the other hand, a series of incorrect responses could cause the machine to go back over a section of the material, or to present supplementary information intended to aid slow learners.

A teaching machine can only be as effective as the programs prepared for it by competent teachers. Given a source of good programming material, however, a teaching machine can perform most of the functions of a private tutor. In a formal school system, a battery of teaching machines could be very useful for giving supplementary material to both gifted and retarded students on an individual basis, and to facilitate make-up work by students who have been absent from regular classes. A group of machines in a public library, accompanied by a library of good lesson materials, would permit any interested youth or adult to take a course in almost any subject, working at a speed commensurate with his or her available time and learning ability. It is even conceivable that the cost of teaching machines can be made low enough that they can be purchased for the home, where they could be used for the continuing education of both children and adults.

POTENTIAL BENEFITS

Electronic aids to education offer a great deal more than stop-gap solutions to the current problems of teacher shortages and overcrowded classrooms—they provide an opportunity to make major advances in the quality of education.

As long as educators keep their attention properly focused on *educational objectives* and regard electronic devices only as helpful tools for attaining those objectives, there is little danger that our children will become mere stereotyped products of pushbutton educational factories. On the contrary, the greater efficiency made possible by electronic aids should increase the chances for individual attention to each child. Applied with intelligence, electronic devices can help to widen the mental horizons of all American young people.

For Mr. Wentworth's biography, see p. 62, Vol. 5, No. 4.

The David Sarnoff C

To: Duane C. Brown . . . *for development of original and effective solutions to complex problems of missile and rocket trajectories at the Atlantic Missile Range.*

DUANE C. BROWN, Data Reduction Analyst with the RCA Service Company at the Atlantic Missile Range, Patrick AFB, Florida, has been selected for the 1960 David Sarnoff Outstanding Achievement Award in Engineering. Mr. Brown, who holds an MS in Mathematics, began his career in 1952 at the Ballistic Research Laboratory, Aberdeen Proving Grounds, Maryland. While there, he established an important professional reputation in the field of photogrammetric research.

In 1955, he joined RCA at the Atlantic Missile Range. There, he further distinguished himself by becoming one of the world's authorities in photogrammetry. In this work, he developed new mathematical techniques for the precise determination of geodetic positions, utilizing flares ejected from missiles or satellites. An important immediate application will be the geodetic location—to an order of magnitude better than previous techniques—of the antennas for a high-precision tracking system. He also contributed a major part of the conceptual thought for this system, which is important to the future capabilities of the Atlantic Missile Range as an adequate testing facility for space exploration.

An additional important effort was his solution of the complex problem of computing a best estimate of trajectory from a mass of often-redundant data. Conventional methods rely on elimination of determinable systematic errors from each tracking-data source and then computing a trajectory for each source. Mr. Brown's techniques allow coordinated analysis of data from all tracking equipment to give a best estimate—a significant advance in missile-guidance evaluation.

Mr. Brown is a member of the American Rocket Society and the American Society of Photogrammetry. At the age of 30—with his professional career only beginning—he has gained international reputation for his work with ballistic cameras and data-reduction. His achievements are a hallmark of the immediacy and importance in modern technology of applying vigorous analytical talent to engineering problems.

The 1960 Individual Awards for Science and Engineering

To: Dr. Leon S. Nergaard . . . *for basic and practical contributions to the science of microwave electron tubes and thermionic cathodes.*

DR. LEON S. NERGAARD, an associate Director of the RCA Laboratories in Princeton, has been selected for the 1959 David Sarnoff Outstanding Achievement Award in Science. Dr. Nergaard began his distinguished RCA career in 1933 as a member of the Electron Tube Research Group in Harrison, N. J. During nine years there, his many research contributions included a thorough exploration of ultra-high-frequency measurements and the development of a wide-band television transmitter tube. He was also responsible for major advances in inductive output power-tube theory and application, making possible the first television relaying experiments, forerunners of the extensive present-day relay networks.

Dr. Nergaard moved to the RCA Laboratories in Princeton in 1942, where he spent most of the World War II period in the development of pulse radar tubes. His subsequent study of microwaves and new methods for their amplification was a factor in establishing the Corporation as a post-war leader in that field. After the war, Dr. Nergaard was selected to head a small group undertaking fundamental studies of oxide-coated cathodes. One of his findings led directly to great improvement in the life and reliability of electron tubes and helped eliminate a common cause of operating failure in television receivers. Early in 1957, he undertook direction of a research group on microwaves and gaseous electronics. He is now engaged in research that ranges from masers and parametric amplifiers to the use of microwaves for containing thermonuclear plasma.

Dr. Nergaard is a Fellow of both the American Physical Society and the Institute of Radio Engineers, and a member of the American Association for the Advancement of Science and Sigma Xi. He has received two RCA Laboratories Achievement Awards, has been issued 24 patents, and has published many articles in technical and scientific journals. His continually productive career as a scientist stands as a model of the vital link between research and application that is a key to a vigorous technology.

...tstanding Achievement Awards

. . . . and announcing two new Awards

The Team Awards for Science and Engineering

THE DAVID SARNOFF individual awards, whose 1960 recipients are named on the page opposite, were established in 1956 to commemorate the fiftieth anniversary in electronics of David Sarnoff, Chairman of the Board. Now, similar, complementary annual awards for group effort in both research and engineering have been created—the David Sarnoff *Team Awards* in Science and Engineering. It is anticipated that announcement of the first team awards will be made concurrent with the 1961 individual-award selections.

WHY TEAM AWARDS

In today's technology, many research and engineering problems must be attacked in coordinated fashion by a group, rather than an individual, if an efficient solution is to be attained. The very organizational pattern of many segments of RCA reflects this, through the creation of special groups or projects to accomplish a specific task. The result of such group effort might well be an outstanding research or engineering achievement; yet, it would be impossible to single out an individual as totally responsible. For these reasons, the new Team Awards in Science and Engineering have been conceived to bestow honors that will parallel the established individual awards.

SELECTION CRITERIA—TEAM AND INDIVIDUAL

All engineering activities of RCA Divisions and subsidiary companies are eligible for the Engineering Team Award; their Chief Engineers may present nominations for the team award annually—just as for the individual award. Similarly, members of the Research Staff of the RCA Laboratories are eligible for the science awards; nominations are made by the Research Directors of the Laboratories. The Selection Committees may pass over any of these awards for a given year if in their opinion no suitable candidates are presented.

The Selection Committee for both the individual and team awards in engineering includes: the Senior Executive Vice President, Chairman; the Vice President, Research and Engineering, the Vice President, Engineering; the Vice President, Product Engineering; the Director, Communications Engineering; and the Vice President, Personnel.

The Selection Committee for both the individual and team awards in science consists of: the Senior Executive Vice President, Chairman; the Vice President, Research and Engineering; the Vice President, RCA Laboratories; the Director of Research, RCA Laboratories; and the Vice President, Personnel.

The team awards will consist of gold medals and citation certificates to each member of the teams selected. Each medal will be engraved with the name of the recipient and the year of the award; the citations will list the members of the teams and describe the achievements.

SIGNIFICANCE OF THE AWARDS

The distinction these four awards confer on their recipients is evident when it is realized that *all* RCA engineers and scientists are eligible. Thus, these awards stand as recognition of *the outstanding* recent engineering and scientific achievements throughout the Corporation.

To quote David Sarnoff, "Scientific research and engineering are creative and constructive forces that bring forth new ideas, new products, new services, and continually renew the vitality of business and industry. They stimulate business growth and economic strength and are the foundation upon which RCA is built."

THE LANGUAGE LABORATORY

by **L. J. ANDERSON, Mgr.**
Sound and Visual Engineering
IEP, Camden, N. J.

During the past few years, there has been a gradual, but evident, shift in emphasis in language teaching. The old concept of teaching—read and translate first—is being replaced by teaching *to speak and understand the language* as it is used in the native country.

An outgrowth of this concept is the *language laboratory.* It is based on teaching the language in the same fashion that a child learns his own native tongue—listening and repeating until the sounds are accurately imitated. It is, therefore, a place where each student can hear the language spoken by a native and can attempt privately to reproduce the sounds that he hears. The advantages of this system over that of classroom work, which it supplements, are:

1) The time that the student can practice is greatly increased, since he can devote the entire period to this effort rather than divide the time with some 20 or 30 classmates.
2) It removes much of the inhibition that a student may have as a result of possible ridicule by fellow students of his efforts at learning. This is accomplished by making the system a private, individual one as far as each student is concerned.

The method had its origin in one form or another in the Armed Services where it was imperative to teach large numbers of service personnel to speak and understand foreign languages in a relatively short time. Since then, colleges have been experimenting and developing the method with astounding results, and it is now obvious that its application at the high school level is justified. There is no good reason why it should not be extended to the grade school level.

THE BASIC SYSTEM AND POSSIBLE VARIATIONS

The basic system consists of 1) a language program source prepared, preferably, by a native of the country whose language is being studied, 2) a booth for each student containing a microphone, amplifier, and headphones so connected that the student can hear the program source and, during blank periods in the program material, repeat to himself the phrase or sentence he has just heard. The microphone and headphone are used to give privacy and to enable the student to hear himself as he sounds to others.

All of the RCA systems are variations of this basic concept and allow as extensive an assortment of features as may be deemed necessary for a particular application.

Fig. 1 shows a block diagram of the simplest system, on which all of the variations and extensions are built. It consists of a program source, a student booth containing an amplifier, microphone and headset. At the present time, magnetic tape is well-accepted as a program source principally because good-quality recordings are easy to prepare and duplicate by this medium. Magnetic disks have been used to some extent, since they offer the convenience feature of magnetic tape. At the present state of the art, however, their frequency range and the signal-to-noise ratio cannot match the performance of magnetic tape.

The amplifier utilizes transistors and is provided with two volume controls, so that the student can adjust both the level of the incoming program material and the level of his own voice as heard in the headphones.

The microphone and headset are the elements most likely to limit the overall response-frequency range of the system. Fidelity is important, since the system is to provide an accurate reproduction of the language sounds. Reasonably good results can be obtained with the variable reluctance microphones having a frequency range extending from 100 to 7000 cycles. Performance of the system is considerably improved by using a good-quality dynamic microphone having a frequency range extending from 70 to 12,000 cycles. The improvement obtained is greater than that to be expected from the extended range and is no doubt due to lower distortion.

Headphones must, of course, be used by the students to avoid feedback and to maintain isolation between the adjacent booth systems. At the present time, there is no headphone other than the crystal type available at reasonable cost with the required response range. Except for locations where ambient conditions of humidity and temperature preclude their use, they should by all means be employed in preference to the magnetic or telephone-receiver type of units. Typically, a frequency range extending from 100 to 8000 cycles can be obtained from crystal headphones.

Since the student uses the equipment for a considerable period of time, operating comfort and convenience must be given adequate consideration. The microphone is therefore generally mounted on a gooseneck attached to the booth top. Those headphones available at reasonable cost are somewhat lacking in comfort, and future improvement in this area is to be expected.

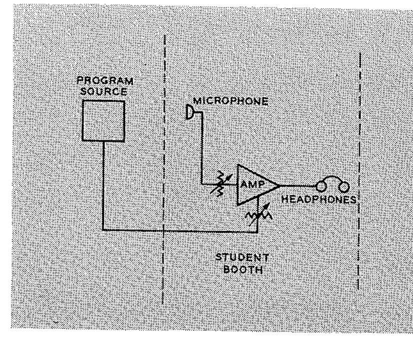


Fig. 1—Basic language lab system.

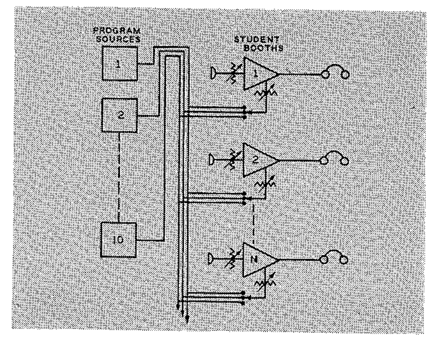


Fig. 2—Program selection at student booth.

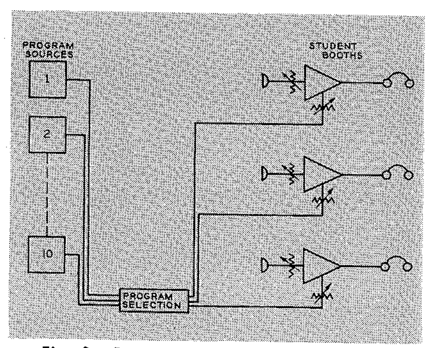


Fig. 3—Program selection by instructor.

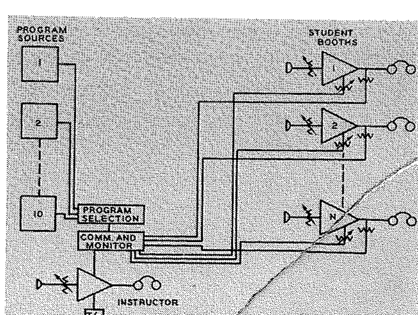


Fig. 4—System with monitoring and communication facilities.

Fig. 2 shows a system that has been extensively used at the college level. Particular success has been had with it by Dr. J. H. Hartsook at Temple University, Philadelphia. Each booth is still a basic system but has the added facility of program selection. As many as ten language courses may be made available simultaneously to any combination of booths provided, of course, that the required number of program sources are installed.

Fig. 3 shows a variation of the above system in which the control of the booth program selection is placed in the hands of the instructor. This removes any temptation the student may have to experiment with languages other than the one he is studying. It is generally felt that this arrangement is much better suited to the high school language laboratory than the system shown in Fig. 2.

Fig. 4 shows a system in which the control of the instructor has been further extended. In this arrangement he can monitor the work of any student without in any way disturbing the student. If he has suggestions to make to the student, he can establish two-way communication with the student without disturbing the remainder of the class.

THE SYSTEM IN OPERATION

The system operation is quite simple. Program selection for the booths is first made. Then during the course of the session, the instructor can monitor the work of any student by shifting a key switch to the monitor position. Depressing the key further removes the program material from that particular booth, and the instructor can communicate with the student by using the microphone, headphones, and talk-listen switch provided for that purpose.

Other refinements to this system include such features as *all-call* by the instructor to the students, *call-in* lights on the instructor's monitor, and communication facility and recording of the student by the instructor.

As might be expected in a method as new as this, there is a considerable difference of opinion with regard to the most effective system. This is most pronounced with regard to the use of tape recorders in each student booth. At one extreme are those who insist that they contribute nothing to the effectiveness of the system; at the other extreme is the claim that they are essential. The truth probably lies somewhere between the extremes, and some of the booths should be equipped with tape recorders in order to handle special conditions such as make-up or advanced work. The use of tape recorders in every booth, particularly at the high school level, could well make operational problems resulting from students handling the tape and maintenance on the recorders' delicate and expensive components.

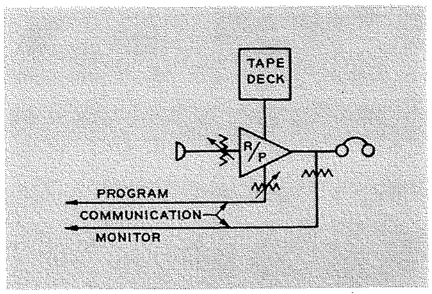


Fig. 5—Student booth with single track tape recorder.

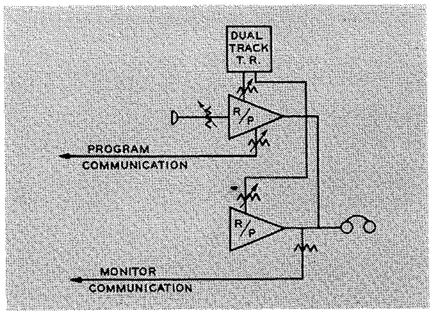


Fig. 6—Student booth with dual track tape recorder.

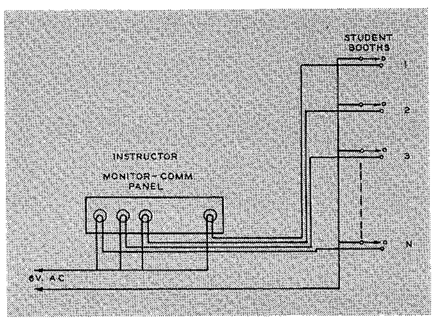


Fig. 7—Student call-in facility.

Figs. 5 and 6 show booths equipped with tape recorders. In such systems the instructor's equipment is in no way changed from that previously described. In the arrangement shown in Fig. 5 the program material and the student responses are recorded on the tape. Following this practice session the student may review his work and compare his responses to the original material by playing back the recorded tape.

The arrangement shown in Fig. 6 has one added feature. The program material is recorded on a master track during the first practice round. Following this the student may repeat his efforts as many times as he wishes by using the master track as a local program source. Another use is to record the lesson material at each booth prior to the class session and have the student use the master track as a local program source. This has the advantage of allowing the student to work at the rate he feels best suited to his needs.

Student call-in to the instructor is readily accomplished by means of lights and switches as shown in Fig. 7. The switches are located in the student booths, and the lights are placed behind a designation strip on the communication panel. Each lamp is adjacent to the communication switch for the particular booth involved.

Fig. 8—Language laboratory, Rosemont College.

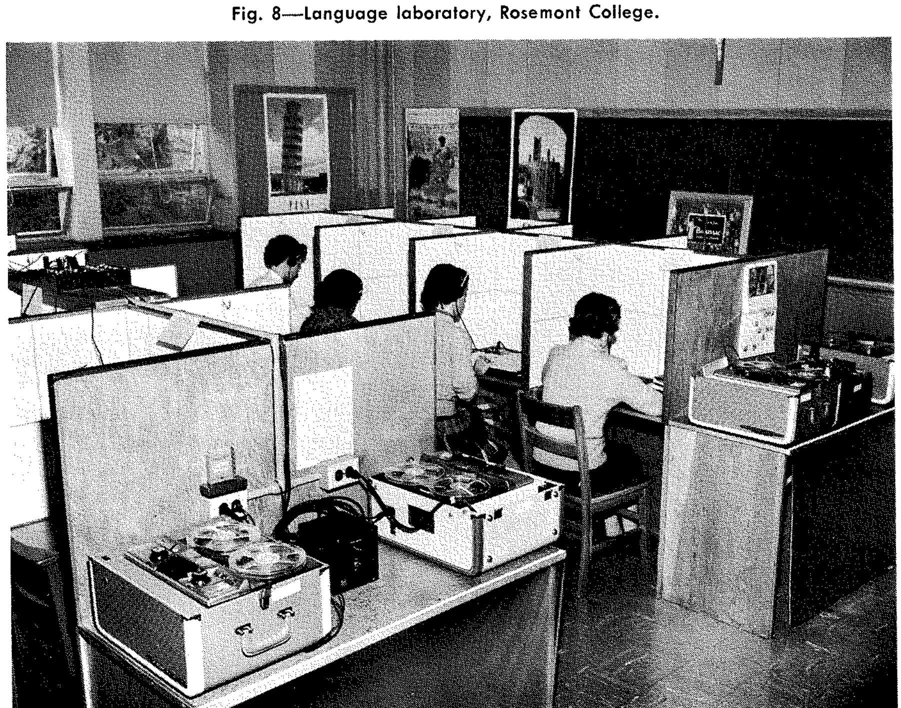


Fig. 8 shows a general view of the RCA-equipped language laboratory at Rosemont College. Four tape recorders provide a maximum of four simultaneous language programs. Program selection is made at the student booth.

Fig. 9 shows the RCA equipment essential to a student booth, namely, an MI-38000-A microphone, MI-38101-A amplifier and MI-138107-A headphones. The particular amplifier shown provides program selection at the booth. It utilizes transistors and operates from a low voltage provided by an MI-38102-A central power supply, making 117-volt a-c wiring to the booths unnecessary. A gooseneck accessory is available so that the microphone need not be hand-held. The amplifier is also supplied as MI-38114-A for flush mounting, as shown in Fig. 10. The internal amplifier construction is shown in Fig. 12.

Fig. 11 shows a typical instructor's console providing two language program sources, program selector panel, monitor and communication selector panel, and the instructor's monitor and communication panel. All of these panels are designed for mounting on standard 19-inch racks to provide flexibility.

Experience has shown that the method is an extremely effective one, and there is no doubt that the value of high school language courses will be much increased through its use. As a matter of fact, authorities in the college field who have considerable experimental experience with the method see no reason why it should not be applied much earlier than high school and possibly to the field of speech correction as well.

ACKNOWLEDGEMENT

Credit for excellence of design of the system and equipment belongs to Messrs. L. M. Wigington, D. C. Connor, and W. F. Hanway. Credit should also be given to Dr. Hartsook of Temple University for his many suggestions and the use of his laboratory for evaluating equipment.

L. J. ANDERSON received his B.S.E.E. from Armour Institute of Technology in 1928. He has been engaged in a variety of Engineering fields including directional antennae, high frequency transmitters, film recording equipment, microphones, loudspeakers, and sound systems. He is presently Manager of the Sound and Visual Engineering activity. Mr. Anderson has been active in EIA Committee work on sound system amplifier, microphone and loudspeaker standards. He has also been active on ASA committees. He is a member of Tau Beta Pi and Eta Kappa Nu.

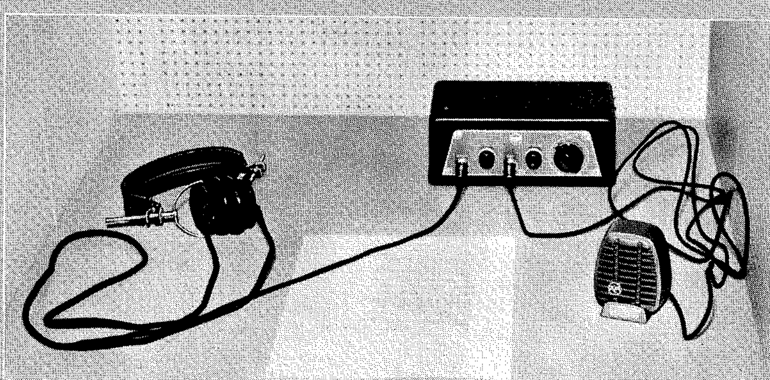


Fig. 9—Basic booth system showing microphone, amplifier, and headphones.

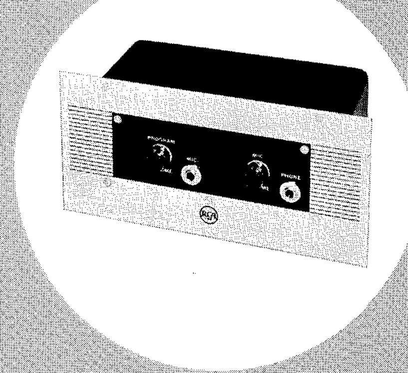


Fig. 10—Flush mounting booth amplifier.

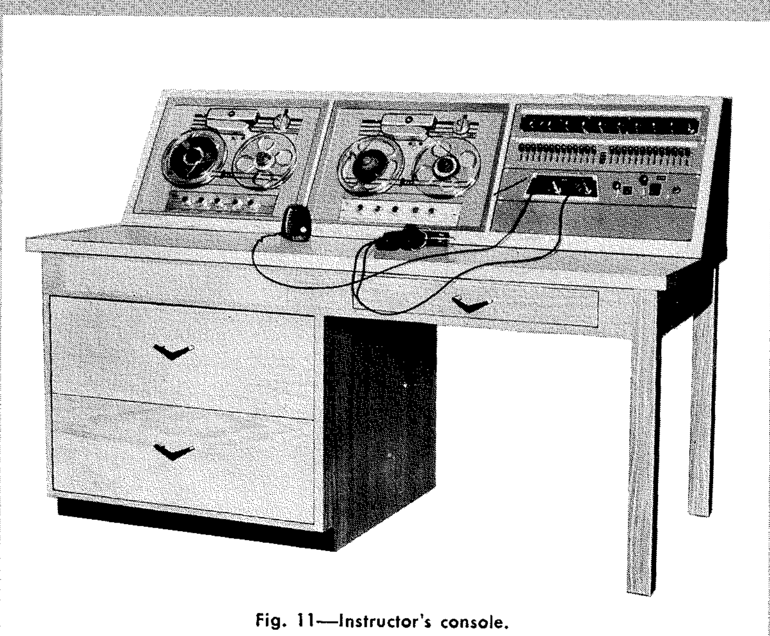


Fig. 11—Instructor's console.

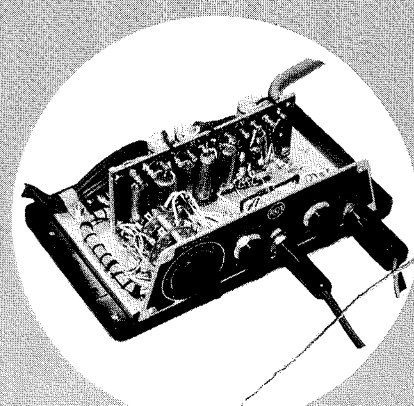
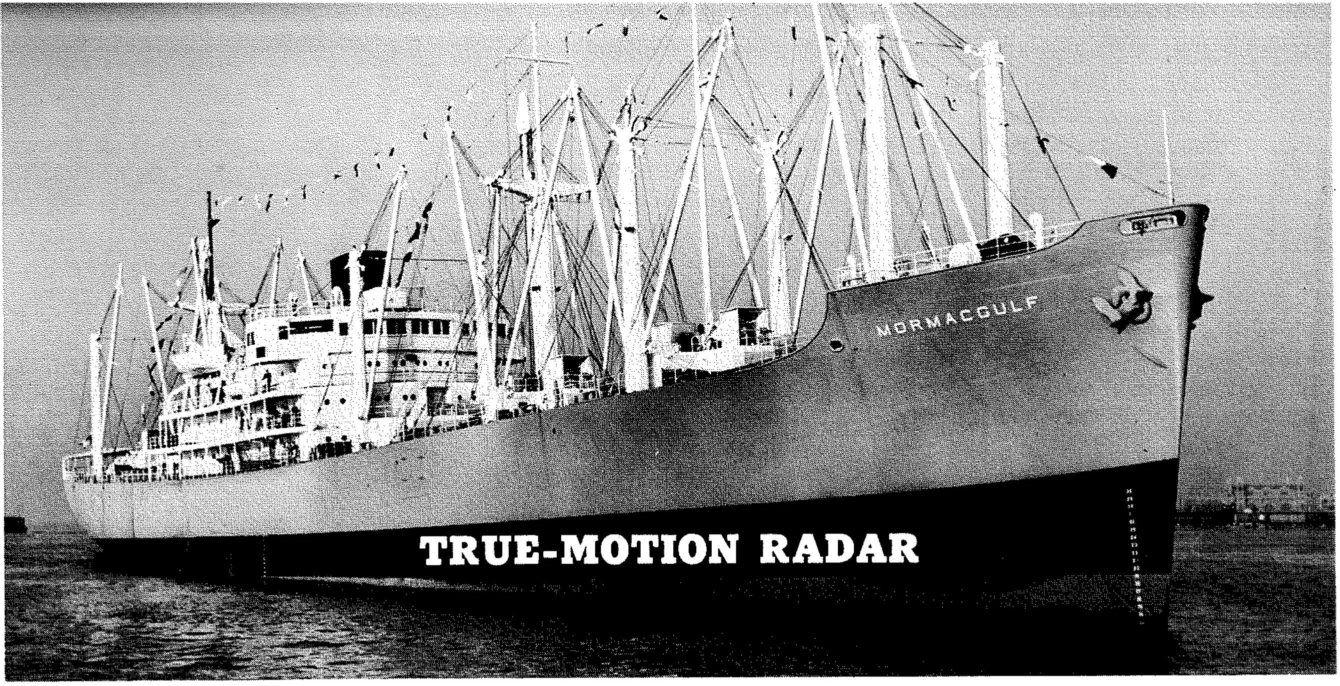


Fig. 12—Booth amplifier with cover removed.



TRUE-MOTION RADAR

by **C. E. MOORE, Mgr.**
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Communications Products Department
IEP, Camden, N. J.

Although maritime nations disagree as to which of several medium- and long-range electronic navigational systems is superior for determining ship position, all have universally accepted radar as an aid to short-range navigation. Recently, an improvement in the presentation of radar data, called *true motion,* has found wide acceptance. Before explaining true-motion radar, some background information will help the reader understand present radar equipment and the navigational problem.

HOW MODERN RADAR WORKS

The radar picture is presented on a cathode-ray tube used as plan position indicator (PPI). Here, one's own position is at the center and the sweep rotates around this point, painting a map of the area, the radius depending upon the range selected. For large vessels, a 16-inch cathode-ray tube is used to show ranges of ½, 1, 2, 6, 16, or 40 miles. To determine the approximate range of objects, four fixed electronic range rings are provided. For more-accurate measurement, a variable range ring, calibrated in miles and tenths of miles between ½ to 30 miles, is provided. Bearings are read from an azimuth scale around the edge of the picture. Either S-band (3000 to 3100 mc) or X-band (9320 to 9500 mc) frequencies are used with a 12-foot antenna reflector, which gives a 2° beam for S and 0.65° beam for X band. The high percentage of systems are X band because the narrow beam gives sharper, better-resolution pictures. X-band pulse lengths are 0.06 microsecond for ranges of ½, 1, and 2 miles, and 0.5 microseconds for ranges of 6, 12, and 40 miles. The high-resolution system is a must for the Inland Waterway System and the Great Lakes.

The picture presented is a continuous study of relative motion where your ship and other ships (the "targets") are moving. Fixed objects also move on the picture because of your own movement. The one thing fixed on the picture is you; you are always at the center of the picture. Now, suppose that you are out in the open sea and observe a target at 10 miles when operating on the 16-mile range. On the reflection plotter you make a mark (Point A, Fig. 1) with the grease pencil and note the time. Six minutes later you make another mark B, and after another 6 minutes you place a mark at C. The line joining these points, ABC, is *not* the true course of the other vessel *because you moved also.* It is the relative line of motion. Suppose you are moving at 18 knots; in the 12 minutes you moved 3.6 miles. From the original point A, you lay off to scale 3.6 miles (AX) and complete the triangle ABCXA, as shown in Fig. 1.

The actual course of the target is the direction of the line XC. The length of the line XC compared with the distance you traveled (AX) is the target's speed. In this case, the other vessel is moving about 12.5 knots. It will cross your bow about 2.6 miles ahead of you at D. If neither vessel changes course or speed, there will be no collision.

Thus, in relative motion, the captain must first evaluate the situation, and then plot those targets which are a potential danger and take corrective action if required. It should also be realized that in many cases there are only two people in the wheel house—the helmsman and a ship's officer. The helmsman has one duty to perform, to steer the ship according to orders from the officer. The ship's officer has one duty, to navigate with safety for his ship, passengers, and crew. To do this, he must continuously measure his position using the radio-direction finder, or Loran or radar, and plot his position on the chart, keeping track of his own speed and, of course, the direction of the wind, its velocity, the sea condition, the weather, fog, rain or snow, and the depth of the water. If the weather is bad he must see that the lookout is on duty, plus answer the bridge telephone. So, he is a busy man. For this reason, plotting is not always rigorously practiced.

HOW TRUE-MOTION RADAR WORKS

In true-motion radar, the face of the cathode-ray tube becomes an area—a chart—where fixed objects do not move and all moving objects, *including one's self,* move at their own rates. Moving targets have tails caused by the long persistence of the phosphor. These tails, or trails, indicate heading, and their length when compared to one's own trail is a measure of speed. Thus, if the target's trail is twice as

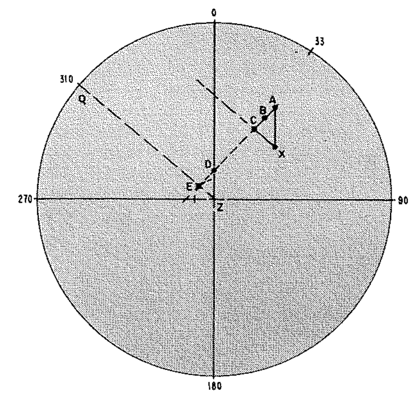


Fig. 1—Radar plotting, relative motion, 16-mile range.
Own Ship Speed, 18 knots
Observed Ship, first plot at A, 10 miles, 33 degrees
Second plot at B, 6 minutes after A, 1.4 miles
Third plot at C, 6 minutes after B, 1.4 miles
AX = own ship movement in 12 minutes, 3.6 miles
AC = apparent course, XC = actual course, 310 degrees
DZ = crossing point, 2.6 miles
EZ = closest approach point, 1.8 miles
Relative speed = AC = 2.8 m. in 12 min. = 2.8 x 5 = 14 knots
CD = 5.2 miles at 14 knots = 22 minutes

long as your own, he is going twice as fast. Of course, the length of trail depends upon the range scale in use. For a given speed, the trails will be longer on shorter ranges because the actual movement across the tube is faster.

The usual practice in providing true motion is to north-stabilize the picture; i.e., the top of the picture is always north, and everyone moves according to his true course. Thus, if you are moving south, 180°, you are actually moving down. Objects seen on the left of the scope are "out the

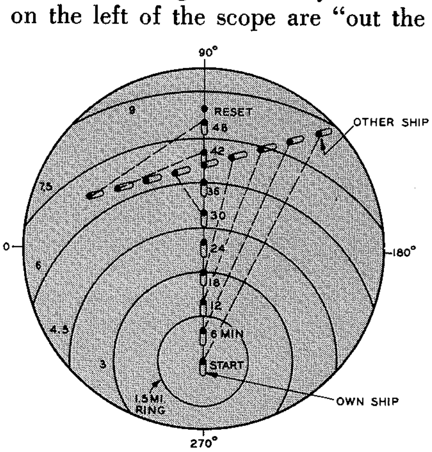


Fig. 2—True motion, showing position every 6 minutes of one's own ship and one other vessel. Own ship speed: 10 knots at 90°. Other ship: 10 knots at 345°; will cross bow in 24 minutes at 2.5 miles. Range scale, 6 miles; view ahead, 9¾ miles; travel time, 50 minutes before reset at 10 knots.

right window" and objects on the right are actually on the left.

This necessitates some mental inversion for proper navigation. Generally, in commercial navigation, skippers always prefer to go up on the scope, so that echoes on the left are from objects on the left or port side and echoes on the right are from objects on the right, or starboard side. In the RCA equipment described in this article, moving up is automatically provided although it is not a primary requirement of true motion. This is done by first north-stabilizing the picture and then automatically rotating the cathode-ray tube assembly so that one's own movement is always up. Zero on the azimuth scale around the tube is always north. The scale reading at the top of the scope is your true

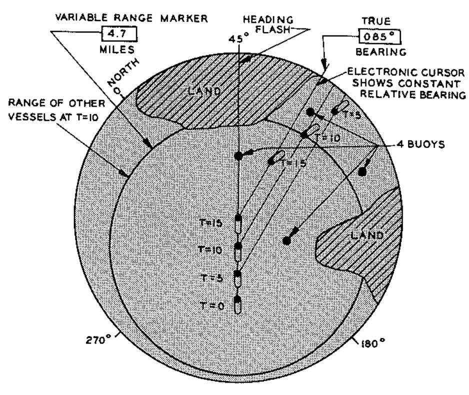


Fig. 3—True motion, showing positions every 5 minutes of typical collision course. Own ship speed: 12 knots at true course 45°. Other ship: 18 knots at true course, 277°. Range scale, 6 miles.

heading. Thus, if this were 180°—you would be traveling south, but the picture is oriented so you move up—the natural view. RCA true-motion equipment is the first on the market to provide this feature.

The true-motion indicator may be substituted for the regular relative-motion indicator on either the current RCA X-band CRM-N1A-75 radar or the S-band CRM-N2A-30 system. The Federal Communications Commission type-approves radar as a system. The new true-motion systems will bear the number CRM-1B-75 or CRM-N2B-30.

The other radar elements, such as the antenna and the receiver-transmitter, perform their normal functions for either relative or true motion. The indicators for both systems are identical, using a 16-inch cathode-ray tube.

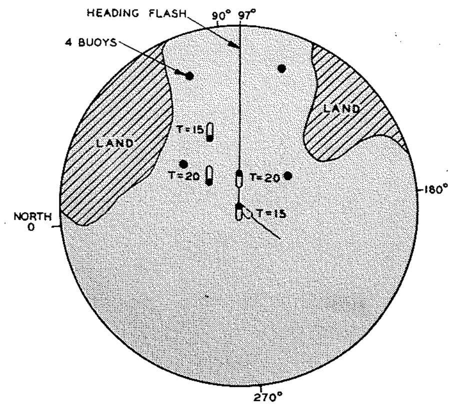


Fig. 4—Picture at T=15, after own ship turned 52° to starboard to avoid collision and enter channel. Own ship speed: 12 knots at true course 97° after turn. Other ship: 18 knots at true course 277°. Range scale, 6 miles.

A function switch provides relative motion on ranges ½, 1, 2, 6, 16, and 40 miles or true motion on 1, 2, 6, and 16 miles. The view ahead on the ½-mile range is considered to be insufficient for true motion, while movement on the 40-mile range produces unusable trails. A third position on this function switch provides off-center relative motion. This allows a longer look ahead on a given range when using relative motion than would be available if one started at the center.

Using true motion, one moves across the tube proportional to his speed and the range scale in use. Actual movement on the cathode-ray tube is due to current through two off-centering coils, one being east-west (EW) and the other being north-south (NS). These controls are usually manually adjusted. In the RCA system the ship's gyro is used to automatically provide the proportion of sine and

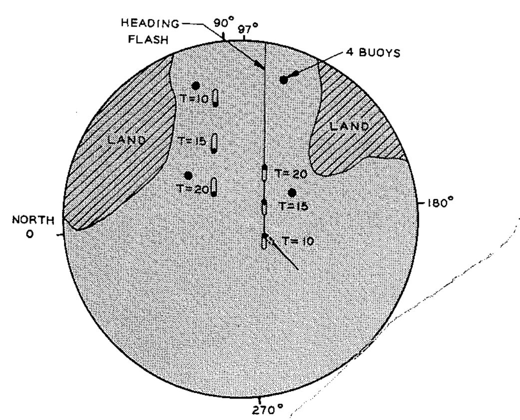


Fig. 5—Picture at T=10, after own ship turned 52° to starboard. Own ship speed: 12 knots at true course 97° after turn. Other ship: 18 knots at true course 277°. Range scale, 6 miles.

cosine vectors through two ball-and-disk integrators driving the EW and the NS potentiometers. Speed is set in manually; the position of this speed control and the range switch determines the speed of the motor driving the ball-and-disk integrators. The motor thus provides the torque to rotate the off-centering potentiometers.

When one's own ship image approaches the edge of the cathode-ray tube, the picture must be reset back to the bottom of the tube. In RCA equipment, automatic reset provides a warning tone 20 seconds before reset at the ¾-radius point. This tone warns the navigator to take a quick look before the whole picture shifts. One's own blip is then transferred to the ⅝-radius point below the center of the picture. Where a critical navigational situation might exist at reset, it may be avoided by resetting early. This is done by pushing the reset button. Fig. 2 shows successive 6-minute positions of one's own ship and a target vessel. Note that the trails give true direction of travel: own course 90°, target course 345°.

Both fixed and variable range rings travel. Heading flash is always up but sometimes is displaced from center because of change in course. Reset always corrects this displacement. Since heading flash is always up, there is no confusion about one's own course, nor is there confusion between the heading flash and the electronic bearing marker. This marker also travels and is used to measure true bearings of objects or to indicate a collision course. This is true of relative or true motion. Such a collision course is illustrated in Fig. 3. If corrective action is taken at T-15, turning into the channel, the result is Fig. 4. If change in course occurred at T-10 five minutes earlier, it would result in Fig. 5.

If one were using the one-mile range, the total miles travelled before automatic reset would be 1.3 miles. If traveling at 5 knots, this would take 16.5 minutes, if at 15 knots 5.5 minutes, and if at 30 knots only 2.75 minutes. The look ahead before automatic reset would be only 0.25 mile. Obviously, this is hazardous. For high speed, a longer range should be used, such as the 6- or 16-mile range. Thus, using radar is akin to driving in a congested traffic circle, in that judgment must be exercised. However, if properly used, true motion will eliminate perhaps 95 percent of the need for plotting. Answers such as *distance of closest approach* and *distance or time of crossing* are more easily obtained from relative motion.

The manual speed control in RCA equipment is calibrated from 3 to 35 mph. The circuits are designed to accommodate control from a log or shaft tachometer, but since corrections are usually required anyway, a single control should be sufficient.

The true-motion indicator is shown closed in Fig. 6 and open for servicing in Fig. 7. The box on top and at the rear, Fig. 6, is the computer. It consists of gyro repeater motor, two synchros, two sin-cos mechanisms, two ball-and-disk integrators, a variable-speed motor, electric clutches, reset mechanism, and off-center potentiometers. The computer may be removed and still permit the indicator to operate as a nonstabilized, relative-motion, relative-bearing type of indicator. Such operation is automatic when the proper cables are joined together.

In Fig. 7, the computer has been removed. The fold-out construction permits easy repair and servicing. Shown are the main chassis, the rotating barrel containing the 16-inch glass cathode-ray tube, the slip-ring assembly, servo amplifiers, electronic marker synchro, and dial head containing edge-lit cursor and built-in reflection plotter which avoids parallax error from both cursor and azimuth scale.

The engineering model is now operating on board a United Fruit vessel plying between New York and Central America. The regular indicator of the CRM-N1A-75 radar system was replaced by the true-motion unit.

Thus, another milestone in the development of RCA navigational equipment has been achieved and is available for those ships that have need of the latest and best equipment.

CHARLES E. MOORE graduated from University of Michigan, with BSEE in 1939. While doing graduate work in Ann Arbor, he was assistant to the Director of Broadcasting. He was on the staff at MIT from 1941 to 1945, engaged in radar development for the Radiation Laboratory. Following this, he joined the Radiomarine Corp. in New York where he was responsible for the development of all RCA commercial radar for ships as well as for military spec radar for the U.S. Coast Guard. At the present time he is manager of IEP Radar Engineering which includes radar, loran, depth indicators, fish finders and navigational instruments. He is a Senior Member, IRE, a member of Eta Kappa Nu, a member and former secretary to Manhasset Bay Power Squadron.

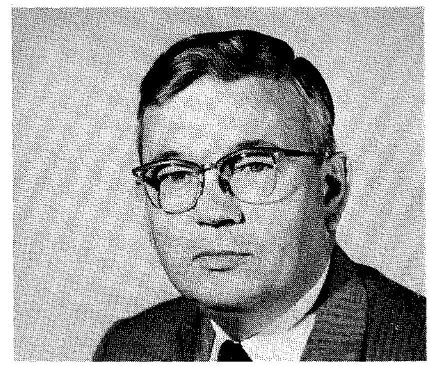


Fig. 6 — True motion indicator. Module on top is the computer.

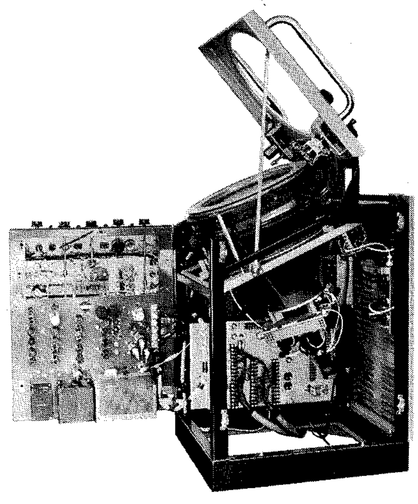
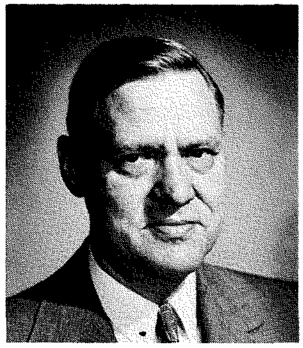


Fig. 7 — True-motion indicator, open for servicing, with computer removed.

ACOUSTICAL CONSULTING SERVICES AT RCA

by **J. E. VOLKMANN, Staff Engineer**
Industrial and Automation Division
IEP, Camden, N. J.



JOHN E. VOLKMANN attended the University of Illinois, where he received his BS in Engineering Physics in 1927, his MS in Engineering Physics in 1928, and Professional Degree as Engineer-Physicist in 1940. Mr. Volkmann has over 31 years' experience with RCA, starting with RCA Research in New York in 1928 as Assistant Physicist in Acoustic Research. In the interim to the present he has worked as an engineer, supervisor, or manager in Acoustic Development for RCA Photophone (New York), RCA Victor Co. (Camden), RCA Manufacturing Co. (Camden), RCA Victor Division (Indianapolis), RCA Victor Division (Camden), and Engineering Products Division. Mr. Volkmann is at present in the Industrial and Automation Division as Staff Engineer. He is a Fellow of the Acoustical Society of America, a Fellow of the SMPTE, a Member of the Sigma Tau and an Associate Member of the Sigma Xi.

EVER SINCE the early days of sound motion pictures, RCA has found it expedient and necessary to offer its sound-equipment customers an acoustical consulting service—sometimes on a chargeable basis, but most frequently as a form of insurance against the use of RCA products in undesirable acoustical environments. At one time, during the peak of sales by RCA Photophone, Inc. (then a separate RCA subsidiary set up for the sale and servicing of sound motion-picture recording and reproducing equipments), when most of the silent-movie theaters had to be redesigned acoustically for "talking movies," between 50 and 100 theater acoustic surveys and analyses were handled per month by several representatives from the Service Department in the Eastern, Central, and Western Divisions under the supervision of the RCA Photophone Engineering Department.

Since many special requests for acoustical advice (about 100 per year and now mostly on new-building projects) still originate in IEP in connection with sound-system sales, an acoustical-analysis and sound-survey service is maintained as a staff engineering function in the Industrial and Automation Division, Camden, N. J. Surveys, however, are also handled locally by IEP Engineering in Hollywood, Calif., in connection with the sound stages and studios of RCA's film recording Licencees. While the bulk of the surveys made relate to the application of specific RCA products (mainly loudspeakers and/or microphones) to a given acoustical environment, occasionally we are called upon to make analyses relating purely to noise problems or to the design of a room without the association of a sound system. Where a sound system is involved, the acoustics of *both the room and the sound system* must be analyzed and carefully coordinated or integrated *in the overall design for good hearing.* It is the following of this philosophy of integrating the overall acoustic design that has led to the successful performance of the more-outstanding RCA sound system installations made over the years. A general description of the nature of these surveys and of some of the more interesting ones follows.

NATURE OF ACOUSTIC SURVEYS

A room acoustic and/or sound-system survey involves either a study of the architectural drawings, particularly in the case of new structures during the planning stage, or a survey of the actual site in the case of existing structures. This study generally includes an analysis of the reverberation time of the room based on the total sound-absorbing power of the walls, ceiling, floor, chairs, and other surfaces and objects in the enclosure. It also includes an analysis of the individual echo reflections from the geometry of the space, particularly with respect to loudspeaker and microphone placement. Lastly, but of first importance, it includes a study of the optimum placement of loudspeakers and microphones with respect to direct sound coverage of the audience area. Stated another way, to properly analyze the acoustics of the space we must include all of the acoustic energy heard at any particular point in the space. This may be expressed simply as follows:

$$E_T = E_D + E_L + E_E + E_R + E_X$$

Where E_T = total sound energy at the listening point

E_D = energy direct from the original sound source

E_L = energy direct from the reinforcing loudspeaker

E_E = the energy of echo reflections (these are considered beneficial if delayed less than 0.05 seconds)

E_R = energy from reverberant reflections

E_X = energy from extraneous noise and distortion.

The foregoing room acoustic energy relation obviously applies to *any* acoustical analysis of rooms—whether sound-reinforcing loudspeakers are used or not.

SCOPE OF CURRENT SURVEYS

To show the general scope of the room acoustic consulting activity practiced at RCA, a number of photographs are presented on these pages. Brief descriptions of some of these activities follow.

Radio City Music Hall

One of the most valuable aspects of any continuing consulting service is that it quite often results in repeat business and frequently leads to new developments. This has been true in the case of Radio City Music Hall, where RCA not only had representation in the early planning stage on the auditorium acoustics and on the sound movie system and sound reinforcing system specifications (in 1930-32), but also has continued to act in a consulting capacity on every major change and improvement in the sound equipment and auditorium acoustics since then. As a result, RCA developed the first multiple-channel stereophonic sound reinforcing system for a theater auditorium, which was installed in Radio City Music Hall in 1935. The circles in Fig. 1 indicate the location of the stereo reinforcing speakers in the present system, installed in 1955.

Fantasia and Eternal Road

Of early historical interest in the stereophonic recording field were the special large projects in which RCA participated on a grand scale, including the acoustical consulting for the Walt Disney's *Fantasia.* For this, RCA provided all of the sound equipment and services for the nine-channel film-recording system used by Leopold Stokowski and the three-channel reproducing system used for road showing—the forerunner of stereophonic sound in the theater. Fig. 2 shows the polycylindrical bandshell designed for recordings by Leopold Stokowski at about this same time.

Another special multi-channel film-recording-and-reproducing-equipment project that required acoustical consulting services from RCA was *The Eternal*

Road production by Kurt Weil in the Manhattan Opera House, New York, N. Y. Here, the orchestra was completely absent from the auditorium because of elaborate scenic requirements on stage and in the orchestra pit. Hence, the musical score was rendered entirely by means of high-fidelity optical film recordings. This multiple-channel sound system included special switching facilities for controlling the direction of sound from various different locations on and around the stage.

Hollywood Bowl and Other Outdoor Stereophonic Installations

The more recent adaptation of stereophonic sound to *Cinemascope* and other wide-screen forms of motion-picture presentation has led to more and more consideration of the benefits of spatial and directional sound effects in the field of sound reinforcement and for general sound-system applications. Fig. 3 shows the location of the loudspeakers recommended to our West Coast sound distributor for the multiple-channel sound system in the Hollywood Bowl, while Fig. 4 shows the suspension of the special 180° radial loudspeakers designed for Commercial Radio Sound Corporation for the multiple-channel sound system in the Marine Theater at Jones Beach, Long Island. The latter is used for such outdoor extravaganza productions as *Showboat* and *Song of Norway*.

Distributed Stereophonic Sound In the Home

Often, the study of an acoustic problem in one application leads to the application of sound systems in other areas, as in the case of the acoustic design of the 35-mm projection room for the home of a distinguished Washingtonian. Here, the opportunity was offered to present the idea of supplementing the regular sound-movie projection system with a separate high-fidelity and stereophonic record system in which four speakers were fitted into the corners of the ceiling of the projection room, or the Pavillion Room, as it is called. The stereophonic sound system also extends to other areas such as the drawing room, and library. Probably representing the first application of distributed stereophonic sound in a home, this system permits the piping and recording of live stereophonic sound picked up in the Pavillion Room as well as the reproduction of regular stereo records. Other areas covered by the high-fidelity sys-

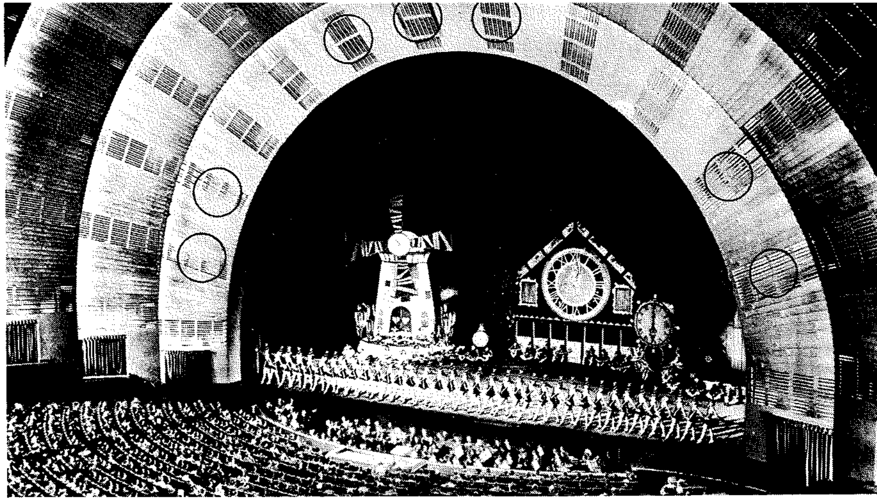


Fig. 1—Radio City Music Hall Theater Auditorium. Circles indicate location of stereo reinforcing speakers.

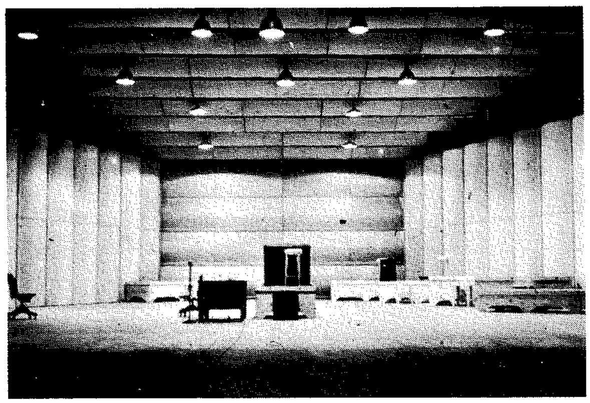


Fig. 2—Polycylindrical bandshell designed for recordings by Leopold Stokowski.

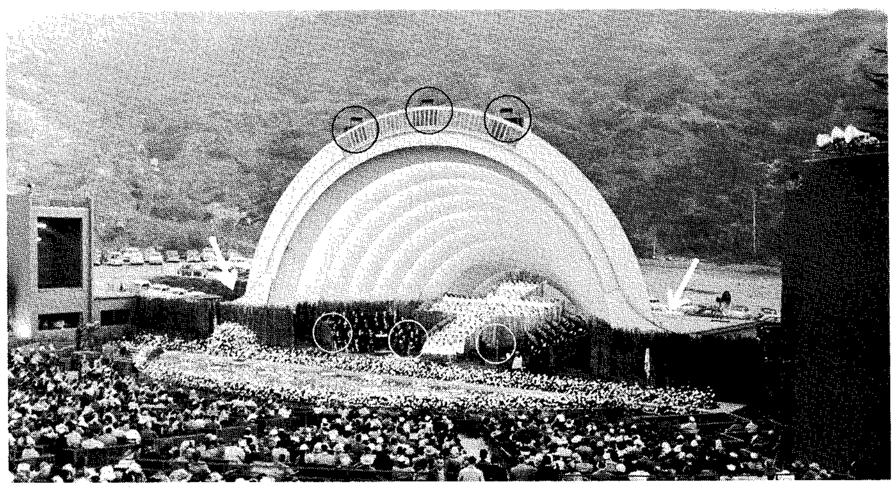
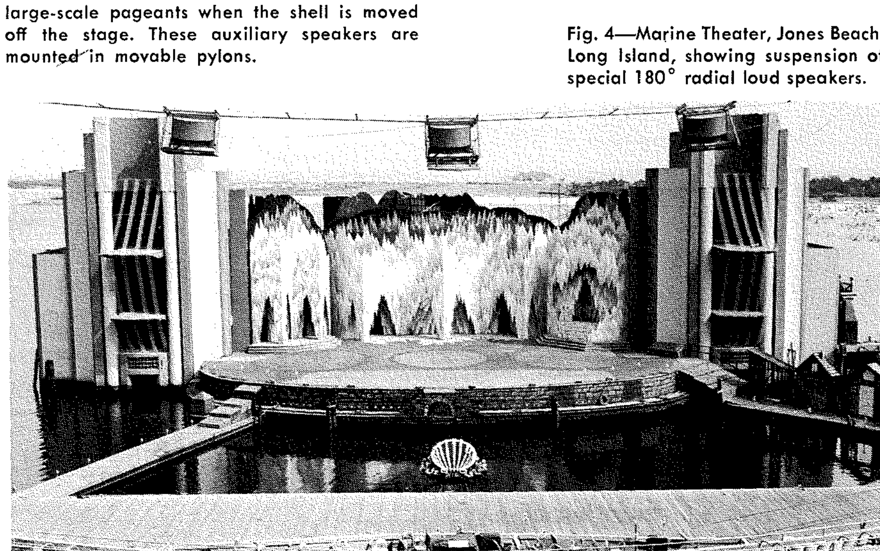


Fig. 3—Hollywood Bowl. Encircled is the basic microphone and loudspeaker system. Arrows indicate supplementary loudspeaker locations for use either with the shell speakers or for large-scale pageants when the shell is moved off the stage. These auxiliary speakers are mounted in movable pylons.

Fig. 4—Marine Theater, Jones Beach, Long Island, showing suspension of special 180° radial loud speakers.



tem include the stair hall, dining room, porch ceiling, outdoor gardens, and control room.

Fig. 5—Design of a new stereo-sound recording studio in the NBC Bldg. Hollywood, California.

Fig. 6—Acoustical details of the studio shown in Fig. 5.

New RCA Recording Studios in Hollywood

The recording of stereophonic sound in small studios has led to the need for designs in which it is possible to get greater separation between various musical instrument groups without making the studio feel too dead for the musicians. Fig. 5 shows the design of one of the new studios opened by the Record Division in the NBC Building in Hollywood this past year. The horizontal reflector vanes and vertical serrations, which are an important part of the shape and acoustic design, are shown in the close-up view, Fig. 6.

Screening Room for TV Advertising

The growth of TV advertising has led to more and more agencies setting up their own viewing or screening studios with the attendant requirements for good listening-room acoustics. The recent design of a room for a prominent agency in New York City is shown in Fig. 7. Here, good sound diffusion, an important element in the control of small-room acoustics, was obtained by the angular or diamond pattern of the walls and ceiling.

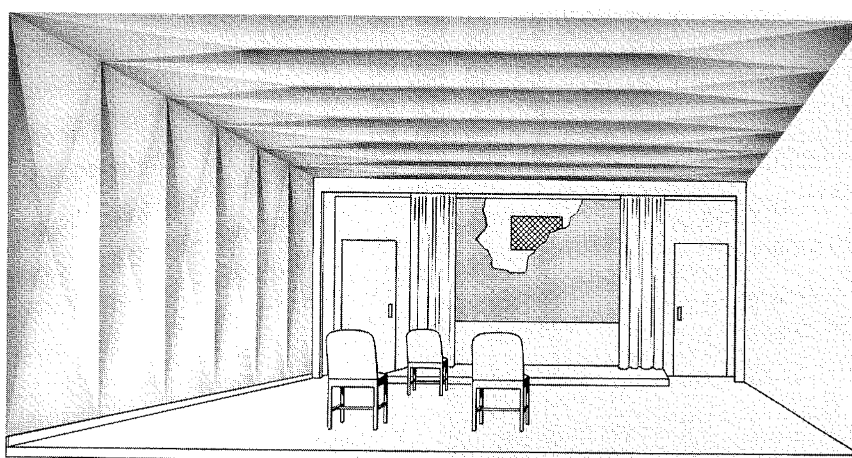


Fig. 7—A design of angular or diamond-shaped sound-diffusing panels for good listening-room acoustics.

Basilique Notre Dame Du Cap

Acoustic survey work on large new projects often extends over a period of several years insofar as the elapsed time is concerned. Fig. 8 shows the wood mockup model for a new basilica in Canada during the earliest planning stage. This is the time when acoustical consulting is the most fruitful both for the architect and his client, and for RCA. Early consultation permits establishing basic acoustic requirements and resolving the many problems relating to physical location and appearance of loudspeakers, and acoustic treatment. When this project is completed, it will consist of a multiple-channel sound system with directional sound reinforcement from the chancel and choir areas as well as a distributed stereo system for the reproduction of music. Fig. 9 shows a plan view of the multiple loudspeaker locations required to meet the basic acoustic coverage requirements.

LOUDSPEAKER DESIGNS FROM ACOUSTIC SURVEYS

As mentioned earlier, acoustic analysis on a specific project often results in new product developments or special designs. Fig. 10 shows two special loudspeaker designs resulting from acoustic survey activities, namely: the two-way cubical loudspeaker for the New York and San Francisco World's Fairs, and the two-way corner horn for Walt Disney's *Fantasia*. As an interesting sidelight, mention should be made of the world's largest two-way high-quality loudspeaker system, designed for the New York World's Fair *Perisphere*. This loudspeaker, built in the ground directly under the *Perisphere*, radiated over an angle of 360° and consisted of 24 low-frequency units and 24 high-frequency units. The low-frequency section of the speaker was poured in concrete and was 22 feet in diameter.

RCA PLANT PROJECTS

RCA's acoustical consulting activity naturally has included analyses and recommendations for projects within

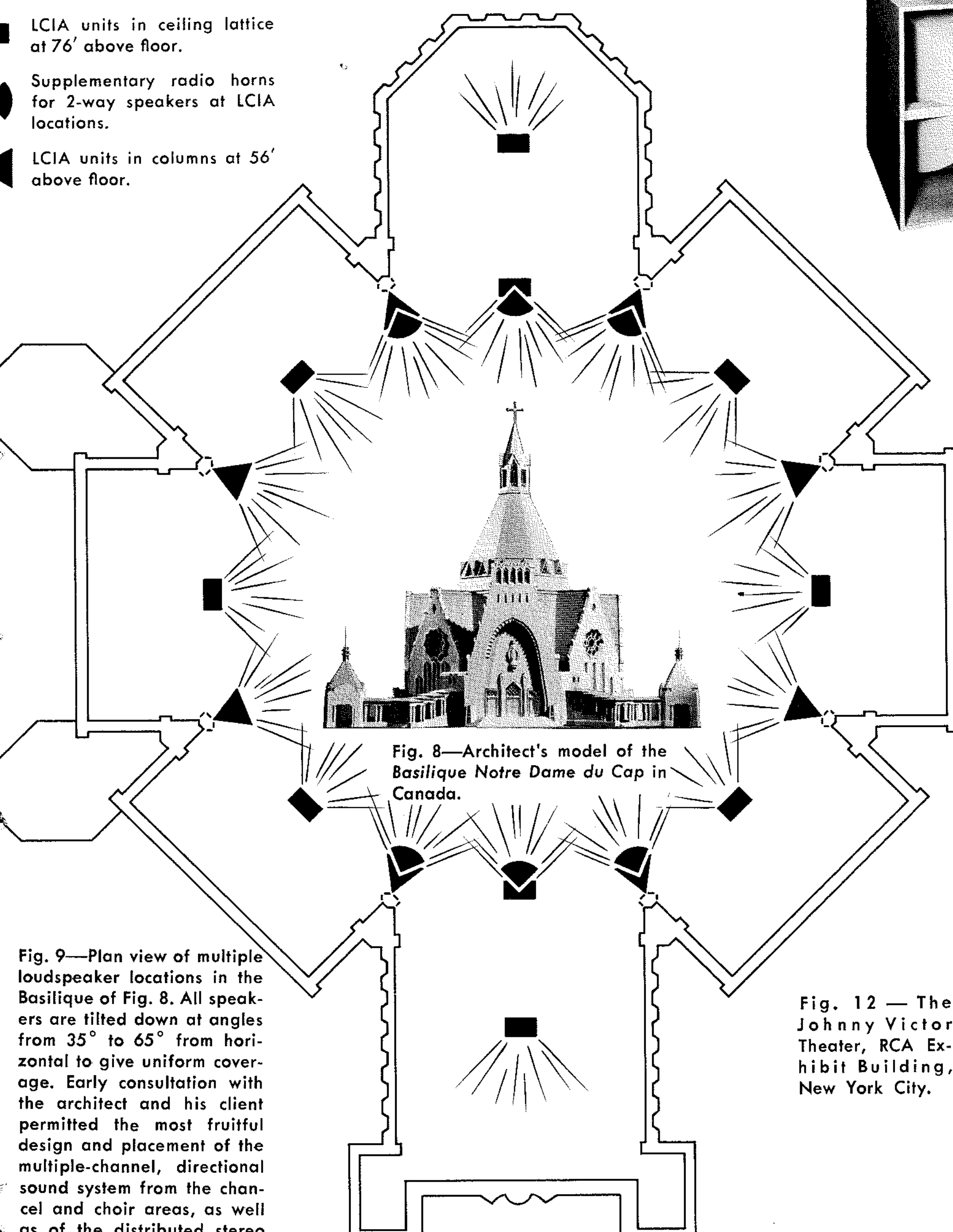


Fig. 8—Architect's model of the *Basilique Notre Dame du Cap* in Canada.

Fig. 9—Plan view of multiple loudspeaker locations in the Basilique of Fig. 8. All speakers are tilted down at angles from 35° to 65° from horizontal to give uniform coverage. Early consultation with the architect and his client permitted the most fruitful design and placement of the multiple-channel, directional sound system from the chancel and choir areas, as well as of the distributed stereo system for music reproduction.

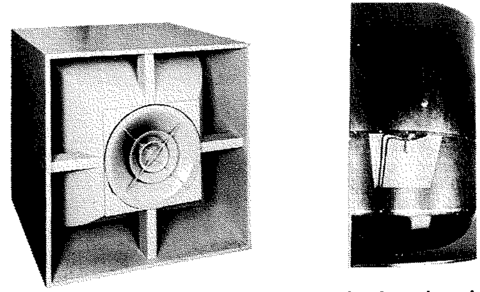


Fig. 10—Two special loudspeaker designs that resulted from acoustical surveys. Left, two-way cubicle loudspeaker for the New York and San Francisco World's Fair; right, two-way corner horn for Walt Disney's *Fantasia*.

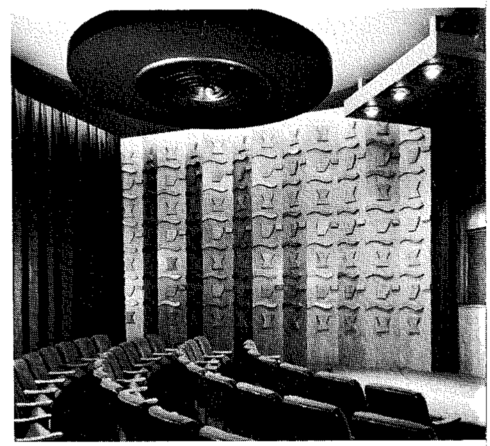


Fig. 11—The RCA Little Theater, Building 2-1, Camden, N. J.

Fig. 12 — The Johnny Victor Theater, RCA Exhibit Building, New York City.

the company such as the Little Theater (Fig. 11) in Building 2-1, Camden, N. J., the Johnny Victor Theater (Fig. 12) in the RCA Exhibit Building in New York City, record test booths for the Record Dept., RCA Victor Recording Studios in New York, Chicago, Hollywood, Argentina, and Spain. A view of the Little Theater in Fig. 11 shows how the acoustical diffusion and architectural-decor requirements were met in a unique and unusually attractive design.

NEW SURVEYS AND SUBJECTIVE TESTS

In almost any engineering survey work, one of the problems is getting accurate and sufficient information to make a proper analysis. In the case of room acoustic analysis, it is essential that the consulting engineer be furnished with up-to-date architectural drawings showing the floor plan, longitudinal and transverse sections as well as the specifications on the finish and construction of all interior surfaces and furnishings of the room. In addition, in the case of structures already completed, it is always helpful to have photographs, preferably stereoscopic slides, taken from different vantage points such as the last row of seats in the balcony, the front row at the sides, and from the stage at the center line of the auditorium.

Room acoustic design is as much an art as it is a science and, therefore, usually depends more on subjective listening tests than on quantitative physical tests. This situation, the acoustic engineer will tell you, arises not from any complexity of the theory but from the general problem of making objective measurements. Particular difficulty is experienced indoors, where a multiplicity of reflective wave patterns arise. These vary in length from the very large to the very small relative to the dimensions of the objects and surfaces in the room.

As long as RCA continues in the sound and picture business, and people have ears to hear and eyes to see, there will be a need for the company to provide auxiliary engineering consulting services such as described herein.

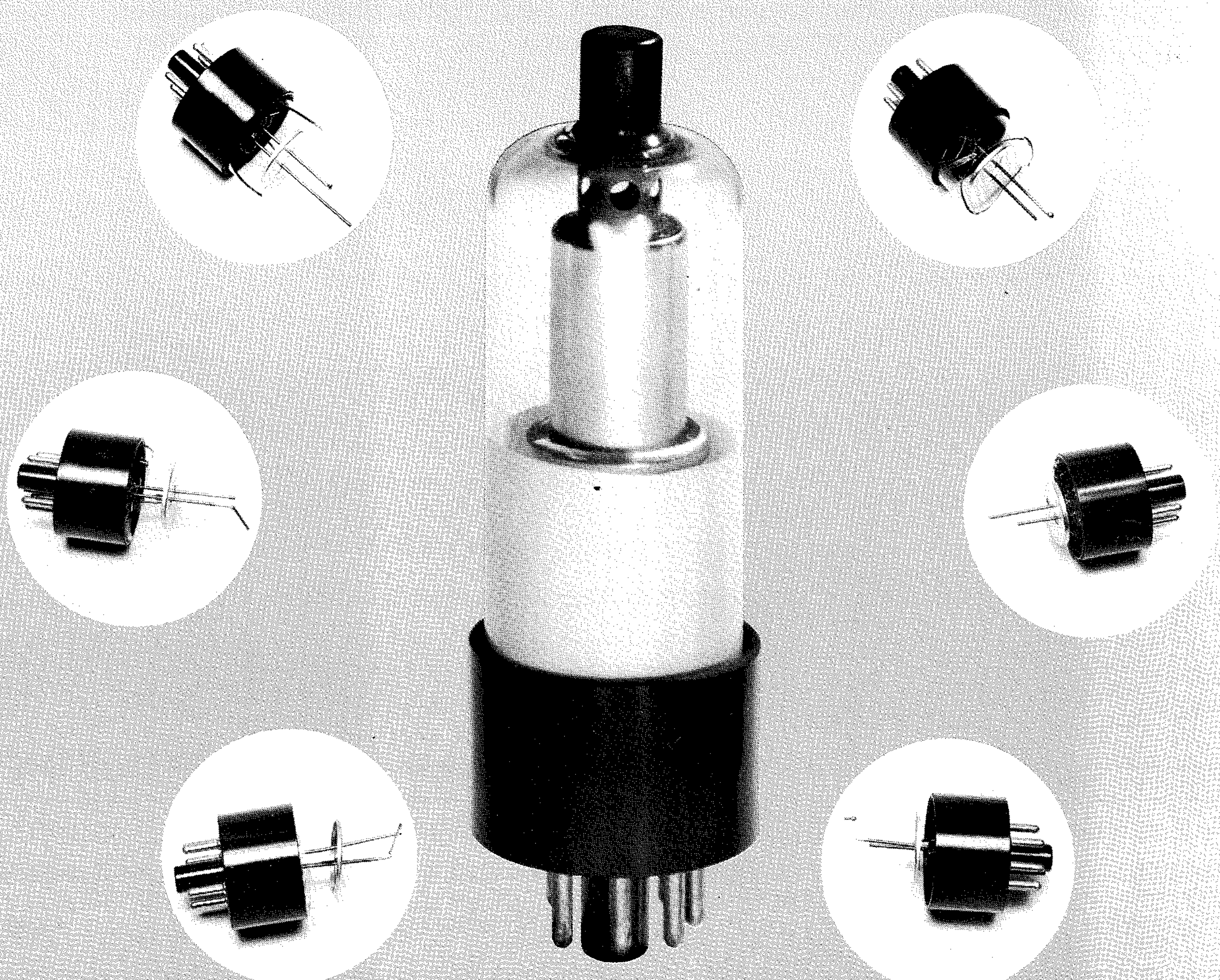
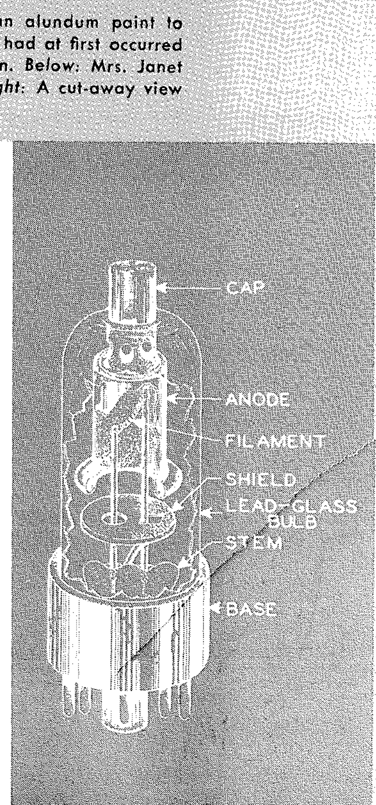


Fig. 1—*Above:* "White banded" 1B3-GT, which had its glass bulb protected with an alundum paint to reduce the number of "melted-lead", or open-filament, failures which had at first occurred during high-voltage life tests. Typical failures of this sort are shown. *Below:* Mrs. Janet Deckert, the author, examines some of the defective tubes. *Below, Right:* A cut-away view of the 1B3-GT.

JANET DECKERT received the B.S. degree in Electrical Engineering from Swarthmore College in 1942. She joined the Electron Tube Division of RCA in Harrison, N. J. the same year, and has since worked in Harrison and Woodbridge as a factory type engineer on receiving tubes designed for use as horizontal-deflection amplifiers, dampers, or high-voltage rectifiers in deflection circuits of television receivers. She is presently Manager of Glass Tube Engineering at the Woodbridge plant. Mrs. Deckert is a registered Professional Engineer in the State of New Jersey and a member of the Society of Women Engineers.



TUBE TYPE 1B3-GT, AN ENGINEERING CHALLENGE

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Glass Tube Production Engineering
Electron Tube Division
Woodbridge, New Jersey

OVER THE PAST 12 years, the rapid design changes in television sets have imposed many new requirements on the individual tubes used in the key circuits. During this period many unusual problems were encountered in the manufacture of one particular type, the 1B3-GT high-voltage vacuum rectifier tube, because of the increasing demands of circuit designers. Fig. 1 shows the white-banded 1B3-GT, and samples of one kind of failure—"melted-lead," or open-filament—that was encountered, and which will be discussed later.

This article describes how RCA's production engineers solved these problems, and explains some of the unique physical characteristics that were associated with the 1B3-GT during its development, such as the white-banded 1B3-GT, the red-etched tube (of 1955 to 1958), and the "shorty" 1G3-GT/1B3-GT).

ORIGINAL DESIGN (1946)

The 1B3-GT was first announced by RCA early in 1946. The original tube was designed to handle a peak inverse plate voltage of approximately 25 kilovolts for use in the small-screen television receivers then being produced. Because of the high-voltage requirement, this type represented an important new step for receiving-tube manufacturers. Hitherto, high-voltage rectifiers were produced in relatively small quantities and were available at a cost not practical for entertainment application. The only serious problems encountered on early production runs of the 1B3-GT were cracked bulbs and broken filaments. Both of these problems were the result of factory processing procedures and arose primarily because receiving-tube manufacturing was pioneering in a new field.

During factory processing of these early tubes, the plate assembly was first sealed into the bulb, the bulb assembly was accurately spaced with reference to the glass stem which holds the filament, and then the two parts of the tube were joined on a glass sealing-and-exhaust machine equipped with a special type of bulb holder. This machine also degassed the parts and pumped the tubes to a very good vacuum (Fig. 2).

Glass failures often occurred because the differences in the temperature coefficients of expansion between the plate cap (a chrome-iron alloy) and the bulb (a lime glass) resulted in compression stresses on the outside bulb surface and tension stresses on the inside bulb surface. Seal stresses were further increased during the radio-frequency degassing of the plate in the exhaust processing of the tubes. In the early days, factory rejects and field replacements due to plate-seal cracks averaged almost 10 percent of the total tube production.

Filament failure of the early tubes was traced to a brittle condition of the tungsten filament wire caused by overheating. The overheating apparently occurred when the wire, which was only 0.0012 inch in diameter, was welded to the 0.040-inch nickel support rods. A satisfactory solution to this problem was to use nickel-plated iron instead of nickel for the support rods and to employ a capacitor-timer welder. The weld was thus made in a shorter time and less heat was conducted to the filament.

Another disadvantage of the early 1B3-GT was the occurrence of glass electrolysis in two areas. The electrolysis was discovered by factory engineers during the analysis of tubes that had been operated at peak inverse plate voltages of either 25 or 30 kilovolts for 500 hours or more. The areas involved were at the plate-cap seal and the bulb wall opposite the gap between the plate and the shield. After a number of tubes were examined, it was noticed that the electrolysis was always greatest in the bulb area that contained the tube identification etch. Because tube etches are made with an ink having a large percentage of silver, it was theorized that this etch lowered the resistance of the glass between the plate connection and the base. Consequently, in 1947, the tube identification etch was removed from the glass envelope and only a base brand was used to identify the tube.

GREEN OXIDE AND ELECTROLYSIS

As part of an over-all cost-reduction program in 1949, a radical change was made in the construction of the 1B3-GT, and an improved sealing machine was used for joining the plate assembly to the bulb. The new tube structure had a 4-lead pressed stem in place of the original 8-lead, 1-inch button stem. The filament was welded directly to the two stem leads centrally located in the pressed stem on each side of the exhaust tubulation; consequently, the two filament support bars were eliminated. The new plate-sealing machine had 24 sealing heads, as compared with 8 heads on the sealing machine previously used, and more than tripled the number of assemblies that could be produced in an hour.

When the new sealing machine was first put into use, the number of tube failures due to glass electrolysis increased during the required 500-hour life test. Investigation showed that the glass electrolysis had increased in the area of the plate-cap seal. Milton Jones, an experienced glass technician, observed that the burner over the bulb at the main "punch-out" position on the 24-head sealing machine was accumulating a large deposit of green oxide which was apparently of the same chemical composition as the green chrome-iron oxide of the plate cap, while the corresponding burner on the 8-head machine had no such deposit (Fig. 3). Investigation showed that the air pressure necessary to blow the hole in the bulb dome on the 24-head sealing machine was more than double the air pressure on the 8-head sealing machine. (This difference was related to the speeds of the machines: on the 8-head sealing machine the bulbs are in each position about 7 seconds, while on the 24-head sealing machine they are in each position only 3 seconds). The green deposit on the burner, therefore, was an indication that the air pressure of the new machine was sufficient to dislodge some of the green chrome iron oxide from the plate cap and to deposit it on the glass-bulb surface as well as on the burner. Such bulb deposits could be the cause of the increase of electrolysis failures. Spe-

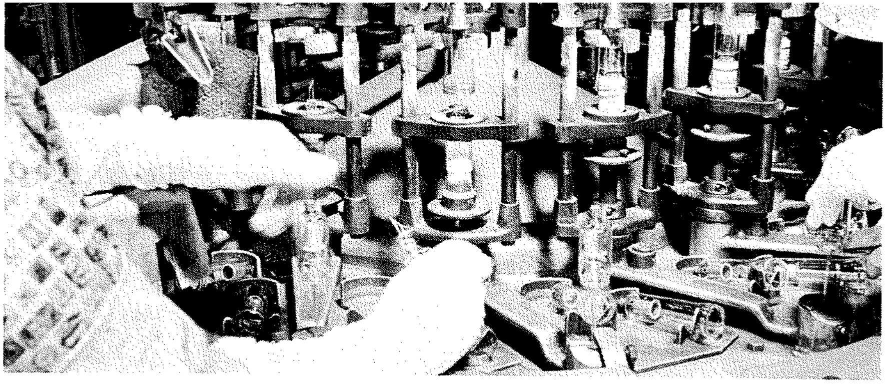


Fig. 2—The glass-sealing-and-exhaust machine.

cial tubes using plate caps having a hard gray oxide surface rather than the green chrome-iron oxide surface were sealed and life-tested successfully. As a result, changes in oxide texture and air pressure were made, and again glass electrolysis was under control.

X-RAY STUDIES

Following a request from the Harrison Safety Committee to analyze the 1B3-GT for X-ray radiation, tubes were studied for radiation during the high-voltage aging step called "40-kilovolt spot-knocking". The experimental setup which was developed for these tests consisted of a lead slab about 6 inches square and 1/8 inch thick having 9 small holes drilled through it, plus a holder for a 10-inch-square piece of X-ray film. Because the lead slab stopped most of the X-rays, the photographic pattern made by the X-rays transmitted through the 9 holes permitted an estimate of the intensity of the X-rays. It was also possible, by drawing threads from the X-ray prints on the photograph through the holes to the tube, to pinpoint the source of the X-rays quite accurately. X-ray photographs of about 10 different 1B3-GT structures indicated sufficient X-ray intensity to require tube modifications.

Further tests indicated that X-ray radiation could be reduced by replacing the standard lime-glass bulb with a lead-glass bulb and by minimizing the number of metal points on the stem shield and getter subassembly. These X-ray tests, together with the increased resistivity of lead glass to electrolysis, led to the exclusive use of the lead-glass bulb early in 1951. Life tests comparing the two types of bulb glass showed that the lead glass tube was able to operate for 2000 hours without excessive signs of the electrolysis which was so prevalent on the lime-glass tubes before 1000 hours of operation.

The X-ray tests also led to significant changes in the tube structure; namely, the elimination of the mica, the use of a new flatter stem shield, and the removal of two stem leads, all on the basis that a simpler tube structure would result in fewer possible sources of X-ray radiation. (See cutaway view in Fig. 1.) In addition, the elimination of the mica brought about an unexpected improvement in the emission level of the tubes after 500 hours of operation.

THE WHITE-BANDED 1B3-GT

In 1951, when the size of picture-tube screens increased from 7 and 12 inches to 17 and 21 inches, the high-voltage requirements of the television set manufacturers rose accordingly. Consequently, the life-test voltages of the 1B3-GT were raised from 30 to 35 kilovolts. During life testing at these higher voltages, however, a number of "melted-lead" or open-filament failures were encountered. These are shown in Fig. 1.

Numerous theories were advanced as to the cause of these "melted-lead" failures, including gas arcs, reverse emission, and field emission. The production engineers suspected that gas was a part of the problem, and substantiated this theory by showing that "hot spots" were forming on the bulb surface at the 35-kilovolt life-test operating voltage. It was thought that gases were being liberated by the bulb wall at these "hot spots." In an effort to suppress the evolution of gas, the glass bulb was protected with an alundum paint, and, in April 1952, RCA brought out the "white-banded" 1B3-GT (pictured in Fig. 1). This banded tube reduced the number of "melted-lead" failures to a level sufficient to satisfy the 500-hour life-test requirements.

The coated bulb had one major drawback, however. The sodium silicate binder used as an adhering agent for the alundum chemically attacked the glass and caused it to become brittle and very susceptible to damage due to impact. The white band, although distinctive and attractive, was not destined to remain with the 1B3-GT.

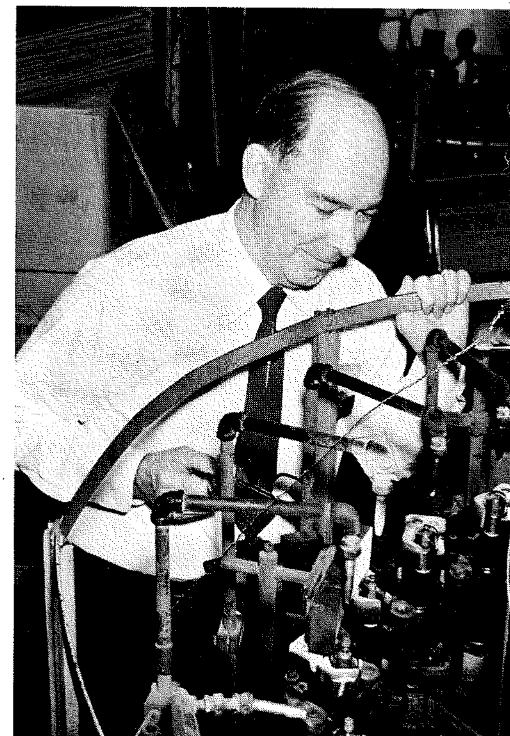
H_2 FIRING AND THE "RED ETCH"

By March 1953, a completely new process, the firing of the glass bulb at a temperature of 300° C for 10 minutes in a hydrogen atmosphere, was being evaluated (Fig. 4). This process leads to the formation of a monomolecular layer of lead hydride on the glass-bulb surface which reduces its electrical resistance. It has been proven that lower glass resistivity helps to prevent excessive "charging-up" on the surface of the glass, i.e., the formation of "hot spots" on the bulb wall during high-voltage operation.

From a production viewpoint, the H_2 firing process offered many other advantages, such as:

1. Reduction of factory shrinkage due to broken bulbs and the electrical characteristics of emission and breakdown.
2. Reduction of factory bulb costs compared with the expensive white-banded bulb.
3. Elimination of the field problem of impact cracks in the white-band area.
4. Improvement of the life-test results at the 35-kilovolt life-test operating voltage.

The new H_2-fired 1B3-GT was well re-



ceived in the field. To distinguish fired from unfired bulbs, however, the factory used a special nonmetallic etching ink that turned red during the H_2 firing. This red etch, which was used merely to facilitate factory identification of fired bulbs was interpreted by some customers to indicate danger.

RECENT MANUFACTURING CHANGES

A program designed to evaluate each part of the 1B3-GT and each process during its manufacture was recently undertaken in an effort to eliminate completely the "melted-lead" filament failures which were still occasionally found in the tube after 300 hours of life operation. The Woodbridge factory engineer, Dr. Chin Jung Cheng, enlisted the aid of the Harrison Equipment Development engineers and their high-speed motion-picture camera (see RCA ENGINEER, April-May 1958) in his study of these filament failures. Special tubes, in which holes were drilled through the plate so the filament could be viewed, were operated at higher-than-normal filament and peak-inverse plate voltages to induce "melted-lead" failures. At the moment any arcing or excessive heat was visible in these tubes, the high-speed motion-picture camera was triggered and the heat producing action was recorded on film.

The films clearly showed the mechanism of the "melted-lead" filament failures. First, the filament would vibrate and loosen particles of its barium coating. These particles in turn were pulled to the plate by electrostatic force. Next, these particles would become white hot due to the forward electron bombardment and would emit electrons. The filament support rods, which acted as the collecting point for this reverse emission flow, would become red hot and eventually melt. As a result of the film analysis, an improved filament was developed for the 1B3-GT which possesses greater resiliency and thus reduces filament vibration during high-voltage operation, and has a coating which is very adherent to the filament wire and has no tendency to flake off barium particles.

Glass quality has also been improved in recent years. Closer tolerances have been placed on purchased glass bulbs and stem tubing with regard to temperature coefficient of expansion. Physical dimensions have been standardized, and bulbs are carefully inspected for cleanliness. At the plate sealing machine, controls for dome strain viewed both axially through the bulb top and vertically at the cap, have been initiated and are held to very tight limits.

Recently, 1B3-GT factory processing has also changed. New aids at mounting permit rapid and accurate assembly (Fig. 6). Also, the finishing operations of low-voltage aging, high-voltage spot-knocking, and factory testing have been combined in one automatic machine (Fig. 5).

THE 1B3-GT SHORT VERSION

No history of the 1B3-GT would be complete with a few words about the "shorty" type 1G3-GT/1B3-GT. This tube is identical to the 1B3-GT in basic design and electrical characteristics, but it has a maximum seated height of only 3 inches. This shorter structure is obtained as follows:

1. The plate is 1/8 inch shorter.
2. The stem shield is welded 5.7 millimeters lower, i.e., at the top of the glass stem press.
3. The gap between the shield and the bottom of the plate is reduced by 2 millimeters.

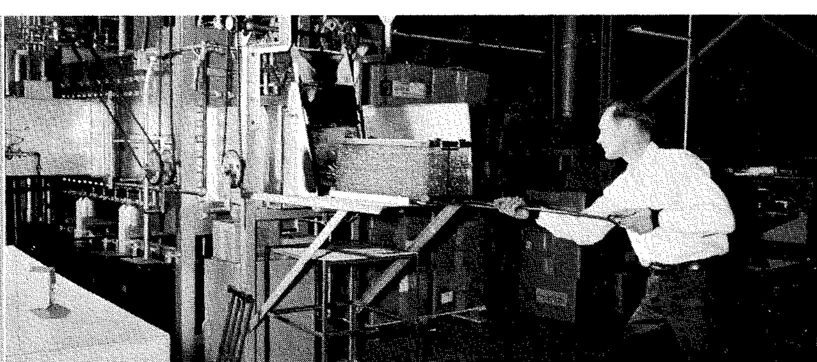
Because of the smaller structure, however, the 1G3-GT/1B3-GT is more susceptible to high-voltage arcing, and added precautions in processing are required. These precautions include a 35-kilovolt d-c spot-knocking instead of the r-f 40-kilovolt spot-knocking used on the 1B3-GT, and an operation check at a peak d-c plate voltage of 18 kilovolts.

THE FUTURE 1B3-GT

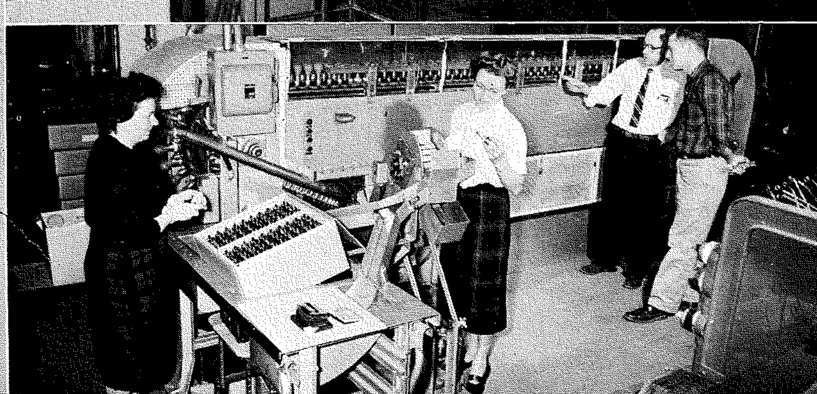
The present 1B3-GT has received wide acceptance because of its high quality and trouble-free performance in TV sets. If television sets continue to change in future years, however, so will the individual tubes used in the key circuits. Factory engineers are already evaluating innovations which might further improve 1B3-GT and 1G3-GT/1B3-GT tubes. The "white-banded" and the "red-etched" versions have been exciting chapters in the history of the 1B3-GT, but future developments on this type may offer a challenge which will be even more exciting and rewarding.

. 3—M. Jones observes the in "punch-out" position on the head sealing machine.

. 4—M. McCarthy, furnace hnician, loading 1B3-GT glass lbs into the hydrogen firing nace.



. 5—Automatic machine for finishing operations of low-tage aging, high-voltage spot ocking, and factory testing. t to right: Mrs. Teresa Maul, chine operator; Mrs. Janet ckert; F. Dunne, foreman; and Fagan, technician.



g. 6—Mrs. Ruth Hoffman, pervisor, observes Miss Cathne Deckus performing one of improved mounting operans.

PIEZOELECTRIC TRANSDUCER CIRCUIT ANALYSIS

by **J. M. FORMAN**
Electron Tube Division
Lancaster, Pa.

Because of their high-frequency response, piezoelectric transducers have been widely used to measure shock and vibration conditions. The performance of a piezoelectric transducer, however, depends to a large degree on the characteristics of its associated equipment. Such equipment must be selected properly to assure accurate reproduction of the quantity that the transducer is sensing. The electrical measuring equipment must provide wide linear frequency response, ample signal amplification, essentially zero phase shift, and wide-band coupling between high and low impedances. A basic understanding of the electrical performance of piezoelectric accelerometers is necessary for evaluation of system limitations.

Equivalent-circuit techniques provide a means for analyzing the behavior of piezoelectric elements. Fig. 1 shows the generally accepted equivalent electrical circuit for a quartz crystal. A typical curve of output voltage as a function of frequency for this circuit is shown in Fig. 2. This response curve shows the occurrence of two resonant conditions, parallel resonance and series resonance. The parallel resonant or anti-resonant frequency (f_p) is somewhat higher than the series resonant frequency (f_r), depending upon the value of the output capacitor C_o.

The complexity of the type of network shown in Fig. 1 makes circuit analysis difficult. At audio frequencies, however, the series combination, L,C,R, is essentially an open circuit compared to the capacitor C_o. The equivalent circuit of a piezoelectric transducer, therefore, can be represented by the simplified diagram shown in Fig. 3.

The transducer is represented by a constant-voltage generator, e_g, in series with its internal capacitance, C_a. Shielded cable, having a capacitance C_c, connects the accelerometer output to the high input resistance of a cathode-follower (or equivalent amplifier) circuit represented by R_L. An external shunting capacitor, C_s, is frequently employed to attenuate the unusually high output from the crystal pickup prior to the cathode-follower input. This arrangement helps to avoid grid-current conduction and overloading of the cathode-follower stage.

The symbols used in Fig. 3 may be defined as follows:

e_g = transducer voltage output
C_a = capacitance of accelerometer
C_c = shunting capacitance of cable
C_s = auxiliary shunting capacitance
R_L = resistance shunting accelerometer due to input resistance of cathode follower and leakage resistance of accelerometer and cable
e_o = voltage input to cathode follower
i_1, i_2 and i_3 = individual branch currents
i_t = total accelerometer current
e_{c_a}, e_{R_L}, e_{c_c} *and* e_{c_s} = voltages across respective components in network

From the electrical synthesis of the network shown in Fig. 3, the following relations can be shown:

$$i_1 = \frac{e_o}{X_{c_c}} \qquad i_2 = \frac{e_o}{X_{c_s}}$$

$$i_3 = \frac{e_o}{R_L} \qquad i_t = \frac{e_{c_a}}{X_{c_a}}$$

where X_{c_c}, X_{c_s}, and X_{c_a} are the react-

Fig. 1—Equivalent electrical circuit for a quartz crystal.

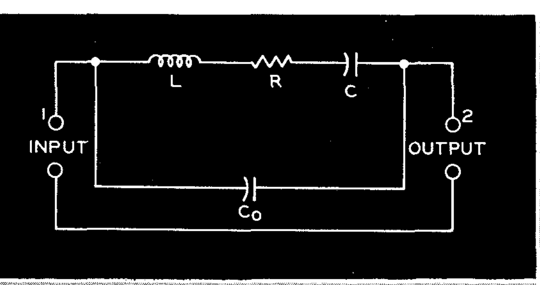


Fig. 2—Response curve for circuit shown in Fig. 1.

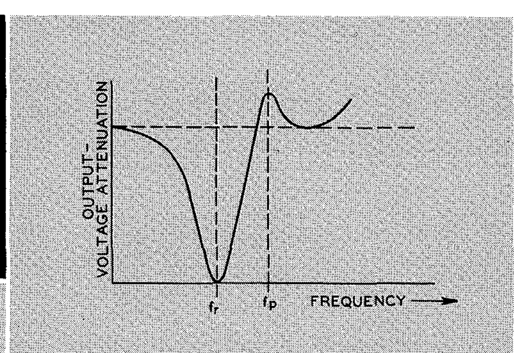
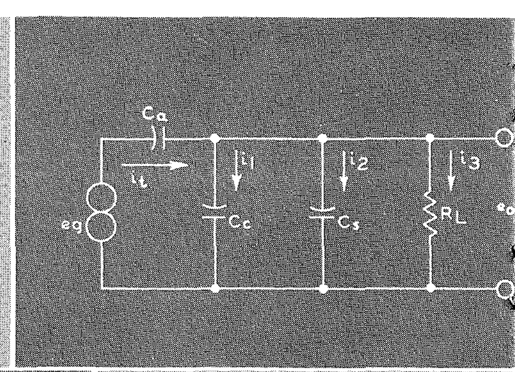


Fig. 3—Equivalent electrical circuit for a piezoelectric system.



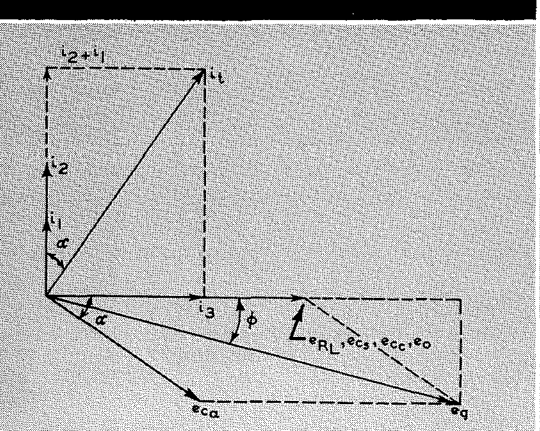


Fig. 4—Vector diagram of voltage and current phase distribution in circuit shown in Fig. 3.

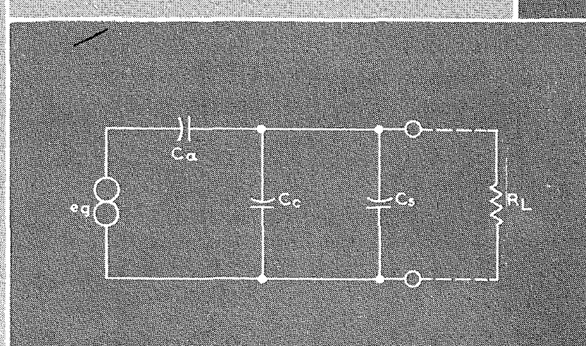


Fig. 5—Simplified form of circuit shown in Fig. 3.

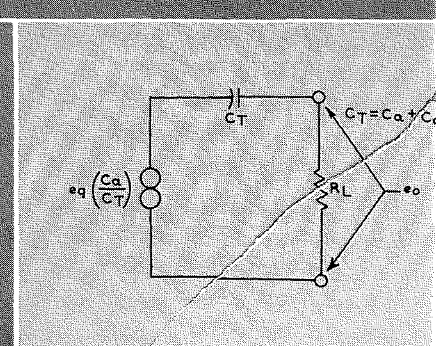


Fig. 6—Simplification of network shown in Fig. 5 by means of Thevenin's Theorem.

ances of capacitors C_c, C_s, and C_a, respectively.

A vector diagram of the voltage and current phase distribution is shown in Fig. 4. The phase equation can be developed from trigometric relationships, as follows:

$$\sin\,(90 - \alpha) = \cos\,\alpha = \frac{i_1 + i_2}{i_t}$$

$$\cos\,(90 - \alpha) = \sin\,\alpha = \frac{i_3}{i_t}$$

$$\tan\,\phi = \frac{e_{c_a}\,\sin\,\alpha}{e_o + e_{c_a}\,\cos\,\alpha}$$

$$\phi = \tan^{-1}\frac{e_{c_a}\,\sin\,\alpha}{e_o + e_{c_a}\,\cos\,\alpha}$$

The sine and cosine functions can then be replaced by previously established current relationships, as follows:

$$\phi = \tan^{-1}\frac{\dfrac{e_{c_a}\left(\dfrac{e_o}{R_L}\right)}{\dfrac{e_{c_a}}{X_{c_a}}}}{e_o + e_{c_a}\dfrac{\left[\dfrac{e_o}{X_{c_c}} + \dfrac{e_o}{X_{c_s}}\right]}{\dfrac{e_{c_a}}{X_{c_a}}}}$$

$$\phi = \tan^{-1}\frac{\dfrac{e_o X_{c_a}}{R_L}}{e_o + e_o\left[\dfrac{1}{X_{c_c}} + \dfrac{1}{X_{c_s}}\right]X_{c_a}}$$

$$\phi = \tan^{-1}\frac{\dfrac{X_{c_a}}{R_L}}{1 + X_{c_a}\left[\dfrac{1}{X_{c_c}} + \dfrac{1}{X_{c_s}}\right]}$$

$$\phi = \tan^{-1}\frac{\dfrac{\frac{1}{wc_a}}{R_L}}{1 + \dfrac{1}{wc_a}\left[\dfrac{1}{\frac{1}{wc_c}} + \dfrac{1}{\frac{1}{wc_s}}\right]}$$

When this equation is divided by $\frac{1}{wc_a}$, the following relationship is obtained:

$$\phi = \tan^{-1}\frac{\dfrac{1}{R_L}}{wc_a + wc_c + wc_s}$$

This relation can be simplified by factoring and transposition, as follows:

$$\phi = \tan^{-1}\frac{1}{wR_L\,(c_a + c_c + c_s)}$$

If the quantity $(C_a + C_c + C_s)$ is represented by C_T, then

$$\phi = \tan^{-1}\frac{1}{wR_L\,C_T} \qquad (1)$$

The phase angle ϕ between the voltages e_g and e_o represents the phase difference between the self-generated voltage output of the accelerometer and the voltage input to the cathode follower. Its value varies with frequency and is a function of the product of frequency and the time constant $R_L\,C_T$.

The circuit shown in Fig. 3 can now be simplified to the form shown in Fig. 5. This network can be further simplified by the application of Thevenim's Theorem to the form shown in Fig. 6.

The following relationship can be derived from an examination of the network shown in Fig. 6:

$$\left(\frac{R_L}{R_L + X_{c_T}}\right)\frac{C_a}{C_T}\,e_g = e_o$$

This relationship can be rearranged as follows:

$$\frac{e_o}{e_g} = \left(\frac{R_L}{R_L + X_{c_T}}\right)\frac{C_a}{C_T}$$

$$\frac{e_o}{e_g} = \frac{R_L\,C_a}{\left(R_L - \dfrac{j}{wC_T}\right)C_T}$$

$$\frac{e_o}{e_g} = \frac{C_a}{C_T}\left(\frac{R_L}{R_L - \dfrac{j}{wC_T}}\right)$$

$$\frac{e_o}{e_g} = \frac{C_a}{C_T}\left(\frac{1}{1 - j\,\dfrac{1}{wC_T\,R_L}}\right) \qquad (2)$$

$$e_o = e_g\left(\frac{C_a}{C_T}\right)\left[\frac{1}{1 - j\,\dfrac{1}{wC_T\,R_L}}\right] \qquad (3)$$

A general equation for equation (2) can then be written, as follows:

$$\frac{e_o}{e_g} = K\,\frac{1\,\angle 0^\circ}{A\,\angle\phi}$$

or

$$\frac{e_o}{e_g} = K\,\frac{1}{A}\angle 0^\circ - \phi^\circ$$

$$\frac{e_o}{e_g} = K^1\,\angle -\phi^\circ \qquad (4)$$

This equivalent-circuit analysis emphasizes the desirability of employing a high-input-impedance cathode follower (high R_L) to obtain a fairly flat frequency-response characteristic down to low frequencies. It is also desirable that the phase shift for the intended frequency range be essentially zero to permit the viewing of nonsinusoidal waveforms. If ϕ is not zero, the various frequency components of the output waveform will be displaced in time with respect to the input waveform. The phase angle ϕ in equation (1) can be made equal to zero even for low values of frequency if the $R_L\,C_T$ product is made infinitely large. The value of C_T can be readily increased by the addition of large values of shunting capacitance (C_s) across the accelerometer output. The ratio C_a/C_T in equation (2) predicts that this approach will reduce accelerometer sensitivity (defined by e_o/e_g) because the accelerometer capacitance (C_a), which usually ranges from 500 to 2000 micromicrofarads, is small compared to C_T.

The associated electronic measuring system, therefore, is equivalent to a high-pass filter having a low-frequency cut-off point determined by the $R\,C$ time constant of the high-input-impedance cathode follower and the total capacitance of the pickup system ($C_T = C_a + C_s + C_c$). Equation (2) indicates that if the phase angle is made equal to zero, signal attenuation can be accomplished by the use of a capacitive voltage-divider technique without degradation of the resolution of the electronic circuit. The voltage output will then decrease proportionally to the capacitance ratio.

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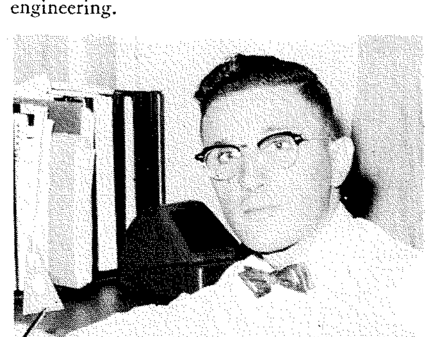
JULES M. FORMAN received the M.E. degree from Stevens Institute of Technology in 1940. He was a Teaching-Fellow at Stevens from 1940 to 1941 and attended Newark College of Engineering in 1942. He joined the life Test and Data Laboratory of the RCA Electron Tube Division in Lancaster, Pa. in 1941, and has since worked on the design of complex electro-mechanical electronic test sets, life-test equipments, and special applications of electronic circuitry for electron tubes. He became an engineering leader of Special Equipment Engineering in 1951. Since 1956 his activity has been directly responsible for environmental engineering testing and evaluation of all new and improved tube ruggedization developments in the Lancaster Engineering Laboratory. Mr. Forman is a member of the Institute of Radio Engineers and the Institute of Environmental Engineers, and holds a professional engineering license in the state of Pennsylvania in electrical engineering.



DESIGN ANALYSIS OF LUNAR TRAJECTORIES

by

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Engineering
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THE RECENT LUNAR PROBES indicate a certain level of understanding of the problem of predicting earth-moon trajectories for free falling bodies. These early attempts were all characterized by a lack of refinement in the control of the trajectory. The approach to the moon was planned in terms of thousands rather than a few hundred miles. However, this lies in the nature of the problem because of the accuracy required at launching, lack of knowledge of the gravitational field of the moon, and the information needed for any corrections in flight near the moon.

The plans for establishing a satellite around the moon, revealed at the time of the earliest probes, were based on a rocket included in the payload for retro-firing at an appropriate point to enable the moon to capture the satellite. However, no precise control was planned.

The general problem of earth-moon trajectories is fairly well understood, and there are several treatments of the subject in the literature. Most of these make approximations which would be violated in an actual flight, but which give results suitable for design planning for lunar probes. For more accurate results the complete equations of motion with all the known perturbations can be integrated by a digital computer.

The trajectory analysis investigated in AEP has been directed toward deriving design data, and therefore, extreme accuracy has not been the aim of the studies. The work has been aimed at digital computer programs which will permit fairly rapid study of trajectories, but which will include the perturbing effects of the sun.

The design data needed falls into two classes, the first related to the inflight changes, the second related to the use of the trajectory characteristics for scientific missions. In the first class the main changes in the trajectory are those for control of perigee or closest approach to the moon, control of the time of return of circumlunar passes to the vicinity of the earth, control for establishing satellites around the moon, and for later probes, control of the point of impact on the moon.

The second class covers the trajectory data needed for stabilization of the lunar probe vehicle for the pointing of sensors and antennas.

DERIVATION OF BASIC EQUATIONS

The classical "many body problem" of physics has never been solved in closed form for the general case. The problem consists of determining the motion of each of n bodies, m_1, m_2, ---, m_n when each body attracts the other bodies by an inverse square law attraction, i.e.,

$$F_{i,j} = -K \frac{m_i m_j}{r^2_{i,j}} \qquad (1)$$

where, $F_{i,j}$ is the force of attraction, $r_{i,j}$ is the distance between the i^{th} and j^{th} bodies, and K is the universal gravitational constant. From Newton's second law of motion and D'Alembert's Principle we have

$$m_i a_i = \sum_j F_{i,j} \quad , \quad i \neq j \qquad (2)$$

Thus, the general equation of motion of the i^{th} body may be written as

$$m_i a_i = \sum_j -K \frac{m_i m_j}{r^2_{i,j}} \quad , \quad i \neq j \qquad (3)$$

Equation (3) is directly integrable when only two bodies are considered. This would correspond to, say, the motion of the moon about the earth (when all other bodies in the universe are neglected) or the motion of a satellite about a planet when the satellite is relatively close to the planet, and the forces of attraction of the other bodies in the universe can be neglected. Thus, in the case of two bodies the problem can be solved in closed form, the results of the solution yielding the orbits of the two bodies. In the case of a space vehicle launched from the earth the orbital

Left to right, Spencer Spaulding, Bernard P. Miller and Edwin Walthall

SPENCER SPAULDING was graduated from Rensselaer Polytechnic Institute in 1947 with a B.S. degree in Physics and in 1950 with an M.S. in physics.

He joined RCA in 1950 as a member of the analytical group in Camden. While associated with this group his assignments included preliminary design studies on bombing and navigation systems, airborne fire-control systems, data handling systems, ground environments for defense missile systems, as well as specific analysis on problems in statistics, information theory, and operations analysis.

Since January, 1957, Mr. Spaulding has been assigned to the Astro-Electronic Products Division working in the area of studies related to advanced systems. Specific work performed includes proposals and feasibility studies of satellite communications systems, lunar surveillance and mapping systems, advanced reconnaissance systems (manned and unmanned) anti-missile defense systems, and damage assessment for a nuclear weapons system.

Mr. Spaulding is presently manager of the Advanced Projects Group.

BERNARD P. MILLER received the degree of B.S.A.E. from Pennsylvania State University in 1950, and accomplished post-graduate work in Aeronautical Engineering at the U.S. Air Force Institute of Technology in 1953-54. He is a member of the Institute of Aeronautical Sciences and is a Registered Professional Aeronautical Engineer. During 1950 he was employed by H. L. Yoh Co., Philadelphia, Pa. where he worked in the structural design and analysis of fin stabilized projectiles. From 1950 to 1953 he was assigned to the Aircraft Laboratory, Wright Air Development Center. During this period he participated in several air frame and component development programs, and served as project engineer on the development and flight testing of ordnance equipment for aerial emergency escape. Upon completion of his post-graduate work at the Air Force Institute of Technology in 1954, he joined the teaching staff of the Department of Marine Engineering, U.S. Naval Academy, Annapolis, Md., as an Instructor of Fluid Mechanics and Thermodynamics. In 1956 he was appointed Head of the Thermodynamics Group at the Department of Marine Engineering, USNA, and served in this capacity until joining the technical staff of AEP, RCA in 1957. Since joining RCA he has engaged in trajectory, propulsion, and over-all system analysis and synthesis on Project Janus and several recent studies and proposals on lunar vehicle systems.

EDWIN WALTHALL received his B.S. degree in Physics from the University of Richmond in June, 1949. He has since done post-graduate study in Physics at the University of Maryland on a part-time basis from 1949-1955. At the present time he is enrolled in the graduate school of Temple University pursuing graduate courses in Physics to complete course requirements for the Ph.D. degree.

Mr. Walthall was employed by the U.S. Naval Ordnance Laboratory as a physicist in June, 1949, and served as a member of the Explosion Effects Division of the Explosives Department until February, 1956. The major portion of his work during this time was in the field of Explosion Physics dealing primarily wth Nuclear Detonations.

He was employed by the RCA Service Company in February, 1956 as an engineer in the Planning and Analysis Section at the Missile Test Center, Patrick Air Force Base, Florida. His primary duties were concerned with the development and analysis of range instrumentation systems. In August, 1956, he transferred to the Defense Electronic Products Division of RCA at Camden, New Jersey, where he was assigned to an advanced engineering development analysis group. In March, 1958, he transferred to the Astro-Electronic Products Division of RCA. He has more recently done analysis work on the AICBM, and several satellite projects.

motion may be an ellipse, parabola or hyperbola depending upon its final velocity and position. If the orbit is a parabola or hyperbola, then the vehicle will leave the earth's gravitational influence going on to infinity or until it becomes trapped in the gravitational influence of another body of the universe such as the sun.

In the general case of lunar trajectories, at least three bodies must be considered, namely, the earth, the moon, and the vehicle and possibly a fourth, the sun. This problem has not been solved in closed form, and must be attacked by some method of approximation. The general equations of motion, considering the four bodies are:

$$m_1\ddot{x}_1 = -K\left[\frac{m_1m_2\,(x_1 - x_2)}{r^3_{1,2}} + \frac{m_1m_3\,(x_1 - x_3)}{r^3_{1,3}} + \frac{m_1m_4\,(x_1 - x_4)}{r^3_{1,4}}\right] \quad (4)$$

$$m_1\ddot{y}_1 = -K\left[\frac{m_1m_2\,(y_1 - y_2)}{r^3_{1,2}} + \frac{m_1m_3\,(y_1 - y_3)}{r^3_{1,3}} + \frac{m_1m_4\,(y_1 - y_4)}{r^3_{1,4}}\right] \quad (5)$$

$$m_1\ddot{z}_1 = -K\left[\frac{m_1m_2\,(z_1 - z_2)}{r^3_{1,2}} + \frac{m_1m_3\,(z_1 - z_3)}{r^3_{1,3}} + \frac{m_1m_4\,(z_1 - z_4)}{r^3_{1,4}}\right] \quad (6)$$

where equations (4), (5), and (6) are the components of motion in the x, y, and z directions and the subscripts 1, 2, 3, and 4 refer to the vehicle, the earth, the moon, and the sun. The coordinate system used is an inertial system whose origin is located at the center of mass of the system (for this case it is approximately the center of the sun). The positions of the earth, sun and moon are functions of time as well as the position of the vehicle, but are known functions of time. Let us consider the magnitude of the terms on the right hand side of these equations. Obviously, when the vehicle is in the vicinity of one of the other three bodies, the term involving that body will be much greater than the other two and the vehicle is said to be under the influence of that body. The region which defines (to a good approximation) "in the vicinity of" can be represented by a sphere of radius

$$r_{inf} = R\left(\frac{m}{m_i}\right)^{2/5}$$

where R is the distance between m and m_i.[4]

One method of solving the three or four body problem would be to integrate numerically the equations of motion. However, this method requires a high speed computer and even then is a very lengthy procedure. In order to reduce the time involved in the calculations an approximate method may be used which assumes that when the vehicle is within the sphere of influence of a particular body the forces acting on the vehicle from the other bodies may be neglected. In this manner a first order trajectory may be determined in closed form. The first order trajectory is considered to be perturbed as a function of the neglected forces (perturbing forces). A step-by-step integration of the perturbing forces will then yield corrections to be applied to the unperturbed velocities and positions yielding a new unperturbed trajectory. The procedure may be repeated to obtain a trajectory of higher order accuracy if desired.

AEP'S METHOD OF ANALYSIS

The discussion in reference 1 indicates that the method used for deriving the results therein presented divided the trajectories into two regions. The re-

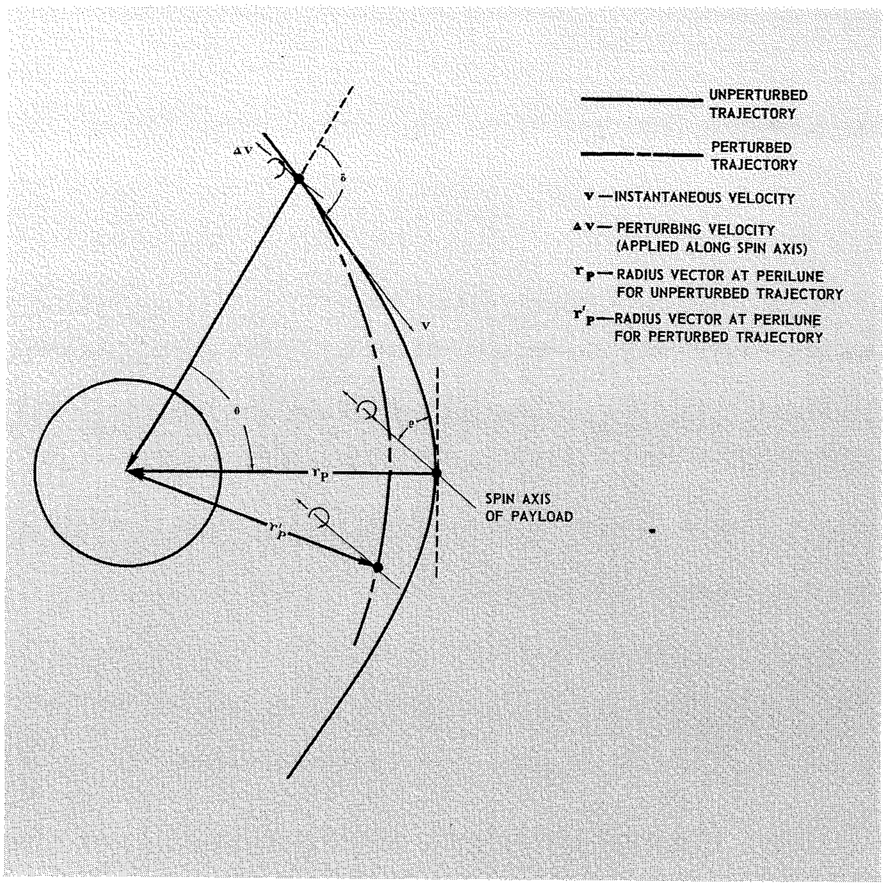

Fig. 1—Perilune control geometry.

gions were the spheres of activity of the earth and moon. In each region only the central field of the one body is considered to be acting.

The approach being pursued at AEP is a refinement on this basic approach. Near the earth the basic elliptical path is assumed as an unperturbed solution. The motion from one point to another is estimated on this basis. The second point is chosen to limit the travel time between points, and thus, the perturbative effects of the sun and moon. Adding the effects of the perturbations to the conditions existing at the second point will define a new ellipse, which is then used to proceed to a third point. This method allows large steps between points, but considers the perturbation effects. A similar procedure is used in the vicinity of the moon, using a hyperbola as the unperturbed path and the earth and sun as perturbating bodies. For a large region between the earth and the moon, straight line motion is assumed for the unperturbed path, and all three bodies are assumed to give rise to perturbations considered to be constant in any one interval. This speeds the calculations in this region.

Other calculations on the trajectory in the vicinity of the moon are being made to evaluate the effects of in-flight corrections made on the basis of lunar observations. For these calculations the effects of the earth and sun have been neglected. This study will permit the selection of trajectories suitable for missions in the neighborhood of the moon. The beginning of these trajectories can then be run backwards to earth using the above described method in order to determine launching conditions.

AN APPLICATION OF AEP'S APPROACH

The path described by a payload in the region of influence of the moon will essentially be a conic with one focus at the center of the lunar mass. The nature of the conic described will be dependent upon the magnitude and orientation of the payload velocity vector. However, the accomplishment of certain experiments near the surface of the moon is dependent upon the payload entering the potential field of the moon, traversing the surface of the moon within a specified altitude range, and subsequently departing the potential field of the moon and returning to the vicinity of the earth. For this case, the velocity in the vicinity of the moon is greater than the lunar escape velocity, and this segment of the trajectory with respect to the moon may be closely approximated by a hyperbola with its focus at the center of the lunar mass.

The launching velocity of approximately 35,000 fps required to achieve this category of circumlunar trajectories can be readily developed by combinations of existing rocket vehicles. However, the absence of sufficient velocity and angle control in the upper stages of these rocket vehicles may cause the trajectory of the payload to deviate from a specified altitude range in the vicinity of the moon. Consequently, in order to control the trajectory of the payload in the vicinity of the moon, it may be desirable to intentionally perturb the magnitude or orientation of the payload velocity vector. In a practical sense, this perturbation could be accomplished by the use of reaction devices such as gas jets or small rocket motors to impart the desired incremental velocity change to the payload.

The trajectory model used in the following analysis to demonstrate this principle is a simplified approximation to the actual system, and considers all motion to occur in an inverse square central force field. Therefore, in evaluating the sensitivity of the trajectory in the vicinity of the moon to velocity and angular perturbations, factors such as the oblateness of the moon, the gravitational attraction of the earth and the sun were neglected. It is apparent that the neglected factors will cause the actual perilunar altitude to differ from the values obtained by this simplified analysis, however, the general effects of the perturbations will not be altered by this approach.

The following basic expressions relating the properties of a conical trajectory are pertinent to the analysis of the effects of the perturbations (see Fig. 1):

$$r_p = \frac{P^2/A}{1+\epsilon} \qquad (8)$$

$$\epsilon^2 = 1 - \frac{P^2}{A^2}\left(\frac{2}{R} - \frac{V^2}{A}\right) \qquad (9)$$

$$P = rV \sin\gamma \qquad (10)$$

$$r = \frac{P^2/A}{1 + \epsilon \cos\theta} \qquad (11)$$

$$E = \frac{V^2}{2} - \frac{A}{r} \qquad (12)$$

The incremental change in perilunar radius may be expressed as:

$$\Delta r_p = \left(\frac{\partial r_p}{\partial \gamma}\right)\Delta\gamma + \left(\frac{\partial r_p}{\partial V}\right)\Delta V \qquad (13)$$

Thus, the change in the perilunar radius may be considered to consist of a contribution due to a velocity perturbation parallel to the velocity vector $\left[\left(\frac{\partial r_p}{\partial V}\right)\Delta V\right]$, and a contribution attributable to a velocity perturbation perpendicular to the velocity vector $\left[\left(\frac{\partial r_p}{\partial \gamma}\right)\Delta\gamma\right]$. If the velocity perturbation parallel to the undisturbed velocity vector is defined as: $\Delta V = u$, and the change in the orientation of the velocity vector due to a velocity perturbation perpendicular to the undisturbed velocity vector is defined as: $\Delta\gamma = u/v$, then the incremental change of the perilune may be expressed as a function of the sensitivity coefficients of the undisturbed trajectory and the incremental perturbation velocities:

$$\Delta\, r_p = \left(\frac{\partial r_p}{\partial \gamma}\right) u/v + \left(\frac{\partial r_p}{\partial V}\right) v \qquad (14)$$

By appropriate algebraic manipulation and differentiation of equations (8) through (12), the following expressions may be developed for the sensitivity coefficients $\left(\frac{\partial r_p}{\partial \gamma}\right)$ and $\left(\frac{\partial r_p}{\partial v}\right)$

$$\frac{\partial r_p}{\partial V} = \frac{2r_p}{V}\left\{\frac{[1 + Er_P/A] + r_pV^2/2A}{[1 + 2Er_p/A]}\right\} \qquad (15)$$

$$\frac{\partial r_p}{\partial \gamma} = -\frac{2r_p}{\tan\gamma}\left[\frac{1 + Er_p/A}{1 + 2Er_p/A}\right] \qquad (16)$$

The generalized problem of trajectory control in the vicinity of the moon has been parametrically analyzed using an IBM 650 digital computer. Typical of the results obtained in this numerical analysis is the effect of a velocity perturbation parallel to the undisturbed velocity vector on the perilunar altitude. Figure 2 depicts the variation of the sensitivity coefficient $\left(\frac{\partial r_p}{\partial V}\right)$ for an undisturbed trajectory that is defined by a perilunar altitude of *0* miles and a velocity at the perilune of 8888 fps. At a radial location of 15000 miles from the center of the moon the sensitivity of the selected trajectory to velocity perturbations parallel to the velocity vector may be determined to be:

$$\frac{\partial r_p}{\partial V} = 2.640 \times 10^3\, ft/fps$$

This result implies that a velocity perturbation of 200 fps. applied in a direction that is parallel to the undisturbed velocity vector at a radial location of 15000 miles from the center of the moon, is required to change the perilunar altitude of the selected trajectory to 100 miles above the surface of the moon. To achieve this change in the perilunar altitude with a representative type of solid-propellant reaction-propulsion system and 500-pound gross weight payload requires 14 pounds of consumable propellant.

Considering the additional weight of other elements of the propulsion system such as the thrust chamber and the structural mountings, it is felt that the desired change of 100 miles in perilunar altitude can be readily attained with a propulsion system weighing approximately 20 pounds for 500 pounds gross weight payload.

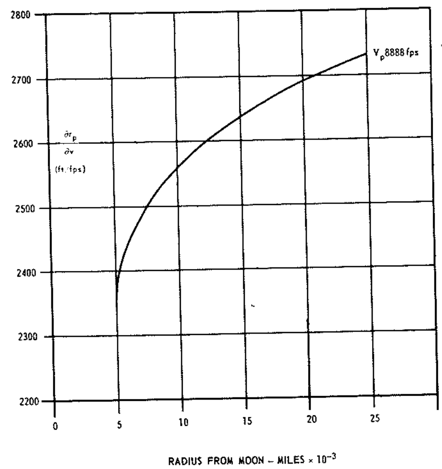

Fig. 2—Sensitivity of lunar perigee to velocity perturbations.

SUMMARY

There are, effectively, two classes of problems which require a study of lunar trajectories.

1. Problems involving the generation of data such as firing tables, require a high order of accuracy in the determination of lunar trajectories. Because of these requirements, the problem must be treated as a four-body problem, and even include second order perturbations (i.e., the oblateness of the earth, the uncertainty with which the mass of the moon is known, variation of the moon's orbit, etc.). This will mean a numerical solution of the equations of motion, and, regardless of the numerical method used, will require considerable time on a high speed digital computer.
2. Problems involving data such as used in design studies, although not requiring the determination of lunar trajectories to a high order of accuracy, will require a broad study of classes of trajectories and parameters to determine gross effects. In this respect, motion of a vehicle in cislunar space can be considered as a special case of the three body problem and in some instances as a special case of the two body problem.

The study of such parameters as general trajectory features, in flight control problems, and control of travel time are examples of the factors which can be economically studied by a simplified approach to the problem.

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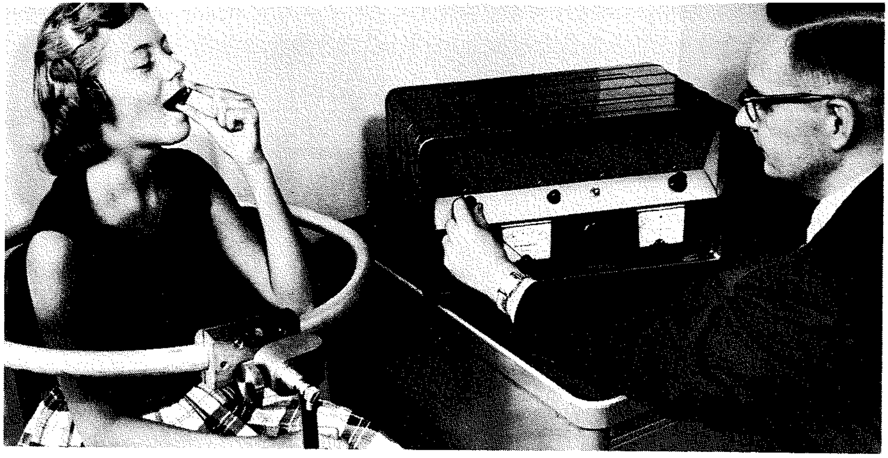
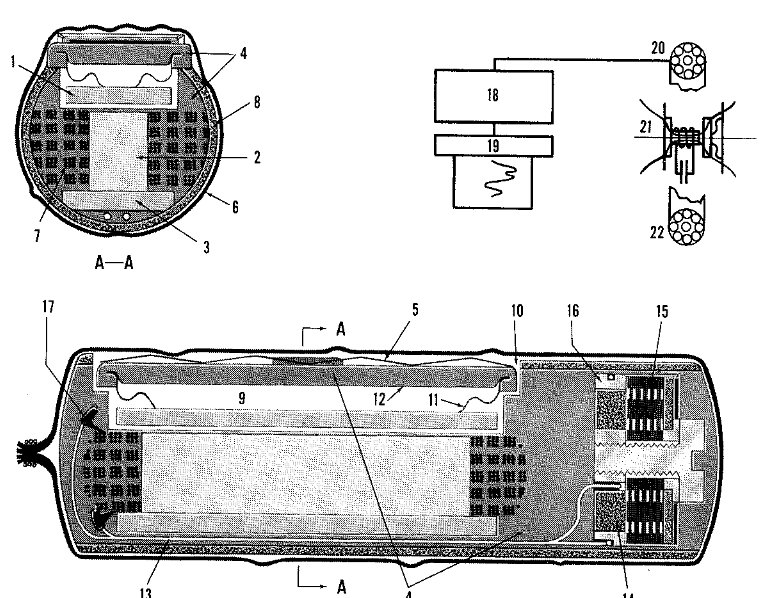


MEDICAL ELECTRONICS: THE PILL THAT "TALKS"

by **H. E. HAYNES and A. L. WITCHEY***

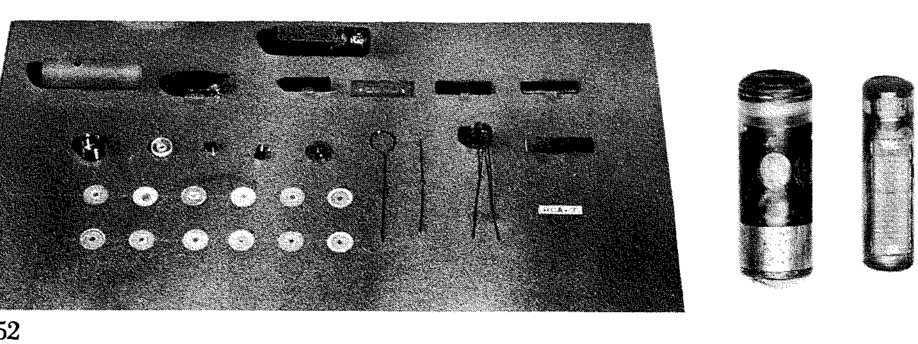
DEP, Camden, N. J.

Fig. 1—Top: administering the passive-pill. Bottom: Sectional view of the passive-pill; length 1", diameter 0.3", weight 2.8 grams.



1 Ferrite armature
2 Ferrite core
3 Ferrite pole piece
4 Scotchcast resin
5 Corrugated Mylar ribbon spring
6 Cylindrical rubber balloon
7 Litz wire core
8 Textolite tube
9 Sealed air cavity
10 Acoustical signal orifice
11 Movable Mylar diaphragm
12 Grounded Mylar diaphragm
13 Connecting wires
14 Textolite insulator
15 Silvered mica disks
16 Brass capacitor can
17 Solder connection
18 The r-f generating and receiving circuits
19 Recorder, time vs. pressure
20 Gaseous or liquid pressure
21 Flux lines
22 24" diam., circular, r-f signal-transmitting and -receiving loop

Fig. 2—Exploded layout of the passive-pill components. Inset: the new passive pill (right) shown alongside the original active radio pill, approximately actual size.



During 1956, Industrial Electronic Products (in cooperation with the Rockefeller Institute) developed the *Radio Pill* system—a new electronic aid to medical research. In use, the patient swallowed a thin, sealed rubber bag containing a cylindrical, plastic-covered pill 0.428 inches in diameter and 1⅛ inches long. No strings, wires, or tubes were attached. This pill contained a complete radio broadcasting station: microphone, transistorized transmitter, rechargeable cell, and antenna. Pressure variations throughout the patient's entire digestive tract were broadcast to a nearby external antenna and receiver and then recorded. Outputs from normal patients showed, for example, symmetrical sawtooth pressure variations with amplitudes of 1/20 atmosphere and repetition rates of eleven per minute caused by muscular contractions in digesting food. Two to six days were required for a pill to complete a journey through the body, and each pill may be used for numerous passages.

[Ed. Note: This system was described by the authors in "The Radio Pill," *The Syracuse Scanner* (IRE), Vol. II, No. 4, December, 1957.]

To avoid the problem of the 15-hour battery life in this transistorized *active* pressure pill, a second phase of the Radio Pill program was undertaken. This has culminated in a *passive* pill system, which requires no source of energy whatever inside the capsule and, moreover, provides a 50-percent reduction in pill volume.

THE PASSIVE SYSTEM

The pressure transducer itself is the same, in principle, as that of the active pill, i.e., a variable-reluctance inductor in a tuned circuit exhibiting a resonant frequency which is a function of pressure on the diaphragm. However, the construction of the pill as well as of the rest of the system is quite different. In the passive pill, the energy necessary to set up oscillating currents in the pill is imparted by inductive coupling from an outside circuit rather than from a battery inside the pill; thus there is no limitation on operating life.

* The work described here was performed while the authors were with IEP Engineering.

The pill itself contains only the inductor, with ferrite armature attached to the diaphragm, and a capacitor that completes the tuned circuit. In use, with an external coil encircling the patient, the pill coil can be considered the secondary of a very loosely coupled transformer of which the external coil is the primary.

Bursts of 400-kc current are supplied to the external coil at a 3-kc rate and are damped out quickly in the intervening intervals. During the bursts, the pill current builds up nearly to steady-state a-c value, and in the quiet periods of the primary current, the pill circuit continues to ring because of its high Q. The frequency of such a freely dying-out oscillation is exactly the natural resonant frequency of the circuit, independent of the frequency of the excitation that built up the energy during the burst. Thus, the excitation need only be near enough to the resonant frequency to impart sufficient energy for satisfactory signal strength.

In the interest of maximizing energy transfer between pill and coil, the pill Q had to be made as great as possible in the space available. This value proved to be about 120. Thus, the bandwidth at half-power points is 400 kc $\div$ 120 $=$ 3.33 kc. Therefore, the pill had to be designed to produce a frequency deviation of only this order of magnitude when subjected to full-scale pressure change, in order that it might receive enough excitation energy under all pressure conditions. A tuning adjustment in the exciter takes care of variations among normal-pressure resonant frequencies of individual pills.

While the oscillating current in the pill is dying down, the resultant magnetic field induces a voltage back into the external coil. This voltage is extremely small compared to the burst voltage (of the order of 100 db down); however, its frequency is an exact measure of the resonant frequency of the pill and, hence, is a measure of the pressure on the pill. By properly extricating this frequency information from the voltage appearing across the external coil, a signal representing pressure variations on the pill can be obtained.

PILL CONSTRUCTION

Figs. 1 and 2 illustrate the construction of the passive pill. The coil is flat, of 9/44 Litz wire, and roughly rectangular, with a ferrite core and a ferrite slab on each face. One slab is attached to the mylar diaphragm and is thus the active transducer element. The other slab is fixed in contact with the core, which adds more magnetic material, making the effective cross section of the coil greater and thereby increasing the coefficient of coupling to the large coil. The capacitor is specially fabricated, since no commercial unit of suitable electrical properties and the right size was available. It is of silvered-mica construction, consisting of approximately 12 disks, 0.250 inch in diameter, held together by a screw through the center that also holds the assembly in a cylindrical brass can about 0.100 inch long. After being adjusted to the value of capacitance required for resonating its mating coil at 400 kc (about 320 $\mu\mu$f), the unit is inserted in one end of the pill case and cast in resin. As mentioned previously, a high circuit Q, about 120, is obtained—essential for efficient energy transfer between the coils. To do this requires extreme care in filling all available space with copper, sealing the coil in a dry atmosphere, and several other expedients.

In operation, pressure variations are transmitted across the thin rubber bag whose acoustical transparency is insured by the presence of the corrugated–mylar–ribbon spring whose stiffness is small compared with both the mechanical stiffness of the rectangular corrugated movable mylar diaphragm and the acoustical stiffness of the sealed air cavity. The acoustic signal is then conducted through the acoustic orifices at either end of the moving system assembly and applied directly to the diaphragm, so that an excess pressure causes the movable ferrite slab to move away from the ferrite core. In view of the relatively slow pressure variations encountered in the diagnosis of gastro-intestinal disorders, the moving system was designed to undergo constant displacement when subjected to constant-pressure amplitudes from d-c to 60 cps, the resonant frequency of the system.

Even though the ambient temperature inside the patient is a very stable parameter, the fact that no means of pressure equalization exists between the sealed air cavity behind the diaphragm and the external atmosphere causes the exact position of the movable ferrite slab to be a function of temperature as well as pressure. This situation may be exploited advantageously in view of the desire to harness a compatible temperature-measuring facility. On the other hand, the installation of a controlled leak of suitable time constant would be quite feasible at the expense of a small added volume. The diaphragm for such a moving system must be made from a material which may be formed, is mechanically stable over a moderate temperature range, possesses a minimum inherent hysteresis, is airtight, is transparent to an r-f electromagnetic signal, and can be acoustically sealed to a cavity. Because of these considerations, a mylar diaphragm was selected and set in an epoxy resin casting. It is the resin casting itself which ultimately provides the sealed air cavity and the mechanical grounding for the diaphragm. All of the many methods short of this rather sophisticated endeavor failed to provide a lasting seal and a permanent clamping arrangement. The present scheme yields a separate moving system assembly which may be positioned and fastened to the main pill body by straight-forward cementing techniques.

EXTERNAL APPARATUS

The external coil is 24 inches in diameter, wound inside a gapped 1¼-inch aluminum tube for mechanical strength and electrostatic shielding. It has about 12 turns of Litz wire, equivalent to No. 24 solid wire. Its inductance is around 200 μh. Maximum coefficient of coupling to the pill is about 0.0015, with the pill on the axis and in the plane of the large coil and best oriented.

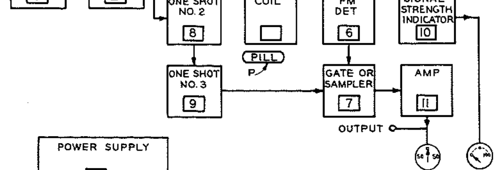


Fig. 3—Passive-pill pressure-telemetering system.

Fig. 3 illustrates the system operation in more detail. Blocking oscillator *1* supplies clock pulses at approximately 3,000 per second, the basic repetition rate of the send-receive operation. Mono-stable multivibrator *2* generates from this clock pulse the excitation burst interval of about 100 microseconds, and turns on the 400-kc oscillator *3* during the period. The r-f burst is amplified at *4* and applied to the large coil, at high level (80 volts peak-to-peak, representing about 2 volt-amperes rms.). Oscillator 3 is damped out quickly at the end of the burst interval, by the low forward biased resistance of the transistor shunted across the tank circuit, as is also the large coil. The latter is accomplished by a diode in series with a resistor connected across the large coil and its tuning capacitor. The diode is nonlinear, offering a low impedance to large currents and a high impedance to small currents; thus, the large burst current dies away quickly to a small value, but the coil current exhibits a moderate *Q* (about 20) for the small-amplitude signal received back from the pill. This *Q* value is a compromise between a large value desirable for high energy-coupling efficiency and a low value needed to cause the burst energy to dissipate to practically zero before the pill current has died down seriously, i.e., before the "echo" has died away.

Several stages of amplification and limiting are then applied to the coil voltage (block *5*). These act to build up the received signal to about as great a value as the excitation voltage during the burst, while continually clipping the burst voltage itself. After this process, the composite signal is applied to f-m defector *6*. The detector output consists basically of a d-c voltage changing (at the 3-kc rate) between a value representing the burst frequency, which is nominally constant, and a value representing the pill return frequency, which is varying with pressure.

The next step is to sample this waveform at those instants when it represents pill frequency, ignoring the rest of the wave. This is done by a transistor-switch *7* which simply connects the discriminator output to a storage capacitor at the desired time and disconnects it the rest of the time. Proper timing for the switch is obtained by two additional monostable circuits *8* and *9*. The first of these generates an interval beginning at the end of the burst pulse and ending enough later (about 80 microseconds) that the sending coil voltage has died down to substantially zero. At that time, the sampling can safely begin; unit *9* then generates the sampling pulse, which lasts for about 50 microseconds. This is the end of one cycle, and soon thereafter the next basic timing pulse from unit *1* occurs, initiating the next cycle.

The voltage across the sampler storage capacitor is the required output. Since sampling pulses occur at a 3-kc rate, the frequency response of the electrical system is more than ample for the system bandwidth required. (The theoretical limit in frequency response would be 1500 cps.).

Block *10* is a signal-strength indicator, consisting of an envelope detector followed by a bridge-rectifier and meter, which indicate the amplitude modulation of the signal as it appears at the output of the next-to-last stage of the amplifier-limiter. Zero modulation here would indicate complete limiting, i.e., that the return part of the signal had been brought up to full limiting. The meter does not read percent modulation as such, but is indicative of it. Any reading below about 70 indicates sufficient signal for good immunity to signal strength variation; however interfering noise may require a somewhat lower reading for satisfactory freedom from noise. This depends on the location in which the equipment is used. With the proper pill orientation, meter readings of 70 or less are possible when the pill is near the external coil axis and is located twelve inches or less from the plane of the external coil. Thus, for a fixed external-coil position, the region where the pill may satisfactorily telemeter local pressure conditions is defined by two 24-inch-diameter, 12-inch-altitude, base-to-base cones. Placing an object like a steel pocket knife directly beside the pill but off the pill's coil axis does not affect the system's operation. The external coil is readily movable to permit rough tracking of the pill in position and orientation. Suitably close working range and avoidance of nulls can thus be assured.

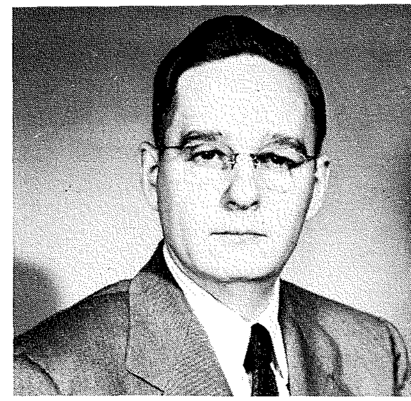
Block *11* is a cathode follower output stage followed by a two-stage R-C low-pass filter with an approximate cutoff frequency of 10 cps.

The photograph of Fig. 1 depicts the entire apparatus, including external coil, as it might be set up for use.

Experience With The System:

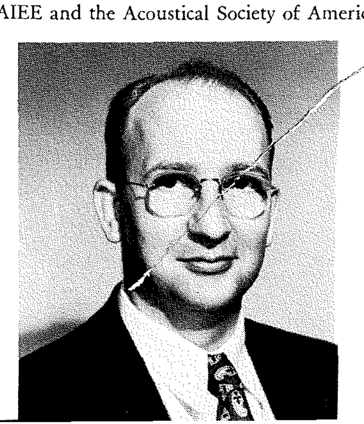
In the early part of 1959 the system equipment and five passive pills were delivered to the Veterans Administration Hospital in New York City for medical research and evaluation. To date the equipment has been used on several patients with apparent success. This work is jointly under the sponsorship of the Veterans Administration and the Rockefeller Institute.

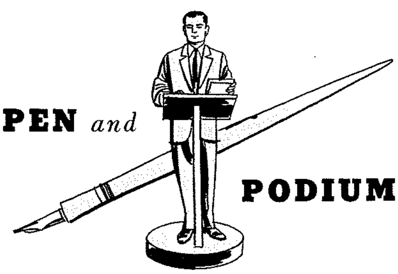
(Special credit is due Messrs. Juan Amodei and A. I. Aronson for valuable contributions in the circuit development.)



HAROLD E. HAYNES received the B.S. in E. E. from the University of Nebraska in 1939. After a brief period as instructor in electrical engineering at the South Dakota School of Mines, he joined RCA in 1940. He has been in DEP Development Engineering and its predecessor groups since that time, with the exception of the years 1957-58 in IEP Advanced Development, and at present has the position of Staff Engineer. His areas of technical activity have included sound recording, audio circuits, infrared detection systems, specialized electro-optical systems and analysis, industrial inspection systems, and bandwidth reduction coding. Mr. Haynes is a Senior Member of IRE, and is a member of the Optical Society of America and a Sigma Xi.

A. L. WITCHEY received a BSEE degree at the University of Colorado in 1944. He joined RCA at Indianapolis, and later did graduate work at the University of Pennsylvania. He has been engaged in acoustical development in IEP until 1959, when he joined the Surface Communications. Division of DEP. He is a member of AIEE and the Acoustical Society of America.





Based On Reports Received Over A Period of About Two Months

HOME INSTRUMENTS

Cherry Hill, N. J.

Tunnel Diode Radio Frequency Amplifier
H. B. Yin, E. Miller, and J. B. Schultz: Solid-State Circuits Conf., Feb. 10, 1960, Philadelphia, Pa. Presented the advantages and disadvantages of tunnel-diode r-f amplifiers and the design equations pertinent to this device, including power gain, bandwidth, and noise factor.

ELECTRON TUBE DIVISION

Harrison, N. J.

The Nuvistor Triode as an R-F Amplifier in TV Tuners
L. Baar: IRE/EIA Radio Fall Meeting, Syracuse, N. Y., Nov. 9-11. The advantages of the new small-signal Nuvistor triode for r-f amplifier service in UHF television tuners.

Jersey Engineers Steer Students Toward Science
R. E. Brown: New Jersey *IRE Newsletter*, Nov. 1959. The work of the New Jersey Engineers Committee for Student Guidance, a committee of the Engineer Council for Professional Development which offers its services to students considering engineering careers.

Seven-Transistor Pocket Radio
H. A. Wittlinger: *Radio-Electronics*, Nov., 1959. A vest-pocket, light-weight, seven-transistor radio which uses readily available components and has sensitivity and power output comparable with good commercial seven-transistor receivers.

Determining Screen-Grid Dissipation in 'Ultralinear' Amplifiers
L. Kaplan: *Audio*, Dec., 1959. A simplified method for determining screen-grid dissipation of beam power tubes in amplifiers using grid No. 2 feedback.

Lancaster, Pa.

The C-Stellarator, A New Research Tool for Hydrogen-Fusion Control Studies
L. B. Headrick: *Yale Scientific Magazine*, November, 1959. The Model C-Stellarator being built by C-Stellarator Associates (formed jointly by RCA and Allis Chalmers) for use in evaluating the conditions necessary to control the hydrogen-fusion reaction.

Luminescence—The Past and the Future
G. E. Crosby: Manhattan Section of Ceramic Society of America, Dec. 4, 1959. Brief theory and various types of luminescence, behavior of luminescent materials, and future possibilities of electroluminescence.

Princeton, N. J.

Electronic Countermeasures, The Art of Jamming
D. J. Blattner: *Electronics World*, December, 1959. The use of electronic countermeasures, the art of jamming or deceiving an enemy's radio and radar, from the beginning of World War I through recent developments.

SEMICONDUCTOR AND MATERIALS DIVISION

Somerville, N. J.

Impurity Segregation in Normally Solidified Gallium Arsenide
S. Skalski and P. Vohl: Battelle Institute Symposium on Semiconductor Compound Crystal Growing, November 4, 1959. Discusses the determination of segregation coefficients of impurities in undoped, normally solidified single crystals of gallium arsenide as revealed by Hall and resistivity measurements as a function of the fraction solidified.

A Portable AM/FM Receiver Using RCA Drift Transistors
R. A. Santilli, H. Thanos: IRE/EIA Radio Fall Meeting, Syracuse, N. Y., Nov. 9-11, 1959. Describes a nine-transistor AM/FM portable receiver designed to use newly developed RCA drift transistor in the tuner and i-f amplifier stages, including capabilities of the new drift transistors and circuit design considerations for the receivers.

Transistorized Automobile Receivers Employing Drift Transistors
R. A. Santilli, C. F. Wheatley: IRE/EIA Radio Fall Meeting, Syracuse, N. Y. Describes various five-stage transistor automobile receivers designed to use newly developed RCA drift transistors in the r-f, converter, and i-f stages.

The Reliability of Transistors in Battery Portable Radio Receivers
R. M. Cohen: IRE/EIA Radio Fall Meeting, Syracuse, N. Y., Nov. 9-11, 1959. Presents data on in-plant and field failure rates for transistors used in mass-produced battery portable radio receivers.

Infrared Studies of Birefringence in Silicon
S. Lederhandler: *Journal of Applied Physics*, Nov., 1959. Discusses the use of birefringent patterns in the study of permanent and elastic strains in silicon crystals grown by the Czochralski technique.

Needham, Mass.

A Thermoelectric Thermostat for X-Ray Diffraction
R. A. Horne, W. J. Croft, L. B. Smith: *Review of Scientific Instruments*, Dec., 1959. Describes a thermoelectric thermostat and associated circuit for use in temperature control of samples during X-Ray diffraction measurements.

Rectangular-Hysteresis-Loop Ferrites with Large Barkausen Steps
A. P. Greifer, W. J. Croft: *Journal of Applied Physics*, December, 1959. Describes the study of large discontinuities (steps) observed in the 60-cycle hysteresis loops of polycrystalline ferrites containing copper at low temperatures.

DEFENSE ELECTRONIC PRODUCTS

Camden, N. J.

Plasma Physics Applications in Electronics
R. E. Skinner: Second RCA Plasma Physics Symposium, Sept. 22, 1959. The theory and application of wave and plasma interaction, emphasizing propagation and microwave generation. Reviews current experimental program in plasma acceleration by M.H.D. forces.

Packing Design Basic Principles
J. L. Krager, Jr.: Awarded third prize Oct. 5, 1959, in the technical paper contest of the Southern Calif. Chapter of the Society of Packaging and Handling Engineers Education Committee in Los Angeles. Discusses the obligation, basic steps and problems involved in speedy and efficient delivery of electronic equipment.

Test Equipment Standardization
H. S. Ingraham, Jr.: Annual Electronic Engineering Representatives Show and Symposium in Philadelphia, Oct. 13, 1959. Program of Test Equipment Standardization in DEP.

Reliability of Electronic Parts
D. I. Troxel: Instrument Society of America, New Jersey Section, Newark, N. J. Nov. 10, 1959. Basic concepts and terminology applicable to electronic reliability and various factors that affect part reliability.

Low-Frequency Amplifiers
M. B. Herscher: Detroit IRE Transistor Lecture Series, Nov. 12, 1959. Application of transistors to low-frequency amplifiers, equivalent circuits, low and high-power amplifiers, operating point stabilization, and noise considerations.

The Specification of Component Part Reliability
D. I. Troxel: November 17, 1959 joint meeting of Philadelphia chapters of IRE-PGCP and PGRQC, AIEE, Science, Elect. & Inst. Div., and ASQC Elec. Div., University of Pa. Evaluation of parts specifications over the past fifteen years, including accounting of efforts in part specification area of the DOD Advisory Group on Reliability of Electronic Equipment and the current DOD Ad Hoc Study Group on Parts Specifications.

How A Publications Dept. Fits into an Organizational Structure
J. F. Biewener: New York Univ. and Society of Technical Writers and Editors Symposium, New York City December 4, 1959. The principal organizational needs of a publications department — proximity to sources of information, freedom of action, and stature.

The New Trend in Minified Communications Equipment
J. W. Knoll: IRE Professional Group on Vehicular Communications, St. Petersburg, Florida, Dec. 3, 4, 5, 1959. Micromodule building block and the current program status, particularly in the area of miniaturized communications equipment.

Component Part Reliability
M. P. Feyerherm: December 10th meeting of the Boston Chapter of IRE Professional Group on Reliability and Quality Control. Factors which affect reliability of electronic component parts and the problems involved in formulating numerical reliability data.

The Determination of R-F Intermodulation Levels
J. G. Arnold: *Electronics*, Nov. 27, 1959. Generation of r-f intermodulation products by transmitters operating in close proximity.

Practical Maintainability Numerics

M. P. Feyerherm and H. W. Kennedy, Jr.: Sixth Nat'l Symposium on Reliability and Quality Control in Electronics in Washington, D. C., January 13th, 1960. An approach to the derivation of numerics relating to the specific areas of corrective and preventive maintenance.

Servomechanism Fundamentals

N. Lauer, R. N. Lesnick, and L. E. Matson: This revised edition being prepared by McGraw-Hill for publication in January, 1960 includes an expanded portion on transfer function methods as applied to linear servos and a thorough treatment of nonlinear phenomena and analysis methods useful for nonlinear servos.

Resistor Reliability-Capability Analysis

B. R. Schwartz: Sixth Nat'l Symposium on Reliability and Quality Control, January, 1960. Discusses a method of using test data from single-environment military component part specifications for the analysis of reliability in terms of estimated drift characteristic for multi-environment electronic equipment.

A Temperature Compensated Current Driver

R. E. Atkins: Submitted as Master's thesis, Univ. of Penna., Feb., 1960. The compensated driver was developed for use with ferrite memory systems. It provides an output current which is directly proportional to the switching threshold of the ferrite storage elements of an extended temperature range.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Television Receivers

J. W. Wentworth and C. M. Sinnett: Will appear in the McGraw-Hill *Encyclopedia of Science and Technology* in early 1960. A simple block-diagram description of both monochrome and color television receivers.

A Hybrid Mobile Two-Way Radio

R. A. Beers: 10th Annual IRE PGVC Convention, St. Petersburg, Florida. Describes a new mobile communications transmitter-receiver unit for the 25-54 mc and 148-174 mc land-mobile communications bands.

NATIONAL BROADCASTING COMPANY, INC.

A Special Effects Amplifier for Noncomposite or Composite, Monochrome or Color TV Signals

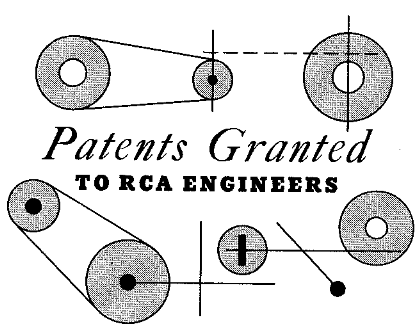
By R. Kennedy: SMPTE Conference, Oct. 8, 1959, Statler-Hilton Hotel, New York. A switching circuit has been designed to produce a doublet impulse transition of 0.05 microseconds. A method of clamping a color signal during the burst interval with crystal diodes is presented.

RCA SERVICE COMPANY

Cherry Hill, N. J.

Some Product "Abilities Important to the Customer"

J. A. Cafaro: 13th New England Quality Control Conference, Providence, R. I. Nov. 4-6th. Concerns the recognition, measurement and specification of a number of product "abilities" instrumental in obtaining full customer satisfaction.



BASED ON SUMMARIES RECEIVED OVER A PERIOD OF ABOUT TWO MONTHS

DEFENSE ELECTRONIC PRODUCTS

Camden, N. J.

Magnetic Scanning Systems

Pat. No. 2,912,493—granted Nov. 10, 1959 to H. N. Crooks and R. C. Bitting, Jr.

Magnetic Memory Systems

Pat. No. 2,911,631—granted Nov. 3, 1959 to C. S. Warren.

Testing Probes

Pat. No. 2,912,647—granted Nov. 10, 1959 to S. Krystek.

Bidirectional Static Magnetic Storage

Pat. No. 2,911,621—granted Nov. 3, 1959 to H. N. Crooks.

Serial Memory

Pat. No. 2,911,622—granted Nov. 3, 1959 to J. N. Smith, and W. R. Ayres no longer with RCA.

Apparatus for Developing an Electrostatic Image

Pat. No. 2,910,963—granted Nov. 3, 1959 to R. Herman.

Electrostatic Printing

Pat. No. 2,910,964—granted Nov. 3, 1959 to A. Stavrakis and H. G. Reuter, Jr.

Protective System

Pat. No. 2,910,626—granted Oct. 27, 1959 to L. I. Koros.

Television Optical System for Hospital Television

Pat. No. 2,911,518—granted Nov. 3, 1959 to L. E. Anderson.

Power Saving and Decoding Circuit for Radio Receiver

Pat. No. 2,912,574—granted Nov. 10, 1959 to W. L. Gensel.

Pulse Amplifying and Limiting Circuit

Pat. No. 2,912,580—granted Nov. 10, 1959 to W. L. Hurford.

Wide Band Signal Amplifier Circuit

Pat. No. 2,913,539—granted Nov. 17, 1959 to H. J. Woll.

Coupling Device

Pat. No. 2,914,739—granted Nov. 24, 1959 to J. J. Ayres, Fred Cohen, and Gerald Brauer.

Electrical Delay Line

Pat. No. 2,916,709—granted Dec. 8, 1959 to F. L. Putzrath.

INDUSTRIAL ELECTRONIC PRODUCTS

Camden, N. J.

Protection System for Cathode Ray Tubes

Pat. No. 2,913,621—granted Nov. 17, 1959 to A. C. Luther, Jr. and L. J. Baun.

Aperture Correction Circuits

Pat. No. 2,913,540—granted Nov. 17, 1959 to A. C. Luther, Jr.

Means for Securing Relatively Movable Members

Pat. No. 2,917,331—granted to J. S. Baer and R. D. Grapes.

Information Storage Apparatus

Pat. No. 2,918,656—granted Dec. 22, 1959 to G. V. Nolde and J. A. Brustman.

Particle Counting Apparatus

Pat. No. 2,918,216—granted Dec. 22, 1959 to L. Shapiro.

Color Correction System

Pat. No. 2,918,523—granted Dec. 22, 1959 to L. Shapiro.

Dynamic Control Circuit for Cathode Ray Tubes

Pat. No. 2,915,582—granted Dec. 1, 1959 to L. Shapiro.

ELECTRON TUBE DIVISION

Harrison, N. J.

Grid Mount and Method of Tube Assembly

Pat. No. 2,913,616—granted Nov. 17, 1959 to M. F. Ammenwerth, and L. J. Caparola, and M.

Tunable Magnetron

Pat. No. 2,915,675—granted Dec. 1, 1959 to F. E. Vaccaro.

Anode Mount for Electron Tubes

Pat. No. 2,918,598—granted Dec. 22, 1959 to G. McNeill Rose, Jr. and W. J. Helwig.

Apparatus for Assembling an Electrode Cage for Electron Discharge Devices

Pat. No. 2,917,812—granted Dec. 22, 1959 to R. K. Wolke, F. J. Pilas, and J. A. Chase.

Dispensing Apparatus

Pat. No. 2,918,198—granted Dec. 22, 1959 to A. G. Kjellsen and H. L. Blust.

Lancaster, Pa.

Cathode Assembly

Pat. No. 2,914,694—granted Nov. 24, 1959 to T. N. Chin.

Tri-Color Kinescope Aging Conveyor Carrier

Pat. No. 2,917,357—granted Dec. 15, 1959 to T. E. Nash and E. E. Hoffmann.

Activated Alumina-Dominated Phosphors

Pat. No. 2,919,363—granted Dec. 29, 1959 to G. E. Crosby, A. L. Smith, and L. E. Shitmer.

RCA VICTOR HOME INSTRUMENTS

Cherry Hill, N. J.

Electrical Signal Amplifiers

Pat. No. 2,913,521—granted Nov. 17, 1959 to L. P. Thomas.

Transistor Deflection System for Television Receivers

Pat. No. 2,913,625—granted Nov. 17, 1959 to M. B. Finkelstein.

Electron Beam Convergence Systems

Pat. No. Re 24,740—granted Dec. 1, 1959 to G. E. Kelly and R. D. Flood.

Self-Tuning FM Detector Circuit

Pat. No. 2,915,631—granted Dec. 1, 1959 to O. K. Nilssen.

KEY POSTS ANNOUNCED IN NEW SEMICONDUCTOR AND MATERIALS ORGANIZATION

Key engineering posts in the Semiconductor and Materials Division's new organizational structure have been announced. In line with expanding business volume and diversification of products and markets, the new Department organization reflects the current specialization of effort in computer materials, industrial semiconductors, micromodules, and entertainment products. The Division Staff (personnel, finance, staff engineering, product assurance, and production) will be concerned with planning and over-all business controls. Engineering posts in the Division staff and product departments (see chart) are as follows :

STAFF ENGINEERING: E. O. JOHNSON, CHIEF ENGINEER

D. J. Donahue, Mgr., Advanced Development; **L. R. Shardlow,** Mgr., Engineering Services; **E. V. Space,** Administrator, Engineering Planning and Contract Coordination; and **R. C. Garno,** Administrator, Engineering Administration.

COMPUTER PRODUCTS AND MATERIALS DEPARTMENT: K. M. McLAUGHLIN, MGR.

J. S. Gifford, Mgr., Product Planning; **R. B. Janes,** Mgr., Computer Transistor Engineering; **F. E. Vinal,** Mgr., Needham Materials Operation; and **W. H. Wright,** Mgr., Computer Transistor Manufacturing.

In Computer Transistor Engineering, Mr. Janes' staff will include **A. Blicher,** Mgr., Computer Device Development; **R. Lohman,** Mgr., Computer Application; **A. E. Chettle,** Mgr., Computer Model Shop; and **J. Rivera,** Mgr., Micromodule Transistor Development.

At the Needham Materials Operation in Needham, Mass., Mr. Vinal's staff includes **L. A. Wood** as Mgr., Engineering. Reporting to him are **J. H. McCusker,** Mgr., Advanced Development; **J. J. Sacco, Jr.,** Mgr., Magnetic Product Development; **L. B. Smith,** Mgr., Engineering Services; and **W. O. Olander,** Mgr., Magnetic Assembly Development and Memory Circuit Development. [Messrs. Sacco and Smith were featured on the cover of the last issue, Vol. 5, No. 4 of the RCA ENGINEER.]

In Computer Transistor Manufacturing under Mr. Wright, **R. E. Rist** is Mgr., Production Engineering.

INDUSTRIAL SEMICONDUCTOR PRODUCTS DEPARTMENT: C. H. LANE, MGR.

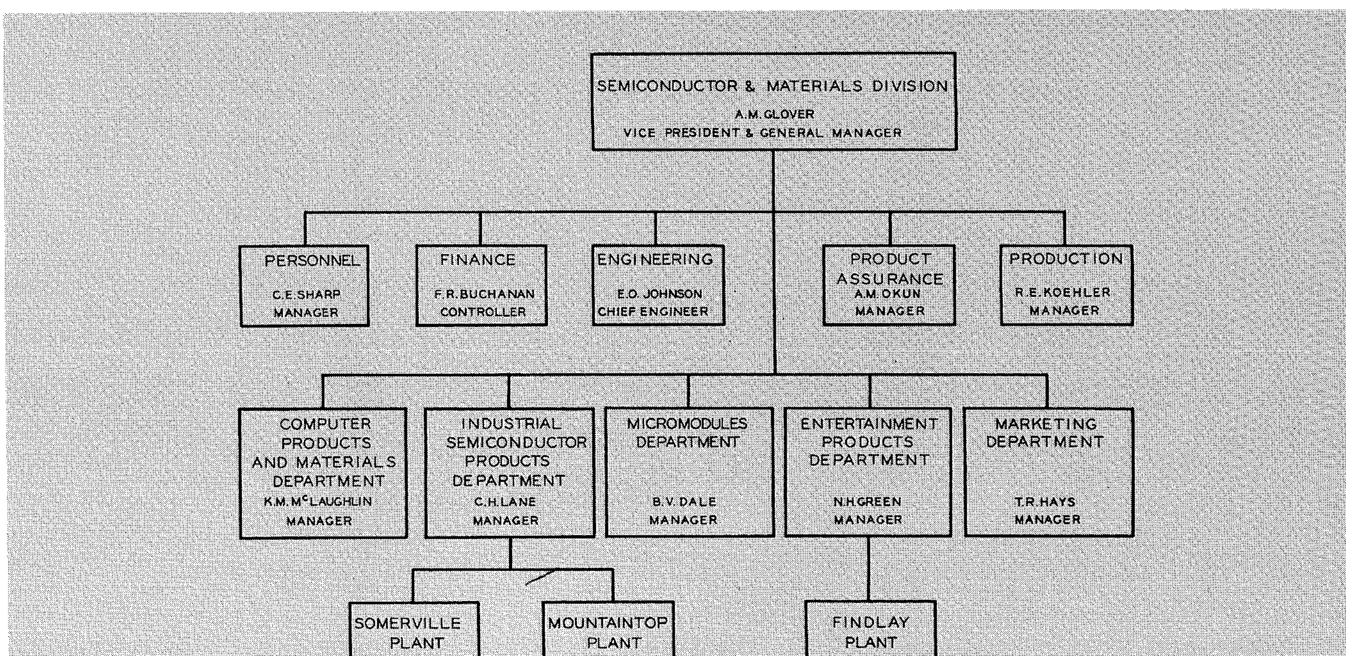
D. H. Walmsley is Mgr., Engineering. His staff includes **R. D. Faulkner,** Mgr., Silicon Rectifier Engineering, and **A. L. Kestenbaum,** Mgr., Industrial Transistor Engineering.

MICROMODULES DEPARTMENT: B. V. DALE, MGR.

L. Good is Mgr., Engineering. His staff includes: **C. K. Morehouse,** Mgr., Component Development; **D. V. Vonderschmitt,** Mgr., Module Development; **F. C. Collings,** Mgr., Design Integration; **L. Campanelli,** Mgr., Engineering Services, and **R. Samuel,** Mgr., Technical Services.

ENTERTAINMENT PRODUCTS DEPARTMENT: N. H. GREEN, MGR.

R. M. Cohen is Mgr., Engineering. His staff includes: **J. W. Englund,** Mgr., Applications, and **H. V. Kettering,** Mgr., Device Development.



RELIABILITY AWARD TO WUERFFEL

The 1959 Annual Award of the IRE Professional Group on Reliability and Quality Control was presented jointly to **H. L. Wuerffel** of DEP and J. A. Connor of the Hughes Aircraft Co. in "recognition of their contributions to the profession," at the Sixth National Symposium on Reliability and Quality Control, Washington, D. C., January 12, 1960.

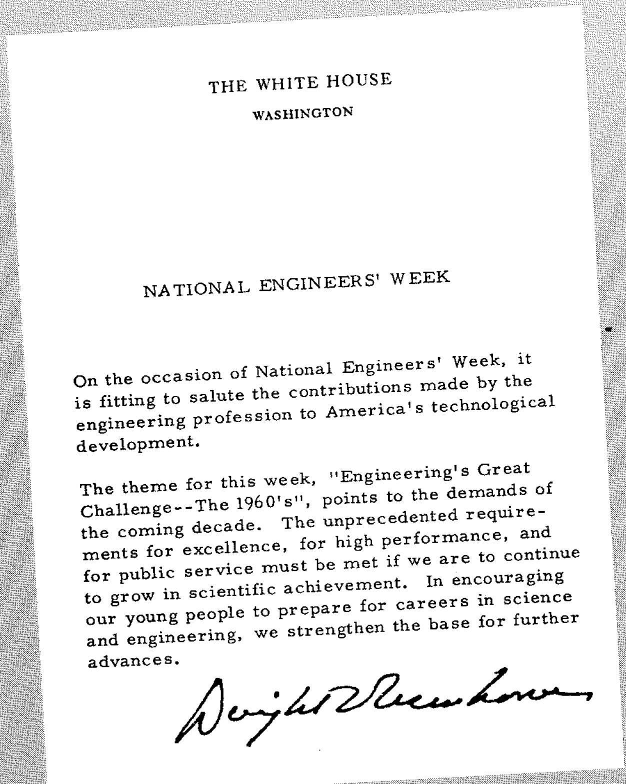
The citation pointed to their work in the RCA report TR-1100, *Reliability Stress Analysis for Electronic Equipment*, as a significant "assemblage of guiding principles, data and graphs for the design of reliable electronic equipment."

Mr. Wuerffel, an RCA ENGINEER Editorial Representative, is Manager of the Reliability and Maintainability Techniques activity in DEP Central Engineering.

SCHADE PAPER CITED

The Society of Motion Picture and Television Engineers (SMPTE) selected **Otto H. Schade Sr.'s** paper *"On the Quality of Color Television Images and Perception of Color Detail"* for Honorable Mention in connection with the Journal Award for 1959. This paper appeared in the December 1958 issue of the Journal of the SMPTE.

NATIONAL ENGINEERS' WEEK FEB. 21-27, 1960


THE WHITE HOUSE
WASHINGTON

NATIONAL ENGINEERS' WEEK

On the occasion of National Engineers' Week, it is fitting to salute the contributions made by the engineering profession to America's technological development.

The theme for this week, "Engineering's Great Challenge--The 1960's", points to the demands of the coming decade. The unprecedented requirements for excellence, for high performance, and for public service must be met if we are to continue to grow in scientific achievement. In encouraging our young people to prepare for careers in science and engineering, we strengthen the base for further advances.

Dwight D. Eisenhower

"ENGINEERS' CONFERENCE" HELD

As a fitting event during "National Engineers' Week," the National Society of Professional Engineers, through the Engineering Society of South Jersey, sponsored an *Engineers' Conference*, which was open to all area engineers. The special meeting was held at RCA Moorestown. Introductory remarks were delivered by **H. W. Phillips,** Mgr. BMEWS Operations Administration. **H. R. Wege,** Vice President and General Manager, Missile and Surface Radar, DEP, delivered a talk on *A New Look at the Engineering Profession.* Talks on professional licensing practices for engineers and on NSPE membership were given by G. N. Dign, New Jersey Board of Professional Engineers and Land Surveyors, and L. T. Klauder, of the Special N. J. Legislative Board.

LEWIS STRAUSS ELECTED TO RCA AND NBC BOARDS OF DIRECTORS

Lewis L. Strauss, former Chairman of the Atomic Energy Commission, has been elected to the Boards of Directors of RCA and NBC. Mr. Strauss served on the two Boards from January to July, 1953, leaving to become Chairman of the Atomic Energy Commission. He succeeds Edward F. McGrady, who retired. Mr. Strauss was for many years a partner in the investment banking firm of Kuhn, Loeb & Company, before resigning all business connections to become a member of the Atomic Energy Commission in 1946. He was a member of the Commission from 1946 to 1950, and Chairman from 1953 to 1958. He also served as Secretary of Commerce and Special Assistant to the President on Atomic Energy.

RAACH APPOINTED STAFF VICE PRESIDENT

Fred R. Raach has been appointed Staff Vice President, Management Engineering. Mr. Raach will be responsible for developing corporate policies and programs in the area of administrative procedures and controls. He will also provide service to the divisions and subsidiaries of RCA in evaluating and improving existing business methods. Since 1945, he has been with the management consulting firm of Robert Heller & Associates of Cleveland, Ohio, where since 1951 he had been a partner.

1959 CORPORATE SALES UP 17 PERCENT

RCA's sales for 1959 increased 17 percent over 1958, and profits after taxes increased 29 percent. Corporate business volume for the year reached an all-time high of about $1.375 billions. Profits after taxes rose to some $40 millions from $30.9 millions in 1958. Earnings per share of common stock increased to approximately $2.65 from $2.01 in the preceding year.

The improvement in earnings, stated RCA Chairman **David Sarnoff,** reflects "increases in virtually all of the company's major operating units, and the cumulative effects of a corporate-wide cost-reduction program." He said that during 1959, for the first time, RCA crossed the "break-even" line and began to earn a profit on the sales of color television sets.

At the year-end, he said, RCA had 86,800 employees, including 6,800 in foreign subsidiaries. This represents an increase of 11 percent over 1958.

"Trends during 1959," said General Sarnoff, "give every reason for confidence in the continuing growth of RCA's business, as well as of the electronics industry and the national economy, in the emerging decade of the Sixties. In the electronics industry, we look for a rise in total business from the present $14 billion to $16 billion in 1960, and to $25 billion in 1965. Such a rate of expansion would make electronics the nation's fastest growing major industry. As a pioneer and leader in this industry, RCA expects a continued increase in its own sales and profits in 1960 and a virtual doubling of its volume in the next five years, as it expands existing activities and takes advantage of new growth opportunities."

RCA AWARDS 61 UNDERGRAD SCHOLARSHIPS

Sixty-one undergraduate scholarships for the current academic year have been awarded students preparing for careers in science, industry, the arts, and teaching. **Dr. Irving Wolff,** Chairman of the RCA Education Committee, stated that 31 of the awards, designated as *RCA Scholarships* and carrying a grant of $800, have been given to undergraduate students majoring in science, music, business administration, drama and educational television. The fields of physics, chemistry, and engineering accounted for 27 of these.

The remaining 30 undergraduate awards are designated as *RCA Science Teacher Scholarships* and are made to students preparing to teach science in the nation's school systems. Twenty of these were awarded to upperclassmen and are valued at $800 each, while the remaining ten are valued at $250 each and were awarded freshmen and sophomore students.

The 61 undergraduate scholarships are a part of RCA's program of aid to education which each year helps more than 80 young men and women further their education at more than 50 colleges and universities. Fellowships for graduate study make up the balance of the program. Total cost of the program exceeds $100,000 annually. Recipients are selected by officials of the school they attend, subject to approval by the RCA Education Committee. In addition to the grant to each student, RCA has made an unrestricted contribution of $500 to each of the independent colleges and universities maintaining the scholarships.

NEW INDUSTRIAL COMPUTER SYSTEMS FACILITY NEAR BOSTON

A new facility to turn out electronic computer systems for controlling factory production will be opened by IEP at Natick, Mass. **T. A. Smith,** Executive Vice President, IEP, has announced that the new plant will be built in the Natick Industrial Center, fifteen miles west of Boston.

Adminstration, sales, engineering and a part of the production activities of the RCA Industrial Computer Systems Department will be housed in the new structure under **C. M. Lewis,** Manager. Until the building is ready, the department will occupy temporary quarters near the site. By mid-summer 1960 a staff of 75 engineers and other personnel will be employed in the Natick operations. Employment is expected to double next year. The RCA 110 industrial process control system, which the Natick plant will design and custom-assemble to meet individual user's requirements, is a flexible and expandable electronic aid for manufacturing plants, public utilities, and the petro-chemical industry, among others.

Mr. Lewis has named **C. E. Asch** as Mgr., Operations Control, and **R. W. Sonnenfeldt** as Mgr., Engineering, for the Industrial Computer Systems Dept.

CAPLAN TO HEAD NEW IEP ACTIVITY

Norman Caplan has been named to head IEP activity in the Washington-Canonsburg, Pa., area. Mr. Caplan will be responsible for overall supervision of the present RCA plant at Canonsburg and the new plant planned near Washington. He will continue in his current post as Manager, Communications Products Department, IEP.

The Washington and Canonsburg plants will turn out a variety of communications equipment, including the RCA *Personalfone*, a citizens band Radio-Phone, and the new ID-150 transistorized mobile radio unit for trucking companies, public utilities, transportation firms and other users. In addition, components will be produced for RCA electronic data processing systems.

RCA INSTITUTES EXPANDS TO CALIFORNIA

On March 1, 1960, RCA Institutes will open a new permanent school in Los Angeles to train technicians for the rapidly growing electronics industry in California. The new school will be located in the Pacific Electric Railway Building in downtown Los Angeles. **Irwin A. Shane** has been named Director of the Los Angeles school. Mr. Shane formerly was Director of the Television Workshop of New York.

RCA Institutes, which celebrated its golden anniversary in 1959, is one of the oldest services of RCA. It was organized in 1909 in New York City as the United Wireless School, and later was known as The Marconi Institute before becoming a part of RCA in 1919. Today, RCA Institutes ranks as one of the leading technical schools devoted exclusively to electronics, and is recognized by the industry as one of its most valuable sources of qualified personnel.

KUNSMAN NAMED EDP VICE PRESIDENT AND GENERAL MANAGER

Donald H. Kunsman has been named Vice President and General Manager of IEP's Electronic Data Processing Division. Mr. Kunsman, who had been President of the RCA Service Company, will direct the growing IEP activity in electronic data processing, including the operation of Computer Service Centers in the New York financial district, in the company's offices at Cherry Hill, and elsewhere.

Mr. Kunsman succeeds **E. Dorsey Foster,** who has been named Vice President, Plans and Programs, IEP. Mr. Kunsman joined the RCA Service Company in 1949 and served in a number of capacities, including those of assistant to the president, budget manager, treasurer and controller, and vice president, before his elevation to the presidency in 1958.

Mr. Foster had been Vice President and General Manager of the Electronic Data Processing Division since November, 1957. He served as Vice President and Director of Planning with the former RCA Victor Division from 1952 to 1954 and as Vice President, Economic Planning, from 1954 to 1957.

Key spots on Mr. Kunsman's staff include **A. S. Kransley,** Mgr., Product Planning, **J. W. Leas,** Chief Engineer and Acting Mgr., Data Communications and Advanced Systems Dept., and **C. M. Lewis,** Mgr., Industrial Computer Systems Dept.

CONRAD NAMED PRESIDENT RCA SERVICE COMPANY

Anthony L. Conrad has been appointed President of the RCA Service Company. Mr. Conrad, who has been Vice President of the Company's Government Services department since July 15, 1957, succeeds **Donald H. Kunsman,** who was appointed Vice President and General Manager, RCA Electronic Data Processing Division.

Succeeding Mr. Conrad as head of Government Services will be **Stephen D. Heller,** who for the last two years has been Vice President, BMEWS Service, at the RCA Service Company's offices at Riverton, N. J. In that position he has been in charge of the Company's role in the planning, installation and operating services of the Ballistic Missile Early Warning System. As Vice President in charge of Government Services, Mr. Conrad has been responsible for direction of the Company's world-wide field service to the United States Government.

GIVEN NAMED MANAGER BMEWS SERVICE PROJECT

William F. Given has been named Manager, BMEWS Service Project. Prior to his appointment, Mr. Given served as Manager, Engineering and Operations, and prior to that he was Manager, Engineering. Both positions were at the Riverton location. Mr. Given will be responsible for the installation, integration, check-out, test operation, and maintenance of the BMEWS network.

ENGINEERS IN NEW POSTS

In IEP, **L. F. Jones** has been appointed to the new position of Mgr., Product Planning; **C. O. Caulton** has been appointed as Administrator, Product Evaluation on his staff. **J. S. Rydz** has been named to the new position of Mgr., New Business Development in the Industrial and Automation Division. **A. F. Inglis** has been appointed Manager, Closed Circuit TV and Film Recording Dept., Broadcast and TV Equipment Division.

In SC&M, **G. H. Ritter,** Plant Manager, Mountaintop, Pa. has named **A. E. Mohr** as Mgr., Production Engineering.

In the Electron Tube Division, **S. M. Hartman** has been named Mgr., Tube Manufacturing at the Marion, Indiana plant. **G. N. Phelps** has been appointed Mgr., Equipment Development for Kinescope Operations.

In DEP, **C. G. Arnold** has been named Mgr., Engineering Projects in the Minuteman Program Management group in New York. **W. G. Bain,** Vice President and General Manager, Communications and Missile Electronics, has assumed the additional duties of Acting Manager, Defense Marketing. **R. V. Miraldi** has been appointed Mgr., Management Engineering.

G. W. Chane has been named to the newly-established position of Vice President, Finance and Administration. Reporting to **John L. Burns,** President, RCA, he will be responsible for the following staff functions: Treasurer, Controller, Personnel, and Management Engineering.

D. L. Mills has been appointed Division Vice President, RCA Victor Home Instruments Operations, responsible for Engineering, Materials, Manufacturing, Personnel, and Finance, and reporting to **P. J. Casella,** Executive Vice President, Consumer Products. Mr. Mills' staff includes **W. E. Albright,** Mgr., Home Instruments Manufacturing; **E. I. Anderson,** Chief Engineer, Home Instruments Engineering; and **J. D. Walter,** Mgr., Materials.

COMMITTEE APPOINTMENTS

Dr. Leopold Pessel, DEP Central Engineering, Camden, has been elected Chairman, Philadelphia Section, American Institute of Mining and Metallurgical Engineers.

Max M. Tall, Mgr., Reliability and Value Engineering, DEP Missile and Surface Radar, Moorestown, served as Chairman of the Program Committee for the Sixth Annual Symposium on Reliability and Quality Control in Electronics which was held Jan. 11-13 in Washington, D. C.

Clifford M. Ryerson, Senior Product Assurance Administrator, DEP, served as General Chairman of the Sixth Annual Symposium on Reliability and Quality Control.

BURNAP HONORED

At the First General Conference of the Joint Electron Device Engineering Council, held at the Bellevue-Stratford Hotel in Philadelphia, **R. S. Burnap,** consultant to the Electron Tube Division, was awarded a special testimonial in recognition of his "outstanding services as Chairman of the Committee on Type Designations and Definitions JTS-7 from the inception of JETEC in 1944 to his retirement in September 1959." The citation went on to state "his long experience and mature judgment were invaluable to the industry throughout this whole period."

REGISTERED PROFESSIONAL ENGINEERS

D. A. Comninos, Home Instruments	Prof. Eng., 10857, N.J.
H. R. Headley, M & SR, DEP	Prof. Eng., 5794E, Pa.
R. W. Cox, Tube Division	Mech Eng., 6212E, Pa.
D. O. Price, Tube Division	Mech. Eng., 6203E, Pa.

B. J. GOLDSTONE

D. J. ODA

R. E. PATTERSON

GOLDSTONE, ODA, AND PATTERSON NAMED ED REPS

The RCA ENGINEER welcomes three new Editorial Representatives to its ranks: **B. J. Goldstone,** who replaces E. W. Keller in the Airborne Systems Division, DEP, Camden, N. J.; **D. J. Oda,** who succeeds J. H. Pratt, for West Coast Missile and Surface Radar, DEP, Van Nuys, Calif.; and **R. E. Patterson,** who takes over for E. O. Selby at Surface Communications Division, DEP, Camden, N. J. All will be members of **F. W. Whitmore's** DEP Editorial Board.

The editors of the RCA ENGINEER would like to extend its thanks to Messrs. Keller, Pratt, and Selby for their active counsel and participation.

B. J. Goldstone received his BEE from Rensselaer Polytechnic Institute in 1946. He received his MSEE from the University of Pennsylvania in 1956 following graduate work at both Rensselaer and the University of Pennsylvania. He joined RCA in July 1947 as a student engineer in the Government Sound Section. There he worked on pulsed communication systems, audio announcing and signal generating systems, aircraft intercom systems, ultrasonic communications systems, and radar timing circuits. In 1953 he transferred to the commercial microwave communication section where he worked on systems engineering of microwave relay systems and multiplex channeling equipment. Since 1954 he has been in the Airborne Systems Division, where he has worked on advanced radar systems.

D. J. Oda graduated from Purdue University with a B.S.E.E. degree in 1949. He joined the RCA engineering specialized training program in July of that year and obtained a permanent assignment in the RCA Aviation Engineering activity located in Camden. For the next seven years he was engaged in the design and development of Military Airborne Electronic equipment. His last year and one-half in the Airborne Fire Control section was as a leader of Design and Development Engineering. In 1957 he transferred to Missile and Surface Radar in Moorestown as leader of the Video Devices group. Soon after, he was promoted to Manager of the Display, Indicator and Equipment Coordination unit in the Information Handling Engineering activity. He transferred to the Design and Development activity of the West Coast Missile and Surface Radar Division in July of 1959. In February of 1957, he received an M.S.E.E. degree from the University of Pennsylvania. He is a senior member of the IRE, a member of Tau Beta Pi and Eta Kappa Nu and has one U. S. patent to his credit.

R. E. Patterson, Administrator of Data Controls in Surface Communications Division, brings into RCA many years of experience in the data field coupled with a formal education in mechanical and systems engineering. Formerly associated with Bell Aircraft Corporation as Manager of Corporate Data Control, Mr. Patterson, working with Air Materiel Command and associated Project Offices, directed the preparation of the first complete missile weapon system handbook program attempted by the Military. His experience includes many administrative positions in engineering covering Project Engineer, Engineering Programming, Logistics Planning and Engineering Drawing Release and Change Control.

NEW RCA BUILDING IN D.C.

A new 13-story glass and aluminum office building rapidly nearing completion at 1725 "K" Street in the nation's capital has been named the *RCA Building,* following the signing of a lease aggregating $2,500,000 by RCA, which will be a major tenant. Occupancy will be taken about March 1, 1960.

RCA will consolidate in the building most of its Washington operations, now maintained at several different locations. Approximately 275 employees will be located there. The structure also will house, on its lobby floor, an RCA 501 Electronic Systems Center to provide data-processing service for government agencies and business clients.

NEW QUARTERS FOR RCA COMMUNICATIONS, INC.

RCA Communications, Inc., has disposed of its properties on Broad and Beaver Streets in Lower Manhattan in New York City and has contracted to become the prime tenant in a new 38-story building to be erected on the same site.

The new building will be built around their present 10-story main radio terminal at 66 Broad Street without causing any interruption of service. Subsequently, the operating center will be refaced and become a part of the larger new building.

ENGINEERING MEETINGS AND CONVENTIONS

MAR. 21-24
Institute of Radio Engineers, National Conv., Coliseum & Waldorf-Astoria Hotel, N.Y.C.

APRIL 4-7
Nuclear Congress, EJC, PGNS of IRE, New York Coliseum, New York City.

APRIL 11-13
Protective Relay Engineers, Annual, A&M College of Texas, College Station, Texas.

APRIL 11-14
Weather Radar Conference, American Meteorological Society and Stanford Research Institute, San Francisco.

APRIL 18-19
Automatic Techniques, Annual Conf., ASME, IRE, AIEE, Cleveland-Sheraton Hotel, Cleveland.

APRIL 19-21
Active Networks & Feedback Systems, International Symposium, Dept. of Defense Research Agencies, IRE, Engineering Societies Bldg., N.Y.C.

APRIL 20-22
Southwest IRE Regional Convention and Electronics Show, Shamrock-Hilton Hotel, Houston, Texas.

MAY 2-4
National Aeronautic Electronics Conference, PGANE, Dayton, Ohio.

MAY 2-6
Western Joint Computer Conference, PGEC, AIEE, ACM, San Francisco, Calif.

MAY 9-11
PGMTT National Symposium, Hotel Del Coronado, San Diego, Calif.

MAY 10-12
Electronics Components Symposium, PGCP, AIEE, EIA, WEMA, Washington, D.C.

MAY 23-25
Seventh Regional Technical Conference and Trade Show, Olympic Hotel, Seattle, Wash.

C. W. SALL—IEP AND RCA ENGINEER LOSE KEY MAN TO PRINCETON

An outstanding editor is one who has the ability to surmount odds that may seem insurmountable to others. Such a man is Chet Sall. During his tenure as IEP Engineering Editor and Editorial Board Chairman for the RCA ENGINEER, Chet has left no stone unturned in encouraging and producing fine articles on schedule, no matter how complex the obstacles nor how stringent the deadlines. At the same time, he has done a fine job as Manager of Technical Publications and as Technical Publications Administrator for IEP. It has been both a pleasure and an inspiration to work with him. We wish him as much and more success in his new assignment with the RCA Laboratories in Princeton.

—*The Editors*