RCA ENGINEER

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AUGUST—SEPTEMBER, 1961

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.

•

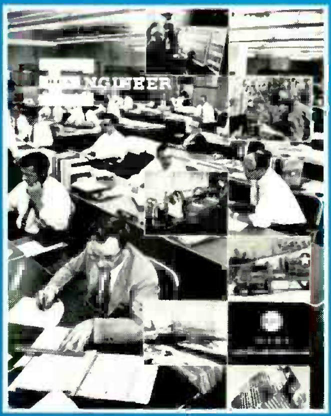
To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field.

•

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

. . . engineers at work in a design and development group in DEP Moorestown. Inset photos are a small sampling of the vast capabilities of DEP engineers in their many locations. Top to bottom: sophisticated data-handling and display techniques; miniature-circuit communications gear; plasma studies, one of many applied-research efforts; automatic test and checkout systems; radar and large defense systems; and satellite and space-vehicle systems.

Basic Research for Defense Electronics

This issue of the RCA Engineer, featuring important aspects of RCA's defense electronics activity, opens appropriately with a word from the research end of our business.

I say *appropriately*, because it is the effective combination of research and engineering talents that has enabled RCA to gain and hold its position of leadership among major industrial contributors to defense and space programs.

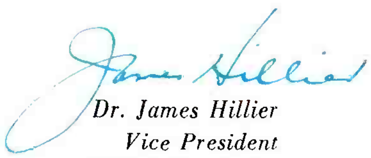
The role of RCA Laboratories in this pattern includes two aspects that deserve special mention here.

Today, about one third of the research at Princeton is being done with government contract support, in projects ranging from basic materials to certain types of experimental apparatus. Some of these projects are being performed on a subcontract basis with DEP and other product divisions; others are covered by contracts directly with government agencies.

However, this is far from being the whole story. The other two thirds of our research, financed by company funds, is at least as important as our government contract work in providing support for the defense program. The reason is in the very nature of the work at RCA Laboratories—exploring new concepts, new approaches, new materials, and new devices that can apply across the board to virtually all electronic goods and services. Our research, in essence, seeks to advance the state of the art in lines that are significant to RCA's business—government or commercial.

We are doing this with an RCA Laboratories technical staff that represents only about 4 percent of the total technical personnel in the Corporation. Being small, it has to be selective. Thus the most useful service that the laboratories can perform is to use its special skills to attack the most critical links in the systems chain—the basic materials and devices—rather than to undertake the comprehensive applied systems work that can be, and is, so ably performed by the product-division development groups.

The point of my message is to focus your attention on this relationship and to urge you to take full advantage of it. This calls for an extra effort in communications, simply because RCA's business is so complex in the technical sense that neither you in the product-division engineering groups nor we at the RCA Laboratories can be constantly aware of every detail in every project in the other's organization. If, for example, you can now foresee where the critical questions are likely to occur in the systems you plan for the future, get the word to RCA Laboratories just as fast as you can—and in the greatest possible detail. You might even find us already approaching the same problem from another direction, unaware of the special need that you have in mind.



Dr. James Hillier
Vice President
RCA Laboratories

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VALUE ENGINEERING is a product-design discipline — a technique of first analyzing the *essential* functions of a product and then systematically developing quantitative methods to achieve those functions at a minimum feasible cost, while assuring maximum product reliability.

Value engineering is not just another cost-reduction program. Rather, it is the very essence of engineering. It is implicit in the creation of products for any highly competitive market. In the production of weapon systems and military equipment, value engineering must be an engi-

An Engineer's Heritage and Discipline

VALUE ENGINEERING

by **A. D. ZAPPACOSTA**
Surface Communications Division
DEP, Camden, New Jersey

neer's way of life if we are to survive in the fiercely competitive cold-war environment.

The Government has defined value engineering as:[1]

"An intensive appraisal of all the elements of the design, manufacture or construction, procurement, inspection, installation, and maintenance of an item and its components, including the applicable specifications and operational requirements, in order to achieve the necessary performance, maintainability, and reliability of the item at minimum cost. The purpose of value engineering is to make certain that every element of cost (e.g., labor, material, supplies, styling, and services) contributes proportionately to the function of the item."

In Defense work, value engineering determines the standards of a Product Assurance Program whose purpose is to deliver reliable Armed Services Weapon Systems and equipment in a state of tactical readiness. Within the DEP Surface Communications Division, as elsewhere in RCA, a fundamental *engineering approach* to value engineering has resulted in an experienced, cost-conscious engineering department that is progressing in today's highly competitive environment.

DO DEFENSE CUSTOMERS WANT VALUE ENGINEERING?

DEP customers—the military—not only want value engineering, *they require it.*

The Navy has been experimenting with value engineering for five years, and has awarded a number of contracts under which the contractor shares in the rewards of cost reductions therefrom.[2] Their experience shows that value engineering is most effective when 1) the contractor shares some of the gains of an improvement; 2) there is an incentive for contractors to introduce improvements into production; 3) value engineering efforts are applied at the beginning and not at the end of the contract period; and 4) there is no doubt that follow-on production will be ordered. To formalize such concepts, the Bureau of Ships recently issued a tentative value engineering specification,[3] which has been approved by the Department of Defense for Army, Navy and Air Force use.

The Air Force's approach to value engineering began with an interest in "value analysis" in 1955. Now, they expect to award incentive value engineering contracts.[4]

Army ordnance experts in the missile field state that the largest savings from value engineering occur when the effort is applied during the R&D phase of the work and has issued a value-analysis specification.[5]

WHY VALUE ENGINEERING?

Cold-war emergencies have produced urgent Armed Services needs for accelerated deliveries of weapon systems.

Several years ago, a typical normal schedule from system concept to operational readiness was 2 to 5 years. Today, schedules for analogous systems have shrunk to 12 to 18 months. These present stringent time scales exert many pressures on engineering and manufacturing if they are to avoid compromises in the performance and reliability of the system. The problem is compounded by the increasing technical complexity of weapon systems.

The Armed Services are concerned with rising costs and late deliveries of present weapon systems and equipment. Complex weapon systems must be implemented on a crash delivery schedule with minimum expenditure of money and human resources. This is the reason for Armed Services emphasis on value engineering. It is a major challenge to our engineers for the creative engineering urgently needed for our survival.

From the customer's point of view value engineering provides maximum value for minimum expenditure of material and human resources. Dollar savings in the original design are multiplied from three to fifteen times throughout the life of the equipment. Just as important as dollars is the saving of human resources resulting from the maintainability of a simple functional design versus an unnecessarily sophisticated functional design.

From the engineer's point of view value engineering gives:

1) Better understanding of the essential function of his design with a method of achieving this function for the lowest total cost.
2) The inner satisfaction of creating a reliable, manufacturable product meeting essential functional requirements at a cost which makes the customer want to buy.
3) Recognition from his associates and management as well as from professional societies for his creative ability to produce a job well done, technically and economically.
4) The feeling of personal achievement as a citizen in the efficient utilization of our natural resources.

From the point of view of company management, it improves technical and business reputation, increases chances of not only first-production but also subsequent production contracts, and takes jobs away from our competition.

WHO HAS REAL RESPONSIBILITY FOR VALUE ENGINEERING?

The basic responsibility for effective value engineering lies with each member of a product-engineering team, which may include system, development, design, project, and supervisory engineers, and marketing and Armed Services representatives. They are assisted by many experienced talents: senior mechanical and electrical designers, management, marketing representatives, and support groups such as drafting, purchasing, subcontracting, model shop, manufacturing, quality assurance, maintenance engineers, and Armed Services engineers.

It is the responsibility of senior engineers and supervisors, as value engineering missionaries, to teach the doctrine of *maximum product for minimum cost.*

The challenge is to develop a value-engineering capability supported by product-assurance manufacturing programs that deliver reliable products in a state of tactical readiness with long life. Our interest in the operational use and the maintenance of our products by the Armed Services personnel must constantly serve as the most valuable source of product improvement ideas.

A. D. ZAPPACOSTA received his diploma in EE from Drexel Institute in 1936 and is a Registered Professional Engineer, State of New Jersey. From 1936 to 1940, he joined the Philco Radio and Television Corporation as development and design engineer on broadcast, shortwave, and export type receivers. From 1940 to present day, he has been a member of the RCA engineering staff. During World War II he was development and design project engineer on SONAR equipment for the U. S. Navy. As a result of this SONAR experience, PPI and SECTOR-SCAN types of SONARS were developed for the U. S. Navy. Also, considerable original work was completed on Pulse FM SONAR systems. From 1945 to 1950, he was assigned as manager of the Mobile Communications Group. He developed the first commercially available 60 kc Adjacent Channel Communication System in the 152-174 Mc Band for the Police, Fire, and other emergency services. From 1950 to 1955, he was assigned as Manager of the short-range navigational and bombing engineering group. He pioneered the development of the first automatic SHORAN equipment for F-100. From 1955 to 1957, he was assigned to the TALOS Weapon System as design project manager in the areas of analog computers, control computers, and system check-out equipment. Since January 1958, he has been assigned to the following Surface Communications Engineering Projects: (1) GKA-5 Data Link Ground Communications, (2) South Pacific Iono Scatter Communication System, (3) Polaris Communication System Task IX, (4) 466-L Intelligence System, and (5) U. S. Navy Boresight System. Mr. Zappacosta has been granted six patents in the field of SONAR and Communication Systems. He is a Senior Member of the IRE.

FACTORS INFLUENCING PRODUCT COSTS

Effective Communications

Management has a responsibility to create and maintain effective communication methods; the engineer has a corollary responsibility to utilize these methods. The effectiveness of intercommunications in a series-parallel type of project-engineering organization needs constant surveillance to minimize the intangible inefficiencies and frustrations caused by poor communications. Good communications exist when there is a daily flow of ideas exchanged between all associated personnel on the project and supervision. Effective communications usually need the personal interpretation of the printed word.

Product Design Consideration

Value engineering, to be effective, requires the engineer to constantly assess value in each design decision as the product progresses from system concept to finished equipment designed for the Armed Services operational environment. *Each engineer at the start of a new product design must understand and evaluate the influence of his decisions on the ultimate cost of the product.*

Armed with a real knowledge of all factors which influence end cost, he can make effective decisions and tradeoffs as the design progresses. A typical value trade-off check list is shown in Table I—such a list can be for guidance only; it is *not* a substitute for the free, creative, inquiring mind necessary for the solution of difficult problems.

Project Engineering Considerations

The project engineer must maintain truly effective communications with all members assigned to a product-design team from the contract award to the end life of the equipment. He sets the competitive pace and spirit of the product team. The project engineer complements the effectiveness of design engineers by providing daily assistance—coordinating and expediting all technical, financial, and customer activities. He keeps the design engineer informed in all phases of the program. His need for a working knowledge of cost factors is as great as the design engineer's. The cost factors must be personally outlined for his particular project. A typical value trade-off check-list for the project engineer is shown in Table II.

Product Design Reviews

Every *product-design review* is a value-engineering review. Starting with the operational end use of the system equipment, and with the over-all understanding of the system design and reliability goals, the engineer is ready to review the suitability of applicable military specifications.

The military specifications are valuable in guiding the design. Many times, they may be modified to meet the *exact* needs of a new system or equipment. From the breadboard to the prototype phases of a design, the engineer must choose reliable circuits and components. Current component survival-rate data, field-failure data, state-of-the-art knowledge, manufacturing processes, and cost data must be on hand to assist his trade-off decisions. Many experienced talents from drafting, purchasing, model shop, manufacturing, quality assurance, marketing, field-support, engineering consultants, and the Armed Services are available to assist his design decisions. The engineer, backed by such advisors and with a sound understanding of the Armed Services operational needs, can add his creativity to the system designs.

Effective scheduling of design value-engineering reviews concurrently with electrical, mechanical, and reliability reviews is the joint responsibility of the design and project engineers. Design reviews are most effective at the time of contract award, bread-board phase, prototype, environmental test, field test, manufacturing processes, final design, production support, field installation, and the operational use of the product. Design reviews *are not a substitute* for daily personal communications and decision-making.

MEASURING VALUE ENGINEERING

A quantitative approach to value-engineering savings requires a tough and soul-searching engineering insight—a technique that does not produce immediate spectacular results. But, the *long-term benefits* will be improved efficiency in all elements of the organization. This improved efficiency can result from an objective appraisal of all of cost estimates that experience gain or loss variances vs. budget. This approach is in practice today in all competitive industries. What is needed is a systematic method of monitoring all of our product costs with rapid decision-making *to control* the gain or loss variances.

Product Cost

The cost of a new product—equipment or whole system—can be expressed as a series of dollar expenditures, which when added together, represent the total expenditure for materials, facilities, and human resources. To obtain a product with functional capability, *every element of cost* must be scrutinized for maximum value vs. lowest cost.

SurfCom AN/PRC-25 value-engineering review: (l. to r.) W. J. Lynch, W. B. Harris, J. L. Slivinski, C. M. Ledig, M. DiGangi, W. A. Harris, C. L. Whitman, C. M. Smith.

SurfCom weapon-system value-engineering review: (l. to r.) J. J. Davaro, Dr. E. I. Gavurin, E. J. Westcott, J. J. Burns, C. H. Taylor, R. J. Farquharson, M. Raphelson, E. Miller, A. J. Saponaro, J. Dziel.

SurfCom PRC-51 value-engineering review: (l. to r.) W. R. Thompson, C. E. Sweetman, F. L. Bennett, J. N. Lehman, R. A. Beers, L. E. Potter, S. V. Mormile.

TABLE I — PRODUCT-DESIGN FACTORS INFLUENCING VALUE TRADE-OFFS

1. Contract Award

End use objectives of equipment and over-all system
Real operating environment
Experience level of users
System specifications
Security requirements
Availability of Customer-Furnished equipment
Equipment specifications
Reliability *MTBF goals; component specifications
Field feedback on similar equipment
Product-assurance specifications
Human factors specifications
Engineering and manufacturing schedules and cost

2. Preprototype Model (Breadboard)

Preliminary schematics
Preliminary material lists and drawings
*MTBF goals
System specifications
Equipment specifications
Manufacturing methods: fabrication, tools, assembly, test and quality control
Maintainability methods and field test equipment
Communications with all personnel assigned to program

*MTBF—Mean Time Between Failures

Cost and schedule
Customer changes

3. Prototype Model (Manufacturing Model)

Final schematic, detail and assembly drawings
Final material lists and documentation of non-standard parts
Final system specifications
Equipment performance specifications
Manufacturing processes, tools and test equipment, quality control standards specifications
Maintainability, field test equipment specification
Operator training material
Maintenance procedures
Spare parts lists
Environmental tests
Patent disclosures and approvals
Predicted reliability *MTBF specification
Packing design
Communications with all personnel on program
Cost and schedules
Customer changes

4. Environmental and Field Service Tests

Product performance vs. tolerances
System changes as necessary
Design changes as necessary
Maintainability changes
Reliability *MTBF results
Human factors design changes as necessary
Final operation manuals
Maintenance manuals
Final bill of materials
Final manufacturing drawings
Assembly, test and quality control specifications
Communications with all personnel
Release for production
Program for engineering design changes
Cost and schedules
Customer changes

5. Manufacturing Support

Specifications for subcontractors
Quality assurance standards
Use of non-standard parts
Special assembly methods
Test process
Special test equipment
Production tests
Quality acceptance of product
Environmental tests
Reliability *MTBF data
Control of engineering changes
Cost and schedules

6. Logistic Support and Installation

Equipment spare parts provisioning list
Installation spare parts
Final instruction books
Installation engineering
Site surveys
Installation drawings
Installation and test specifications
Training of operators
Customer changes

7. Operational Field Tests

Over-all system performance vs. specifications
Acceptance tests with armed services personnel
Approval of reliability (*MTBF data) performance
Product improvements

8. Positive and Negative Feed-back Data from Tactical Operations

Comments from armed services operating personnel
Note areas for product improvement
Note areas for new system concepts
Note maintainability and logistic support problems
Product improvement program for customer

Equipment: VHF COMMUNICATION RECEIVER — Review No. 2 — Date: 3/9/50

Review Status: Contract Award ___ ; Breadboard X ; Prototype ___ ; Mfg. Processes ___ ; Environmental Tests ___ ; Field Tests ___ ; Final Design ___ ; Production ___ ; Field Installation ___ ; Operational ___

Quantity: Models 2 — Production 2000

ENGINEERING COST	Estimate	Actual to 3/?/50
E.E. & M.E.	17,000	1,000
Drafting	[illegible]	200
Purchased Eng.	None	
Materials	1,250	250
Model Shop	1,350	300
Others	150	

MANUFACTURING UNIT COST	Estimate	Actual
Purchased Mtl.	34.25	
Fabricated Mtg.	3.75	
*Assembly Labor	[illegible]	
*Test Labor	5.55	
Tools	1.50	
Test Equipment	.25	
Packing	.75	
Spares	2.50	
Manuals	.50	
*Less Overhead		

A. Recommendation: Improve the intermodulation response and desensitization of the receiver when receiving a 1 μv signal in the presence of one or two interfering signals with amplitudes of 0.1 to 0.5 volt and separated by 0.035% and 0.07% in frequency. This improvement may be realized by using Triode grounded grid R.F. Amplifier and Mixer plus a unique AGC system instead of pentodes. Also, the major gain must be realized after the channel selectivity tuned circuits.

Originated by: R.A. Beers

B. Estimated Net Savings

1. Manufacturing Cost/Unit = \$10 x 2000 units = \$20,000
2. Additional Engineering Cost -3,000

Net Savings \$17,000

Design Team Members:
R. A. Beers
W. I. Gensel
C. A. Houser
D. T. Rockwell

Prepared by: R.A. Beers
Approved by: A. D. Zappacosta
Date: 3/?/50

Fig. 1.—Value-engineering review form. (This recommendation resulted in U. S. Patent 2,715,180 issued to R. A. Beers, 8/9/55).

TABLE II — PROJECT-ENGINEERING FACTORS INFLUENCING VALUE TRADE-OFFS

1. Business Management

Security
Customer relations
Negotiations and renegotiations
Contract administration
Specifications
Availability of government furnished equipments

2. Project Schedule

Engineering releases
Manufacturing target dates
Environmental test dates
Installation schedule
Training schedule for users of equipment
Over-all completion target dates

3. Fund Allocation and Control

Appropriations
Disposition of Funds
Cost estimates
Control of expenditures
Deviation approvals
Engineering changes

4. Selection of Subcontractors

Subcontracting administration
Subcontracting cost control
Subcontracting engineering and manufacturing liaison

5. Engineering Responsibilities

Systems, development, design and reliability specifications
Human factors specifications
Systems integration
Test equipment design
Patent approval
Technical documentation

6. Manufacturing Requirements

Engineering releases
Factory follow-up
Test and inspection specifications
Quality control specifications
Equipment acceptance test specifications
Packing design
Shipping instructions
Authorization of engineering changes

7. Field Operations

Maintenance and operational manuals
Site installation
Operational tests
Spare parts
Analysis of performance
Waivers
Product improvements

8. Manpower

Proper balance of talents
Morale

9. Customer Relationship

Approval of program and changes
Status reports
Final acceptance
New business

The total product cost, C_t, from engineering concept to end life can be represented by a summation of all major costs:

$$C_t = \sum_{i=1}^{n} (C_1 \pm \Delta C_1) + \sum_{i=1}^{n} (C_2 \pm \Delta C_2) \ldots \sum_{i=1}^{n} (C_n \pm \Delta C_n),$$

Where: $i = 1, 2, 3 \ldots n$, equals the number of elemental costs in the major costs, $C_1, C_2 \ldots C_n$ and $\pm \Delta C_1, \pm \Delta C_2, \pm C_n$ are the total cost gain or loss variances in each of the major costs.

The analysis of the gain and loss variances, $\pm \Delta C_1, \pm \Delta C_2 \ldots \pm \Delta C_n$, in each major product cost provides a source of guidance for all members of the product design team for creative value engineering. The increment of variance $+\Delta C_1$ represents an over-run of expenditures vs. budget, i.e., a *loss* variance. Then, $-\Delta C_1$ represents an under-expenditure or *gain* variance. The entire fabric of a product from concept to end life is woven with controllable and uncontrollable variances. *No two engineering or manufacturing organizations are alike in their capabilities.* This capability varies from year to year and determines the cost function for $C_1 + C_2 \ldots C_n$, which is valid only at the time of evaluation.

As our proficiency enables us to meet our present costs and schedules, we must set new stringent cost goals vs. schedules vs. functional performance in all of the above elements of cost. As we reach these new goals *we must not be satisfied.* We must continuously search for further optimization of skills, materials, and manpower. By painstaking effort to measure each major element of cost, such as $C_1, C_2 \ldots C_n$, on a milestone basis, the engineer can maintain a continuous search for creative methods to accomplish *the end use objectives of a product at minimum cost.*

Documentation of Costs and Trade-off Decisions

Each product requires an engineering and manufacturing cost estimate. The actual expenditures of funds at the completion of a program vs. budget funds are a measure of performance. A simple form (Fig. 1) shows the financial goals and engineering status of some typical bread-board communication equipment. This form also serves as a record of each product design team member's cost-saving contributions. At each design review of a program, the data is reviewed for present and future guidance.

SUMMARY

Value engineering is basic in all engineering that creates products with end-use objectives. It is the heritage given to us by all past and contemporary scientists and engineers. *Every engineer who has created or improved a commercial product for a highly competitive market knows from experience what value engineering means.* It cannot be learned in two weeks. Value engineering is a life-time discipline in applied sciences to produce functional products with minimum expenditure of money and human resources.

The following systematic guide lines are clear. Our personal engineering discipline requires a constant search for the *current factual data necessary* for value trade-off decisions.

...Know the end-use objectives of the equipment and of the system.

...Know the environment and human factors necessary for operational use of the equipment.

...Obtain data on field failures, system problems, and design deficiencies of similar operational systems.

...Know design specifications (official MIL-SPECS where applicable) and their proper use for successful operational results.

...Know competition: local, foreign, *especially Soviet.*

...Know the state-of-the-art in system concepts; survival rates of components; and reliability prediction of mean time between failures, of equipment and systems.

...Know manufacturing methods, especially automated.

...Know every element of cost from the system concept to the end life of an equipment.

...Learn from equipment environmental and field tests.

...Know the maintenance factors by actual participation in the field use of the equipment, or from first-hand knowledge obtained by personal interviews with user of the equipment.

...Practice cooperation, cost control, and communications with all persons on the program.

...Take advantage of the wealth of talents, experiences, and guidance from associates.

...Develop unity of purpose to meet cost, schedules, and functional performance.

...Develop communication techniques to efficiently utilize our human resources.

...Analyze and record all gain and loss variances vs. schedules and budgeted cost—this is the source of ideas for our present and future guidance.

...*Apply creativity and sweat to all the above items.*

Day-to-day judgement of value depends on our ability to conceive as well as to apply concepts of what constitutes value. These concepts must be based upon our inner resources—they cannot always be gleaned from formulae taken from handbooks. No table of cost trade-off factors or organizational procedures can substitute for the engineer's inventiveness, initiative, and perseverance.

Each one of us must accept the challenge to leave a heritage of value engineering *greater* than the one we have inherited.

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Since our plans are significant to the welfare of each RCA engineer as well as to the Corporation, I am pleased to have the opportunity to review with you business prospects and trends in the defense industry, DEP goals, and the manner in which we intend to achieve them.

THE OUTLOOK FOR DEP

by **ARTHUR L. MALCARNEY**
Executive Vice President
Defense Electronic Products
Camden, N. J.

Adaptation to changing conditions is one of the essential requirements for survival and growth in a dynamic industry. Since an organization exists to satisfy the needs of the customer, adaptation is reflected in timely possession of appropriate technical skills, adequate facilities and effective organization.

Adjusting to the volatile conditions of national defense requires an underlying philosophy of flexibility. We cannot expect to grow and prosper if we merely seek business which utilizes our existing technical skills and organization. Instead, we must change the organization and its existing skills in accordance with the availability of business and the present and future requirements.

Obviously, timeliness is critical to adaptation, and intelligent forward planning is the key to being ready.

DEFENSE SPENDING TO INCREASE

The economic picture for defense is one of growth over the next five years. In 1960, Department of Defense (DOD) expenditures amounted to approximately $41.2 billion, and it is anticipated that approximately $42.5 billion will be spent in 1961.

Indications are that DOD expenditures for fiscal 1962 will approximate $43.8 billion, and many industry observers estimate an annual increase as high as $2 billion per year thereafter. A more realistic estimate is that the annual rate of increase will be $1 billion; thus the DOD budget by 1965 is estimated at roughly $46.1 billion, or 11.2 percent more than 1960.

Government Electronics Market

The outlook for the government electronics market is for even more substantial growth. Over the past several years, electronics and research-and-development (R&D) have constituted a constantly growing percentage of the total defense budget — it is anticipated that this trend will continue.

It is estimated that the military, space, and certain civilian agencies of the Federal Government spent $6.2 billion in fiscal 1960 for electronics equipment and services, or roughly 14.6 percent of the total budgets of those agencies. DOD purchases alone amounted to $5.8 billion, or 14 percent of its budget. By 1965 our industry will be supplying $8 billion to $9 billion of electronic equipment and services to the same agencies, accounting for almost 18 percent of their total budgets. By then, DOD purchases are expected to exceed $7 billion, equal to 15 percent of its budget.

Foresight—The Key to New Business

While the government-electronics market shows solid growth, it is obvious that increased volume is not automatically conferred upon all suppliers of the government. The business will be won by those companies who are ready for it — the companies who possess advanced technical capability, ideas for solving customer problems, manpower, leadership, facilities, and the organization to administer major systems and programs.

Being ready, or "cooperating with the future," cannot be left to chance, for except in unusual circumstances, growth does not just happen. To obtain our share of the market requires that we have the vision and judgment to *anticipate* customer needs, and that we plan to have available the required human and physical resources.

Much of the time and attention of management is devoted to planning. Five-year plans are developed not only for DEP over-all, but also within each of the DEP Divisions and for the product lines within those Divisions. The plans for each current year are necessarily more detailed than for subsequent years, and adaptations are made in accordance with changing customer requirements and internal conditions.

The planning is not always visible to all personnel within the organization, but nonetheless underlies all significant management actions. Because of difficulties in communicating with a large DEP population, and also for competitive reasons, the extent and nature of our planning cannot be widely publicized. However, our engineers are an *integral part* of our management group, and I am personally pleased to discuss the DEP outlook through media such as the RCA Engineer. Throughout the year, we communicate information and policy to our engineers through our management structure and meetings with engineering personnel.

ORGANIZATIONAL RESTRUCTURING

Changes in our organization structure are a necessity in maintaining the flexibility required to adapt to changing conditions. When changes in organization structure are announced, it is usually after intense study of current effectiveness and anticipated market or customer requirements.

For example, in DEP we have had organizational realignments on September 1, 1959 and April 1, 1961. [See C. A. Gunther on *DEP Engineering Organization and Facilities, this issue.*] In each instance, we instituted changes made necessary by current and anticipated market conditions, enabling us to concentrate more effectively our particular capabilities and skills, to service our customers better, and to enhance our potential for future growth. Each change was preceded by studies of approximately six-month duration. Both accommodated present requirements, while permitting anticipated future change with a minimum of disruption.

The process of organization study and change is essential under growth conditions. Where changes can be made on an evolutionary basis, it is obvious that the impact on personnel and procedures can be minimized.

PROJECT MANAGEMENT TO INCREASE

Looking ahead, I forecast a pronounced trend toward more widespread project organizations. The nature of our defense posture requires that we produce hardware and systems of greater complexity in shorter periods of time and within budget. Such programs as Bmews, Saint, DynaSoar, Global Communications, ElCo, and many others have been established on a project basis. This trend will continue and be intensified.

Levels of Responsibility

Increasingly, the customer demands that sole responsibility for project performance be vested in a single Project Manager of stature, so placed in the organization that he can make or obtain decisions rapidly.

We will locate our projects organizationally so that the Project Manager will be reporting to the level most appropriate for the resolution of problems which may arise. For example, if a program is primarily R&D in nature, the Project Manager will report to the Chief

Engineer who can iron out issues which may arise among the engineering sections. If a program involves engineering and manufacturing within a division, the project manager will report to the Vice President and General Manager. Those programs which involve several divisions and outside subcontractors will report to one of the deputies of the Executive Vice President.

Relation to the Functional Organization

The increasing utilization of the project type of organization will bring with it new problems to which we must be alert. Future growth demands that we keep the functional organizations from which the project springs strong and healthy. Although we siphon off key personnel to man the projects, we must maintain sufficient strength to accomplish tasks assigned by the project group as well as other in-house business, and to bring in new business.

Planning must therefore take into account the impact of projects on the functional organization. It is urgent that we train able personnel to replace those drafted for project assignments. Each of our engineers can help in this process by recommending talented candidates to buttress our technical capability.

Another problem arising from project organization is the maintenance of effective communications between the project group and the functional organization. We must maximize the skills and experience acquired from each project to enable us to bid successfully for other projects. This we can do in two ways: *through a healthy relationship and communication between the project and functional organization, and by rotating personnel.*

It is our philosophy that the mission of the project group shall be to accomplish its objectives in the shortest time possible and then be reassigned to other projects or to the functional organization.

A TREND TOWARD COMPLEX SYSTEMS—IMPLICATIONS CORPORATE-WIDE

There is a decided trend in the defense industry toward large systems involving less mass-produced hardware. While in the future there will be less requirement for mass production, both R&D content and hardware dollars will continue to increase. The complexity of current and future systems will draw upon the skills of many and perhaps all DEP Divisions, as well as other RCA product divisions and the Laboratories. Accordingly, our approaches to future systems opportunities will increasingly utilize the broad capabilities within DEP and throughout the Corporation. We will make greater progress by selling RCA and its total capabilities than by selling only the skills within a Division.

Our challenge will be to present the strength of our diverse capabilities without sacrifice of the benefits of Divisional operation.

PRE-EMINENCE IN SELECTED AREAS

Defense electronics is a constantly broadening field and it is manifestly impossible to have representation in all areas. It is our policy to develop pre-eminence in selected technical areas. Our divisional goals, marketing objectives, and RCA funds for applied

Fig. 1—DEP staff meeting. L. to R.: *I. K. Kessler*, Division Vice-President & General Manager, Aerospace Communications & Controls Division; *M. Lehrer*, Manager, Southeast Region, Marketing; *W. G. Bain*, Vice-President & General Manager, Communications & Aerospace; *J. H. Sidebottom*, Administrator, Marketing Staff; *B. Kreuzer*, Division Vice-President & General Manager, Astro-Electronics Division; *A. L. Malcarney*, Executive Vice-President, Defense Electronics Products; *T. W. Massoth*, Manager, Administration; *S. N. Lev*, Division Vice-President & General Manager, Moorestown Missile & Surface Radar Division; *D. B. Holmes*, General Manager, Major Defense Systems Division; *H. R. Wege*, Vice-President & General Manager, Missile & Surface Radar; *W. E. Lloyd*, Controller, Finance.

Fig. 2—DOD defense expenditures by service.

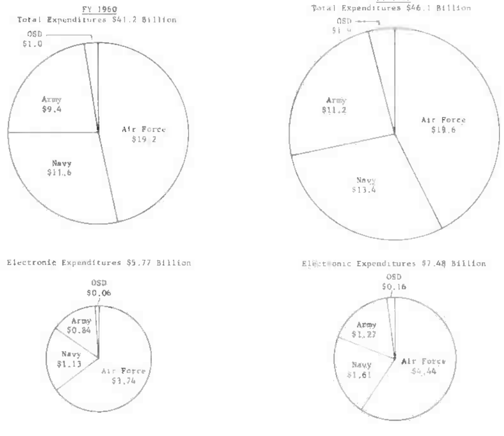
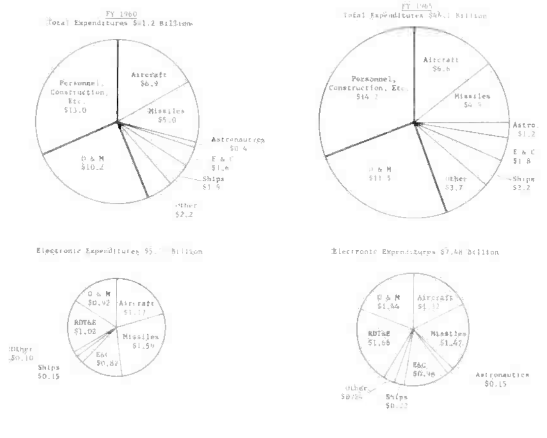


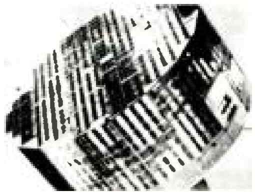
Fig. 3—DOD defense expenditures by budget category.





ARTHUR L. MALCARNEY'S career with RCA is a reflection of his unusual capability and personal effectiveness. After joining the Company in 1933 as a mechanical inspector he became successively an assistant foreman, foreman, and superintendent in manufacturing. Serving as Parts Plant Manager for one year, Art was advanced to General Plant Manager in 1947. He remained in this position until 1953 when he became Manager of Commercial Electronic Products. In October of 1955 he was elected a Vice President. On June 7, 1957 Mr. Malcarney was elected Executive Vice President, Defense Electronic Products, his present position. Art is a graduate of the Advanced Management Program of the Harvard School of Business Administration. Demonstrating his belief that a business and its executives should be good neighbors, Mr. Malcarney has been active in community affairs. After having served in many posts in the Camden County United Fund, he accepted the Presidency for 1961-62. Art's reputation as a competitor carries over from an athletic background. Hunting and fishing have supplanted baseball and football, but his interest in team play is manifest in his organization.





research and development are focused on developing strength in business areas showing potential. Our activities are geared toward business which will not only be currently rewarding, but which may be a springboard for future activity.

We attempt to strike a balance between sustaining bread-and-butter product lines and developing more exotic areas. Mature product lines account for a substantial percentage of our volume, and we cannot afford to overlook their potential for added business. At the same time, it is imperative that we build a technological base so that we may move to the forefront in new and expanding fields.

Communications and radar, for example, are two fields in which RCA has an established position and which contribute heavily to our bookings and billings. We must nurture business areas such as these while moving ahead aggressively and energetically in all forms of advanced work like data handling and space.

DEP AND SPACE

It is clear that the next frontier for man's pioneering spirit is the exploration of space. Indeed, this is one of the battlegrounds in the contest for the minds of men between the Communist and Free World. The technical challenges and business potential in this area are great. DEP has assumed a leadership role in space; it is our plan to broaden in this and other selected areas.

With such projects as TIROS, SAINT, and DYNASOAR, we are building upon a technical foundation involving many years of preparatory effort. But this activity is merely a prelude to a more comprehensive future.

As I noted previously, thorough planning involves the timely availability of manpower, technical skills, appropriate organization, and adequate facilities.

To accomplish our goals in space will require expansion of our physical assets. A substantial addition will be made this year to the Burlington, Mass., plant of the Aerospace Communications and Controls Division, to accommodate the needs of the SAINT program as well as other expanding lines. The plant addition will include a high bay area with a ceiling of 30 feet to permit assembly of the SAINT vehicle.

Another planned addition that will enhance our stature as a contractor in space programs will be the Space Environment Center at the Astro-Electronics Division, near Princeton, planned for completion late this year.

The Space Center will be the focal point for our space activities, which will draw upon the capabilities of all RCA Divisions for our activity in the conception, design, development, and production of earth satellites and space vehicles. It will include a test chamber equivalent in height to an eight-story building, and capable of simulating space environmental conditions. Thermal-vacuum, and temperature-humidity chambers; a complex vibration tester; and a rotary accelerator, in addition to extensive office, laboratory, and shop facilities will provide us with one of the most completely facilitated engineering plants in the space industry.

"TECHNIQUES" CONTRACTS—VITAL TO SUCCESS

Nowhere is careful planning more vital than in maintaining the balanced capability necessary to sustain present business while preparing for the future. While the concept of "team" operation has been overworked, it is nonetheless true that only through integration of the efforts of design-and-development and systems engineers, as well as project engineers, can we achieve our goals.

I am particularly interested in stressing *techniques* contracts, since they afford the opportunity to develop unique insights and approaches as well as basic capability in new areas. Techniques contracts are significant in several respects. Frequently, they may expand into significant R&D and production contracts in their own right. Also, our chances to win large procurements are enhanced if we can propose novel and advanced approaches as a result of our techniques work. *I am convinced* that the company which begins to work on a proposal *only* when a request-for-quotation is issued *seldom* has a real chance to win. Breadth and depth of experience in techniques as well as anticipatory work on a pending procurement are required to win major competitions.

Techniques work can be performed in design-and-development engineering as well as systems sections. Creativity cannot be assigned through the medium of a job specification, and I look to each of our engineers to spark ideas and unique approaches.

So firm is my belief in the importance of techniques development that I have established a substantial 1961 booking goal for techniques contracts in DEP and I am encouraging each of our Divisions to broaden its base in this regard.

MANAGEMENT BY OBJECTIVE

As you are aware, our management policy is to permit each of our Divisions to operate on an autonomous basis. Implicit in this type of operation, however, is the acceptance of goals and the necessity for achievement of objectives.

Planning at DEP and Divisional levels embraces the establishment of targets or objectives designed to improve operating performance or to strengthen competitive position. Planning may be considered to be the road map for operations, and our goals the destinations. You will be interested in several of the areas in which we manage by objectives.

Marketing Activities

In the marketing area, for example, our approach to the problem of getting new business is not broad and diffused. Marketing functions in each of the Divisions focus their efforts on specific product areas based largely on the skills within their associated engineering activities. In addition to the normal selectivity in seeking our new contracts, each Division has singled out three projects of greatest significance to the destiny of the Division. A program has been developed under the sponsorship of Central Marketing to bring all of the resources of the Corporation to bear upon winning these vital projects. This program has been named appropriately *Operation Capture.*

The logic inherent in our Capture approach is also being applied to the technical-proposal effort. Since each of our technical proposals and its associated bid quotation involves effort by engineers with proportional funding, contacts with customers, printing, and other expenses, we will discriminate more finely among the various opportunities to bid. We have established goals for each Division in improving the conversion ratio of proposals to bookings by using selective bidding techniques. In this manner, we can concentrate our efforts and funds in those areas where the pay-off percentage appears brightest.

Control of Costs

Goals, or objectives, are established in each of our areas of operations in the form of budgets, targets, or tasks. Such criteria serve as controls not only to measure performance, but also to bring about improvement in our competitive position. Despite continued growth of the defense market, price competition is intensifying, and the lowest bidder whose proposal is technically acceptable will receive the contract.

Control of costs cannot be achieved merely by attitude or acceptance of the concept. While it is surprisingly easy to accumulate cost, the elimination of costly or wasteful practices, or reassignment of personnel is a painful, difficult process.

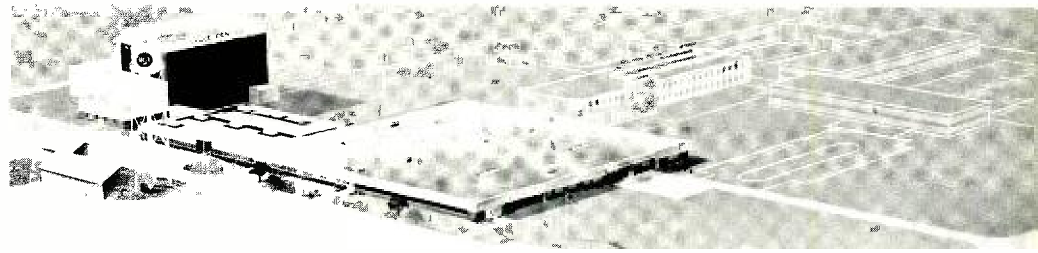


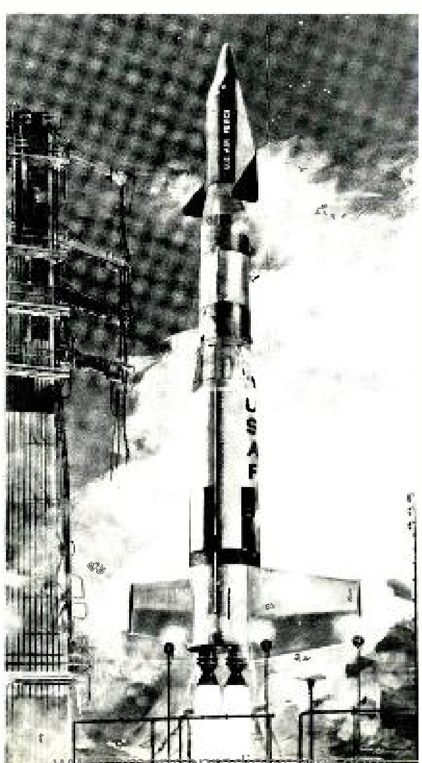
Fig. 5—The DEP Astro-Electronics Division facilities at Princeton, N.J. High structure at upper left is the new environmental test laboratory scheduled for completion in Fall, 1961. In phantom at upper right is potential future facilities expansion. Present facilities are at center.

We have established goals to lower the ratio of indirect-to-direct personnel. We will continue to eliminate unnecessary expenses at all levels of DEP, including higher management. If, coupled with such reductions of overhead expense, *our engineers individually and collectively will concentrate on low-cost design,* we can improve our competitive position immeasurably.

PROFESSIONAL ROLE OF THE ENGINEER

Since we are in the business of supplying technical products and services to the government, much of our success will be determined by the effectiveness of our engineers and scientists. We expect that each of our engineers will make his technical contributions in his area of greatest skill.

Fig. 4—The DYNASOAR



There is *much more,* however, that each individual can contribute through insight into the management process and his personal involvement. As professionals, we do not exist as isolated individuals. We are intimately involved in the welfare of the organization, and in the course of making our technical contributions must be alert to the other factors involved.

Through awareness of our professional status and obligations, we can contribute significantly in advancing the affairs of the Corporation—advancing our personal competence and stature in the process.

The mature professional can contribute by:

...creating *new ideas* to solve military problems,
...actively seeking *lower-cost design,*
...increasing the *technical competence* of the organization,
...developing an *interest in management concepts* while advancing himself professionally,
...recognizing his role as *RCA agent* in all outside contacts, and
...functioning as a *salesman* for RCA and its products

IN SUMMARY

DEP's plans for the future are for growth—in volume and technical competence. I have stressed the planning precedent to growth, the developments and problems to be anticipated, and some of the approaches we are taking to achieve our goals.

I should like to stress our own *obligations* as a major supplier to the government. Through intelligent planning, judicious investment of research funds, rigid economy in design and operations, and emphasis on reliability of equipment, we can discharge our responsibilities as individual and Corporate good citizens.

The disciplines that will advance the affairs of RCA and bring rewards to the individual are *precisely those* that will perform the greatest service to our government.

DEFENSE ELECTRONIC PRODUCTS
. . . Engineering Organization and Facilities

by **C. A. GUNTHER**
Chief Defense Engineer
Defense Electronic Products
Camden, N. J.

Defense Electronic Products is an integrated segment of RCA serving one prime customer—the United States Government. Fig. 1 portrays in a highly schematic fashion the relationship of DEP to other major product or service areas of the Corporation. We are indeed fortunate to operate in an electronics business environment which parallels the scope of the total industry—and therefore contributes so directly to the success of our defense business and technical goals.

CONTRIBUTING INDUSTRIAL ACTIVITIES

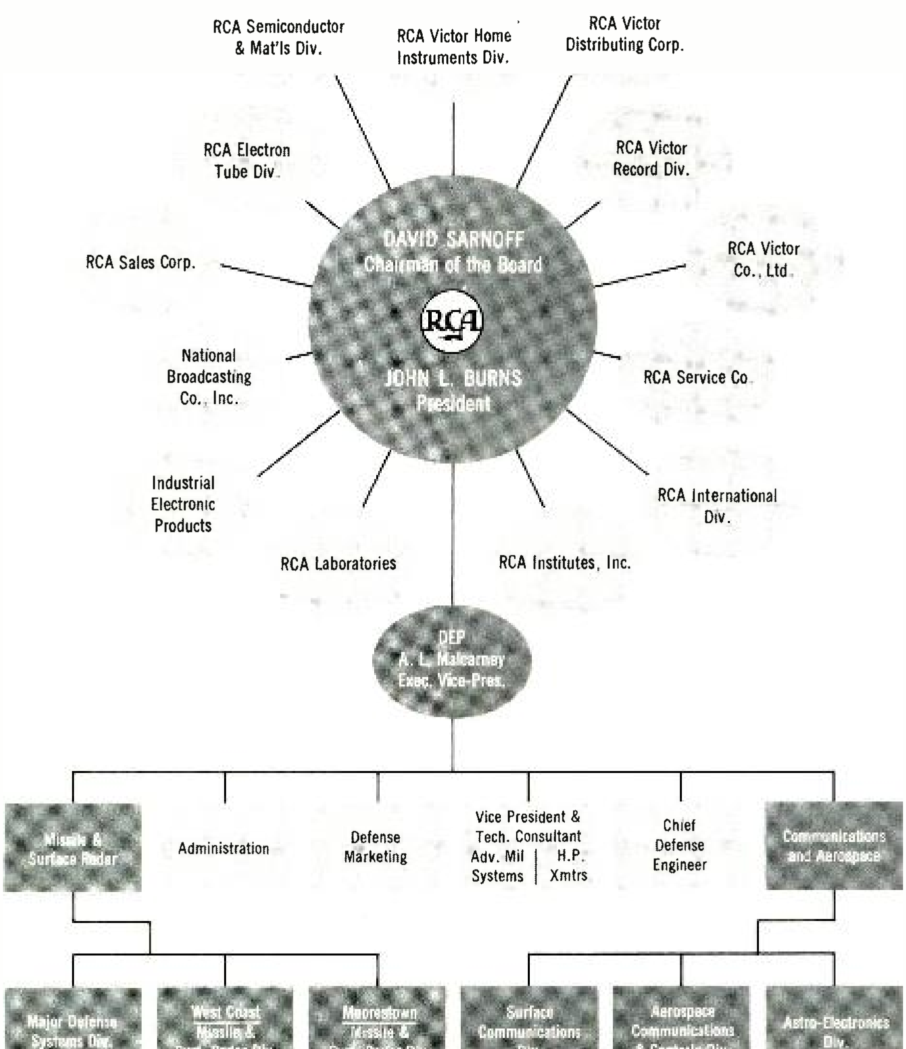
Within RCA's varied business complex, there are specialized engineering activities in virtually every division supplying valuable knowledge to our DEP programs. For example, the RCA Laboratories make important contributions toward our basic research—the foundation of our research-and-development contracts. Commercial product design and development and applied-research engineering areas contribute heavily, too. Home Instruments Division engineers, for instance, originate circuitry important to military communications and displays. The soundness of practically all of our military electronic products hinges upon the effective utilization of electron tubes, semiconductors, computer memory planes, and numerous devices, materials, and components emanating from the RCA Electron Tube and Semiconductor and Materials Divisions.

The RCA Service Company, a world-wide organization, is vital to the effective implementation of RCA's turn-key projects and supports us heavily in other areas, such as BMEWS. RCA International has been a rigorous proving ground for industrial products and a major factor in expanding our business external to the continental U.S. On the surface, NBC may seem to have little relationship to DEP products; on the contrary, its operation involves a very complex engineering system from which much practical knowledge is gained and applied to military systems.

INDUSTRIAL PRODUCTS FOR DEFENSE

Situations arise in the defense business where the operating environment does not require strict adherence to military specifications. In these cases, our sys-

Fig. 1—Organization of Defense Electronic Products related to RCA corporate activities.



MAJOR DEFENSE SYSTEMS DIV.
Moorestown, N.J.
Bedford, Mass.

WEST COAST MISSILE & SURFACE RADAR DIV.
Van Nuys, Calif.
Los Angeles, Calif.

EAST COAST MISSILE & SURFACE RADAR DIV.
Moorestown, N.J.
Riverton, N.J.
Croydon, Pa.
DAMP: USS American Mariner

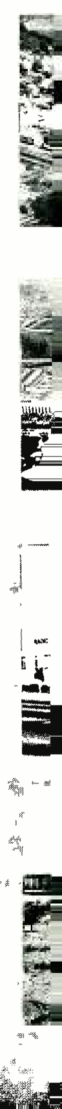
SURFACE COMMUNICATIONS DIV.
Camden, N.J.
Cambridge, Ohio
New York, N.Y.
Tucson, Ariz.

AEROSPACE COMMUNICATIONS & CONTROLS DIV.
Camden, N.J.
Burlington, Mass.
New Castle, Del.

ASTRO-ELECTRONICS DIV.
Princeton, N.J. (Locust Corners)
Princeton, N.J. (at RCA Laboratories)

STAFF: DEFENSE ENGINEERING
Camden, N.J.

STAFF: ADVANCED MILITARY SYSTEMS
Princeton, N.J.



Note: Washington, D.C. offices shown in photo are for general DEP activities. DEP executive offices are in Camden, N.J. Locations at Princeton Labs., Bedford, Mass., and Riverton, N.J., not shown in photos at right.

Individual locations shown at right are devoted to a single DEP activity except for Camden (Surface Communication Division, Aerospace Communication and Controls Division and Staff Defense Engineering)—and Moorestown (East Coast Missile and Surface Radar, and Major Defense Systems Division.)

tems can become more competitive by utilizing high-quality industrial products both individually and as building blocks; TV systems, computers and their components are typical examples.

Industrial Electronic Products, for example, is a major operating unit made up of several separate product divisions and is thus similar to DEP, organizationally. IEP is a substantial supplier of many products and new techniques directly useful in solving problems associated with military electronic systems.

Normally, DEP's products are designed to meet more severe environmental conditions than those encountered in commercial service and, therefore, few military products can be economically justified for direct industrial uses.

Since advances in the state-of-the-art are continuously finding their way into commercial products, it behooves our defense engineers and their management to maintain close contact with all commercial engineering areas; in this way DEP can take full advantage of an unusually favorable technical environment in improving our national defense.

THE DEP ORGANIZATION

Figs. 1 and 2 show the DEP organization and location of major activities.

The Executive Vice President of DEP operates with two line organizations and staff support. Each of these line operations is comprised of three divisions by product areas. Each product division is equipped with its own administrative, marketing, manufacturing, and engineering functions, with the exception of Major Defense Systems Division, which relies on the other two divisions of the M&SR organization for manufacturing.

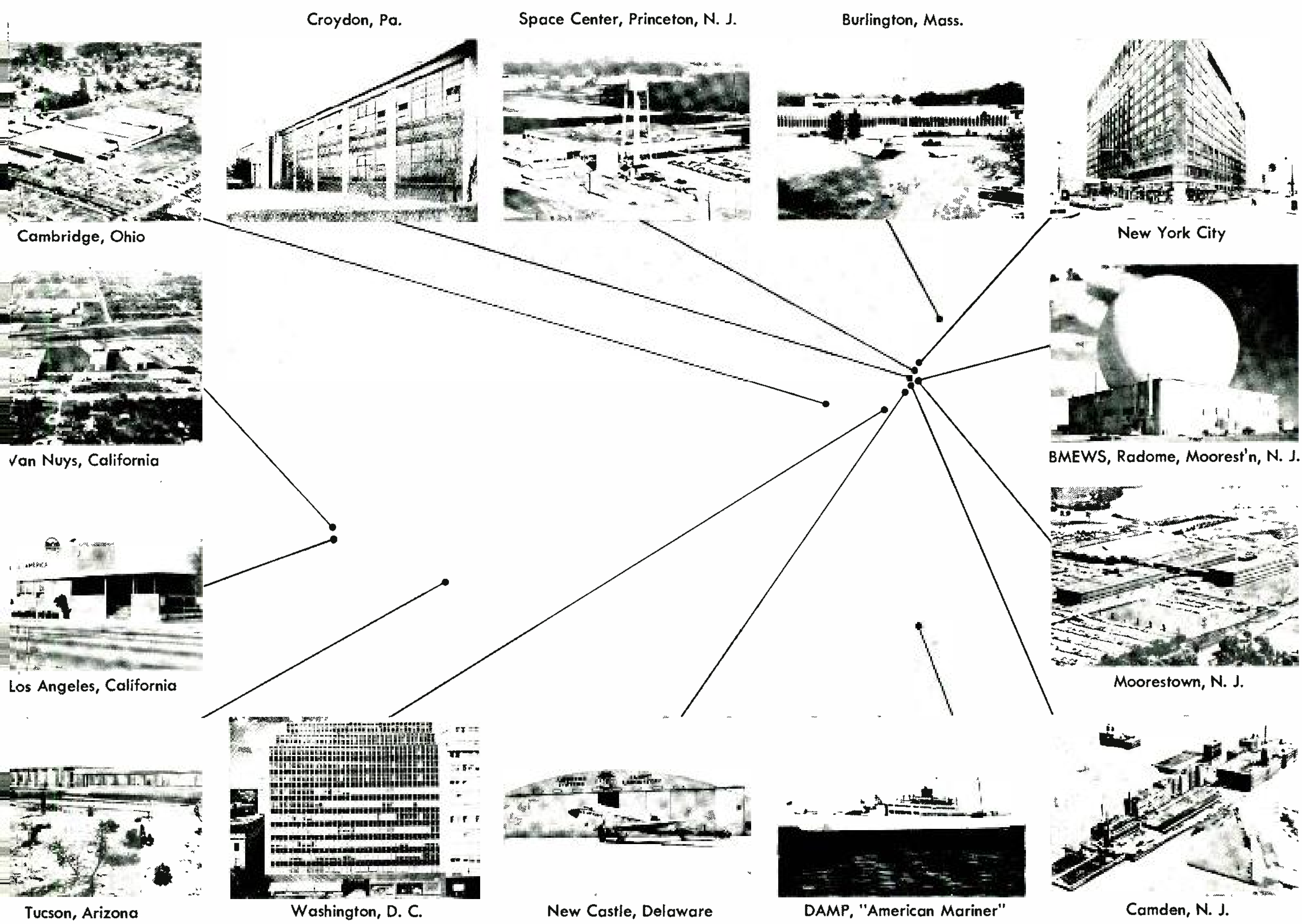
The general philosophy of the engineering organization within a typical division (Fig. 3) will be described in the material which follows. For the sake of brevity, only those DEP staff functions which pertain to the technical activity will be reviewed.

DEP STAFF: ADVANCED MILITARY SYSTEMS, AND HIGH-POWER TRANSMITTERS

There are basically two staff functions (Fig. 1) under the direction of the Vice President and Technical Consultant: one is Advanced Military Systems, and the other the High-Power Transmitters group.

The Advanced Military Systems under Dr. N. I. Korman is located in Princeton and is composed of senior scientific management personnel. Because of the wide variety of disciplines available in this activity, *ad hoc* operations-research teams may be readily formed; they evaluate and explore the possibilities of future military systems to assist in technical planning. As projects demand additional support from either the DEP Staff or the operating divisions, such assistance is integrated for the studies required. When the projects become more mature, they are taken over by one or more of the military product divisions, and AMS continues to provide technical consultation.

Fig. 2—DEP activities and their locations.



The High-Power Transmitter function coordinates associated and related engineering activities throughout RCA. This endeavor involves coordination work within DEP, the Laboratories, the Electron Tube Division, and the Semiconductor and Materials Division.

DEP STAFF ENGINEERING

The Staff Engineering activity, under the supervision of the Chief Defense Engineer, is comprised of the four functions shown in Fig. 4. A major responsibility is to provide engineering and technical counsel to the other DEP staff functions. Another major responsibility is the interdivisional technical coordination of research and development work and administration of DEP's independent research and development program under the direction of the Executive Vice-President and his Staff. This involves coordination with each of the divisions which do research and development; work is based on obtaining independent research and development funding necessary to support the products and systems in their spheres of interest. Each division must be responsible, with DEP Staff guidance, for the appropriate interchange of technical information within DEP, with other elements of the Corporation, and with the engineering community. All of the Defense Engineering Staff functions described below are located at Camden, with the exception of a small but highly competent computer systems activity in Washington.

Product Assurance is a term which has become very meaningful to DEP operations. This staff function parallels the work of its counterparts in the operating divisions to assure optimum tradeoffs of product value, reliability, maintainability, and product quality as well as adequate field liaison.

The *Central Engineering* function works with the operating divisions to establish standards of components, materials, and design techniques. This function is highly important in reducing our costs of purchased materials and making available to the engineer standardized information to simplify his design job. Such standardized methods, distributed to the divisions, facilitate balancing manufacturing load between plants. Central Engineering provides "on-call' consultation service and also performs studies leading to appropriate techniques for measurement of reliability and maintainability.

Applied Research creates and fosters new techniques which may be useful ultimately across-the-board within the divisions. Applied Research is active in signal processing, pattern recognition by simulated neural networks, solid-state circuits, thermoelectrics, recording techniques, high-speed printing, plasma physics, masers, fiber optics, and electrostatic recording and displays. Such research studies usually precede specific divisional interest, yet they lead to new products and systems with no current home within a product division.

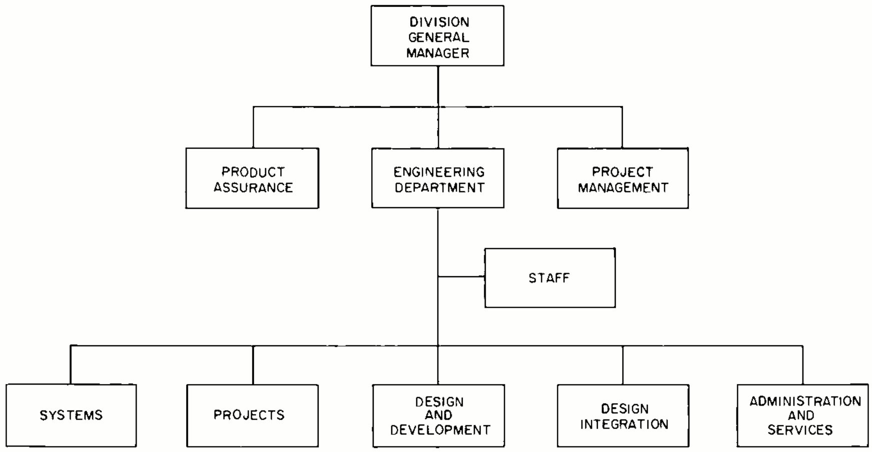


Fig. 3—Organization of a typical DEP Division.

A TYPICAL DEP OPERATING DIVISION

There is a general philosophy or pattern applicable to the organization of the technical efforts within the six operating divisions of DEP. In all cases, there is a vital relationship between marketing and the technical operations. The technical organization in each division is tailored to fit the business requirements, the product areas, and intradivisional geographical requirements. To describe the organization of each division in detail and explain the rationale for modification of emphasis in the pattern could be material for an article in itself. In the interest of brevity, the departmental relationships within an imaginary yet a typical organization (model shown in Fig. 3) are discussed. In addition to these technical efforts, support between Administrative and Service functions are vital to the efficiency of operation of the engineering activities.

Design and Development

The Design and Development function, coordinated by Projects, is responsible for the origination of the design to be produced. The documentation required by Manufacturing, and the cooperation with Manufacturing assisted by Design Integration are essential to the production of a successful product. In this function, there is room for a high degree of creativity and understanding of how the output of this activity will be utilized by others in an effective fashion.

Within the Design and Development function, which usually comprises the largest engineering force, the operation is organized either functionally; — by technical areas such as transmitters or indicators — or by product areas, such as communication engineering or underseas warfare engineering. Although the major effort on techniques resides in design and development, it has been found advantageous to include certain advanced techniques work in some of the Systems activities.

Product Assurance

The Product Assurance function, reporting to the Division General Manager, has the same general assignments within the purview of the division as those of the DEP staff function with respect to DEP's total operations. However, in this case, implementation of Product Assurance fans out specifically into the operating areas where any one element of Product Assurance may logically report at the level most effective in carrying out its mission. For example, Quality Control is very much concerned with the manufacturing-inspection operation as well as testing prototype or field-service models, a responsibility of the Engineering Department.

Formalized design reviews are held in connection with major systems projects or products. At these design reviews, the appropriate engineers, first-line supervisors, design integration personnel, and as required, manufacturing, tooling, purchasing, or marketing support personnel are consulted. Reviews occur at the following phased project milestones: when the system is definitized; when the detailed project specifications are completed; when the work is released for construction of the prototype; and when the project is ready for manufacturing release. At each of these milestones, the project is reviewed for each of the product assurance elements as well as for technical correctness and ability to meet performance requirements. By making this review at the times indicated, appropriate judgment can be applied as to the important trade-offs involved.

Project Management

Project management, as mentioned by Mr. Malcarney in his article, occurs at a level dependent upon the degree of coordination required. When many divisions are involved, this function may report to one of the deputies of the Executive Vice President. If the problems primarily involve activities within the division, the function will report to the Division General Manager. When the project is primarily engineering, and involves coordination between engineering functions with the divisions, it will be provided as in the block labelled *Projects*. When the project resides primarily with a single functional supervisor, he may be assigned full responsibility for the project.

Many of our engineering departments have a small staff of highly competent managerial personnel to advise the department head with respect to plans, policies, and serve as a coordinating function.

Systems

Systems has the task of understanding the basic military requirement and interpreting this requirement into fundamental block diagrams. To achieve this objective successfully, the engineers must keep advised regarding schedules and costs and have a thorough appreciation of the state-of-the-art in connection with pertinent techniques pursued by Design and Development activities within and without the Corporation.

Projects

Projects receives the information formulated in the Systems function and translates this into a detailed workable technical plan with scheduled milestones. In performing this function, Projects draws heavily on the experience of the Design and Development function. As the major project matures from initial systems concept to implementation, there is a gradual shift in major responsibility from Systems efforts to Projects; however, some degree of systems optimization effort will continue throughout the project. Projects is also responsible for the delivery of documentation required under the contract and may be involved in the planning, scheduling, and management of field installation, customer acceptance, and in some cases, field operation.

DECENTRALIZATION OF DEP OPERATING DIVISIONS

The engineering and applied research structures of the various operating divisions is generally the same as that of the typical one described. However, each division will vary from the others in certain small details peculiar to the specific division. Keeping the general organization pattern in mind, the following capsule descriptions of the geographically scattered and specialized divisions may be useful to the reader (see photo-caption montage of Fig. 2).

As a result of careful study during the growth of Defense Electronic Products, plants and technical operations have been implemented at a number of locations in U.S.A. Among the factors considered are diversification to permit decentralization of management. This in turn affords a large organization the ability to make appropriate decisions promptly. From a technical point of view, this decentralization enhances our ability to attract competent engineering and management people. Also, there is an advantage in having certain of our operations located close to the customer. As shown in Fig. 1, and described below, the main operating divisions are grouped into two "line" units (Missile and Surface Radar, and Communications and Aerospace) consisting of three divisions each.

THE THREE MISSILE AND SURFACE RADAR DIVISIONS

The three Missile and Surface Radar line organizations are: the *West Coast M&SR Division;* the *Moorestown M&SR Division;* and the new *Major Defense Systems Division.*

Major Defense Systems Division (MDS)

This new Division is located at Moorestown and acts as manager for major systems within Missile and Surface Radar. It also operates a Ballistic Missile Early Warning Systems liaison office at Bedford, Massachusetts.

The Major Defense Systems Division has demonstrated its capability as a major system contractor by its performance on the BMEWS System—the largest single contract ever awarded RCA. This vast early warning system, consisting of three immense radar installations in Greenland, Alaska, and the United Kingdom, as well as communication links, computers, and displays necessary to present warning information accurately and rapidly to the North American Air Defense Command (NORAD), has been built on a very tight schedule under extremely difficult environmental conditions. The effort involved 485 large companies and 2415 smaller firms as subcontractors or suppliers to RCA.

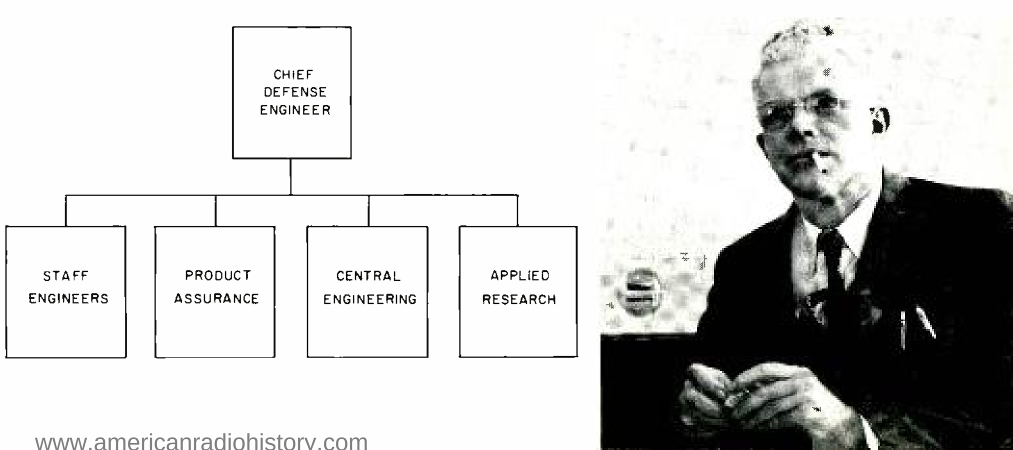
In addition, MDS is concerned with global warning and surveillance systems; aerospace defense system, including advanced AICBM and ASLBM systems; command and control centers, such as NORAD Command Operation Centers and Joint Chiefs of Staff Command Operation Centers; and advanced weapon systems, including ICBM and Tactical Ballistic Missile Ground Environments.

West Coast Missile and Surface Radar Division (WCM&SR)

Located at Van Nuys, California, this Division also operates a manufacturing facility in West Los Angeles. This operation is responsible for the ATLAS Checkout and Launch Ground Based Equipment, an active system at many ATLAS sites throughout the country.

CLARENCE A. GUNTHER graduated from Princeton University in 1926 with the degree of BSE. He entered the employ of the General Electric Company in the Radio Department, and was transferred to RCA at Camden in 1930. He continued to work on special receiver development and soon became Section Leader of the Special Receiver and Direction Finder Group. In 1945 he was appointed to the position of Assistant Chief Engineer of the Engineering Products Division. In 1955 Mr. Gunther was appointed Chief Government Engineer, responsible for the administration and operation of Government Engineering activities, EPD, and received his present post of Chief Defense Engineer for DEP in late 1955. Mr. Gunther served as a civilian advisor to the office of the Secretary of War on air warning and bombing during World War II. He is chairman of the Task Group on definitions of RETMA (EA) Reliability. He is a member of the Radio Pioneers Club; the American Society of Naval Engineers, and the Philadelphia section of the Armed Forces Communications Association. Mr. Gunther received the *RCA Award of Merit* in 1952; and was named a *Fellow* of the IRE in 1954.

Fig. 4—Staff of the Chief Defense Engineer, C. A. Gunther (photo).



Data-processing equipment pertinent to the BMEWS project is designed and built here. Other activities involve ground support equipment, navigational radar systems, and electronic counter measures. This operation is the focal point of military data processing and displays within DEP.

Moorestown Missile and Surface Radar Division (M&SR)

As the name implies, this Division has its home office at Moorestown, N. J. A production facility at Croydon, Pa., and a data reduction facility at Riverton, New Jersey are associated operations.

M&SR systems include radars and sensors operating throughout the entire electromagnetic and optical spectrum, analog and digital data processing and transmission systems, computers, displays and acquisition aids and control systems. M&SR systems are active in the Atlantic, Pacific, and at White Sands Missile Range.

Current projects include: the AN/FPS-16 Instrumentation Radar—the world's most accurate C-band tracking radar—standardized by the direction of the Secretary of Defense for use by our military services throughout the world for precision tracking of missiles; MIPIR, a missile precision instrumentation radar; TRADEX, an instrumentation radar system with the ability to track missiles traveling at extremely high speeds and discriminate the target from a large number of decoys; and DAMP, the Down-range Anti-ballistic Measurement Program that obtains vital information on flight behavior and performance of ICBM's in the terminal phase of their ballistic flight.

Advanced technique work is proceeding in plasma physics, magnetohydrodynamics, and correlation techniques. Transmitters are another important product being developed in Moorestown. The Antenna Systems group was recently designated the Antenna Skill Center for DEP.

THE THREE COMMUNICATIONS AND AEROSPACE DIVISIONS

The Communications and Aerospace line organization is also comprised of three distinct divisions (see Fig. 1). These are *Astro Electronics Division*, *Aerospace Communications and Controls Division*, and the *Surface Communications Division*. Communications and Aerospace at present involve four projects of such character that the Project Management functions have been assigned to the Vice President and General Manager, as a staff activity. These are the ELCO Program based in Washington, D.C., the DYNA-SOAR Program based in Camden, the SAINT Program based at Burlington, Mass., and the Global Communications Program based at Paramus, New Jersey.

Surface Communications Division, (Surf Com)

SurfCom, with its home office in Camden, operates a systems function and carries on some design and development work in New York City and in Tucson, Arizona. The SurfCom manufacturing facility, which includes engineering support, is in Cambridge, Ohio.

SurfCom is active in the fields of digital communications systems and equipment, tactical data processing, intrasite communications, subscriber equipment, input-output devices, acoustical equipment and speech compression. Its systems include global communication systems; radar, telephone, telegraph and cable communications; radio relay; missile range communications; ground-based data-link projects, and switching equipment. Advanced system studies are under way in connection with electronic warfare and intelligence systems, and advanced communications techniques. Current activities include combat radio and DYNASOAR ground communications equipment, the AN/GRC 50 UHF Radio Relay. SurfCom is also the home of magnetic recording for defense applications. In cooperation with the Somerville Semiconductor activity, SurfCom is the father of the micromodule program and is applying this technique to practical apparatus.

Aerospace Communications and Controls Division (ACC)

ACC's operations include facilities at Camden and Burlington, Mass., and an engineering activity at New Castle, Delaware.

In the air-borne communications field, the Camden facility has been highly successful in producing time-division data link systems for the Century Series aircraft and for certain guided missiles. The Systems Support product line provides automatic dynamic testing equipment for manned aircraft, missiles, and space vehicles, thus markedly increasing equipment availability and reducing maintenance time. This division is a leader in underseas-warfare programs, and is competent in the fields of airborne radar, electronic-warfare systems, and advanced radar techniques, including advanced data-processing methods applicable to digital communications systems and reconnaissance. Active in the air-traffic-control field, ACC operates the New Castle engineering facility which includes a flight laboratory and data reduction capability.

The Burlington facility, which supports the SAINT project, is a leader in infrared detection work. This operation produces equipment for the Air Force, performs work on missile seekers, and is doing research in connection with AICBM systems. Activities also include the development of an inertial platform and an associate digital differential analyzer using micromodules, and unique in small size and weight. The control of hydrofoils, work in the field of comprehensive simulation work on missile-borne miniature computers, and advanced work in connection with AICBM radar techniques, satellite tracking systems, and advanced coding methods are other areas of interest.

Astro-Electronics Division (AED)

AED facilities, located near Princeton, N. J., include elaborate equipment for simulating space environment and is the home of the new Space Environmental Center mentioned in Mr. Malcarney's article.

The TIROS weather satellites are typical products of this division, representing a highly successful program which has exceeded the customer's expectations. Tiros II has been in orbit since Nov. 23, 1960 and had taken 30,260 pictures as of May 5, 1961. Projects SCORE and ECHO contained communications equipment reflecting this Division's work. In cooperation with the Electron Tube Division, a travelling-wave-tube system is being developed. Information transmitted from the satellites has been effectively processed by ground-based data-handling equipment. Studies are in progress on advanced space systems and on techniques fundamental to the implementation of these systems. Techniques include television phototape, plasma acceleration, video sensors, special solar power supplies, and involve applied research associated with thermal problems, application of materials, and stabilizing systems.

SUMMARY

In summary, the technical relationship of DEP to other elements of the Corporation, the technical organization between divisions and within divisions have been discussed and the location and product interests of DEP activities have been outlined. It is hoped that those reading this article will find it useful in determining areas to which they can contribute knowledge and with whom they can consult for technical advice; it is also hoped that the reader will have gained a somewhat broader impression of the environment in which we are working.

THREE RCA MEN

ELECTED

IRE FELLOWS

The three RCA men appearing on this page have been honored for their professional achievements by being elected *Fellows* of the Institute of Radio Engineers. This high honor is bestowed each year upon those who have made outstanding contributions to the field of electronics.

. . . for contributions in many fields of radio engineering

THEODORE A. SMITH, Executive Vice President, RCA Industrial Electronic Products, has been associated with RCA since 1925. Mr. Smith supervised the construction of RCA's pioneer TV station *W2XBS* New York in 1928, and later held sales, engineering and administrative posts of increasing responsibility. In 1942, he became Staff Assistant to the Manager of the Engineering Products Department. He was promoted to General Sales Manager of that Department in 1946 after serving for a year and a half as Manager of the Transmitter Sales Department. From 1951 to 1953, Mr. Smith was Assistant Manager of the Engineering Products Department. He then was elected Vice President and General Manager of the Department and became Vice President and General Manager, RCA Defense Electronics Products, in October, 1955. He was elected to his present position of Executive Vice President, Industrial Electronic Products, on June 7, 1957. Mr. Smith holds a Mechanical Engineering degree from Stevens Institute of Technology at Hoboken, N. J. He has a number of patents on television and other products, and is the author of several radio engineering papers. In the Institute of Radio Engineers, he is past chairman of the Philadelphia Section. He is past chairman of the Technical Products Division, Radio-Electronics-Television Manufacturers Association, and a Member of the Armed Forces Communications Association and of the American Society of Naval Engineers.

. . . for contributions in electron optics and electro-luminescence

DR. FREDERICK N. NICOLL received the B.S. degree in 1929 and the M.S. degree in 1931 from the University of Saskatchewan, Canada. He received a Ph.D. in Physics from the University of Cambridge, England, in 1934. From 1934 to 1939 he was a research physicist with Electrical and Musical Industries, Ltd., London, England, working on TV, cathode ray tubes and theater TV projection. In 1939, Dr. Nicoll joined the RCA Manufacturing Company, Camden, where he did work in optics, TV, and low-reflection glass; the latter work received wide-spread publicity in both the scientific and popular press. In 1942, Dr. Nicoll transferred to RCA Laboratories. Dr. Nicoll has had experience in optics, electron optics, and various vacuum devices. He has worked with cathode-luminescent and electroluminescent materials, and photoconductors, in particular with their application to light-amplifier display panels. He holds 50 issued patents in the above fields with more than 20 pending. The results of some of the work have been published in more than 20 articles. He was a recipient of a team award on the tricolor kinescope in 1950 and *RCA Achievement Awards* for team performance in 1951 on electron guns, and in 1954 and 1956 for work on solid-state image-intensifying panels. In addition to the IRE, Dr. Nicoll is a member of Sigma Xi and APS. He is listed in *Who's Who in Engineering* and *American Men of Science.*

. . . for contributions to experimental wave-propagation research

GILBERT S. WICKIZER received his BSEE from Penn State College in 1926. He joined RCA in 1926 in the Transoceanic Communication Facilities at Rocky Point and Riverhead, N.Y. In 1942 he became a member of the Technical Staff of the RCA Laboratories, working at Riverhead, N.Y. In May 1961, Mr. Wickizer assumed the position of Staff Engineer in the Systems Engineering activity of the DEP Major Defense Systems Division at Moorestown. Mr. Wickizer is a specialist in the field of wave propagation — including low-frequency, high-frequency, very-high-frequency, ultra-high-frequency, radio-relay, tropospheric- and ionospheric-scatter, and meteor-path. He has carried on investigations of wave propagation in the diffraction field. He joined with Signal Corps Engineering representation in surveying the diffraction phenomena in the Alaskan, Japanese, and Korean areas. Mr. Wickizer also has been active in the fields of direction finding, frequency measurements, receiving antennas, and field-strength measurements. For the past few years has been active in studying communication possibilities via meteor paths and communications above the maximum usable frequency. In 1954, he received the RCA Laboratories *Award for Outstanding Work in Research* for his investigations of wave propagation in the diffraction field. He holds a number of patents and has authored numerous technical papers. In addition to the IRE, he is a Member of the American Meteorological Society, the Arctic Institute of North America, and Eta Kappa Nu.

HIGH-RELIABILITY COMPONENT-PARTS PROGRAM

I. K. MUNSON, Mgr.
Central Engineering

A. J. SCHWARTZ, Mgr.
Components Standards

B. H. ROSEN, Ldr.
Electron Devices

S. SCHACH, Ldr.
Microwave & Std. Circuits

Central Engineering
DEP, Camden, N. J.

[Note: I. K. Munson is now Project Office Production Manager, DEP SurfCom, Cambridge, O. R. P. Dunphy is now Mgr., DEP Central Engineering.]

The trend in defense contracts is to require more quantitative measures of performance reliability. These stiff requirements depend heavily on selection and use of the right components. This engineering challenge is being met through better practical techniques for measuring quantitative component reliability and improved techniques for component selection, as described here for DEP work on a typical large weapon system.

COMPONENTS OF the very highest reliability obtainable are vital to the over-all success of most defense systems. Yet, as recent as two years ago, a check of a popular professional journal revealed only *one* component advertisement that included reliability (failure rate) in its claims. Today, in sharp contrast, several major suppliers of components have taken the initiative in offering exact reliability guarantees in quantitative terms.

Equipment-development contracts in DEP have evolved similarly, so that an ever-increasing number now require *quantitative* reliability levels of performance. The necessary steps in complying with "figure-of-merit" contracts must include at least system design, component selection, circuit design and component application in the circuit, vendor selection through qualification, design review, testing, and production control. The problem of meeting the demands of such contracts has led to DEP programs for assuring high-reliability component parts, as described herein for one large weapon system.

EARLY TRENDS

When the ARC-21 communications gear required an attack on component selection in 1954, mass testing was employed; failure rates were not available and were not sought. Instead, the approach was to build in margins of safety in component use and to test the equipment in production as final proof of sound design. In retrospect, we observe that the average component failure rate in the 1954 era, as finally used in the ARC-21, was about 0.5 %/1000 hr. There were, however, no transistors in use at that time and internal heating of equipment added to the stresses placed on components.

Major breakthroughs were achieved in system reliability with the advent of transistors, although the first transistorized equipment did not approach an order-of-magnitude improvement. Generally, transistors have been mounted on printed-circuit boards and used in greater numbers than tubes (three transistors are generally required to replace two tubes). Therefore, transistorization increased the number of resistors and associated components. More components always mean more connections; each contact point has a finite reliability level which must be taken into account.

Another significant trend affecting component reliability is the increased use of digital circuitry. Digital communications, automatic test and check out equipment, and radar data-analysis are typical of the many applications using large numbers of digital circuits.

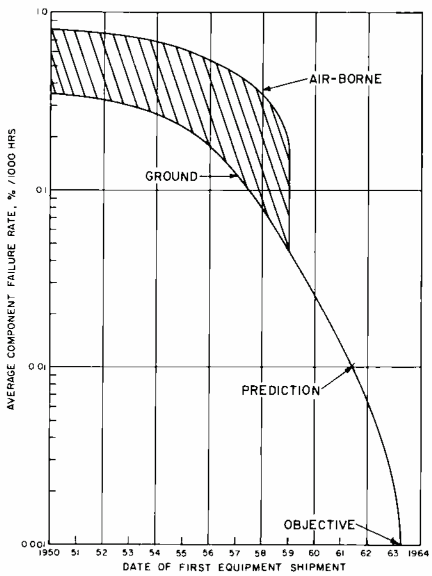


Fig. 1—Component failure rate vs. year of first equipment shipment.

Digital circuits offer many desirable functional design advantages, but involve large numbers of diodes. Fortunately, transistor and diode circuits are low heat generators and low-voltage devices that improve system reliability. The associated circuit needs for low-voltage decoupling capacitors have been largely satisfied by tantalytic capacitors, now used in large quantities. Low voltages and currents created a new kind of "dry circuit" problem in the connector field, although this has not become very troublesome.

Considering all the pros and cons, digital circuitry offers a tremendous advantage because of the high degree of circuit standardization possible. A basic flip-flop or adder circuit is often used in hundreds or thousands of places in a complex system.

The end results of these more recent trends in complex systems is a reduction in the variety of components used, an increase in the quantity of given types of components, and new sources of *un*-reliability to replace some of the old problems.

To a much greater extent, DEP customers have been making definite requirements for reliability in service, and these requirements are becoming more and more demanding of the systems designer. Our military customers have shown a willingness to depart from their usual logistics support practices where the contractor is able to technically justify some other approach. Examples of this are: 1) on-the-site logistics support, 2) automatic test equipment usage, and 3) new concepts in component specification and maintenance.

Consider some of the trends of certain DEP major systems engineered since 1952 in quantitative terms. By counting the electronic parts used in each, and observing the over-all system reliability (failure-rate ratio in percent per 1000 hours), we can arrive at an average part reliability level as a function of time; Fig. 1 is a graph of this function extrapolated out to 1964.

The individual part reliability level improves only as a result of the requirements placed on component manufacturers, development effort by component manufacturers, monitoring of accomplishment through qualification testing, careful application of components in circuits, and in some instances, preconditioning and selection of parts for production. Low-reliability parts are still plentiful, although major suppliers have become quite aggressive in their reliability improvement programs.

Proving reliability statistically at the part level has become necessary to gain meaningful data. When the desired part

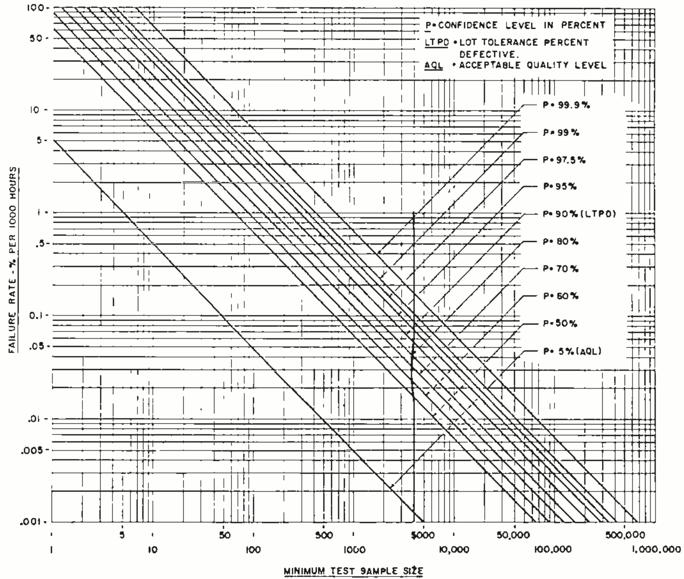


Fig. 2—Minimum sample required to establish failure rate at indicated confidence level. (1000-hour test, no failures during test.)

reliability is high (low failure rate) a large sample-hour product is required. This is evident in the Fig. 2. The confidence level desired also affects the sample size required.

It has been widely publicized that the average component reliability level required for some large weapon defense systems is approaching 0.001%/1000 hr. At a 60-percent confidence level for a typical part, this will require testing 90,000 samples for 1000 hours with no failures.

To strive for such reliability levels, DEP Central Engineering used the following approach in a major weapon-system program:

1) development of a practical program for selection and control of parts;
2) devised a verification test program to substantiate nonstandard part selection and improve their specification;
3) development and establishment of facilities for automatic component parameter measurement;
4) development of part-preconditioning techniques (e.g., *burn-in*, component operation for trial periods to assure highest reliability).

PARTS SELECTION AND CONTROL

Because component control is so vital to an effective parts program, the Systems Project Office teamed up with Central Engineering in establishing a Component Parts Program. To assure the needed control under this program, a Standard Parts Working Group was set up within Central Engineering as the technical arm of the project office on component matters; at the same time, this group works directly with equipment design groups (Fig. 3).

Standard Parts Manual

A manual specifying standard parts, to form the basis for all part selection wherever possible, was provided by the weapon-system prime contractor. Utilization of parts specified in this manual was a contractual requirement with the following exceptions: 1) where no standard part was available or; 2) where the use of a listed standard part would compromise RCA design objectives.

The standard-parts manual specifies parts specially selected as the best avail-

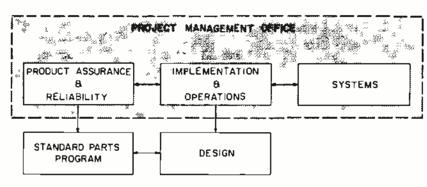


Fig. 3—Relation of standard-parts-program working group to design and project groups.

I. K. MUNSON received his BSEE in 1943 from the University of Nebraska and joined the staff of the Naval Research Laboratory in Washington, D. C., as a Systems Evaluation engineer. In 1955 he received his MSEE from Drexel Institute. In 1948, he joined the National Bureau of Standards, where he worked on the development of National primary microwave power and impedance standards. In 1950, he joined the Bureau of Ships as a Project Engineer in air-traffic control and radar-beacon equipment. In 1953, he joined the Measurements Engineering Laboratory of RCA in Camden, becoming Manager of DEP Standards Engineering. In May 1957 he was promoted to Manager of Operations; in January 1958 to Manager of Central Services and Engineering; and in July 1959 to Manager, Central Engineering. This activity covers application engineering and standardization, circuit and equipment modularization, and reliability analysis. He is a Senior Member of IRE and a Registered Professional Engineer in the District of Columbia.

B. H. ROSEN graduated from Drexel Institute of Technology in 1951 with a BSEE. Until February 1954, he was employed by National Union Radio Corporation, developing and testing cathode ray and special purpose display tubes. He was then employed by Philco Corporation as a component engineer specializing on cathode ray tubes. He joined RCA in December 1954, as a standards engineer on cathode ray tubes. He later became Project Engineer for all types of tubes. In February 1961, he was promoted to Leader of the Electron Device Group, in the Standards Section of DEP Central Engineering. In this capacity, he is responsible for the evaluation, consultation and application of electron tubes and semiconductor devices for Central Engineering. He is a member of the IRE.

SAUL SCHACH received his BEE in 1949 from George Washington University and did a year's graduate work in the Engineering Science and Applied Physics Department of the Harvard Graduate School. Mr. Schach was employed for three years at the Signal Corps Engineering Labs, where he was in charge of a Component Test and Evaluation Group. Before coming to RCA in 1956, he was a Project Engineer on microwave components and assemblies at Airtron, Inc. Since joining RCA, Mr. Schach has worked on the design, evaluation, application, and standardization of microwave devices and transistor circuits. He was instrumental in establishing the *RCA Transistor Circuit Quarterly* manual of semiconductor circuits and in developing microwave radiation detection instrumentation for BMEWS. Among other assignments, he was Administrator responsible for the preparation and direction of a major RCA Parts Program. He is currently Leader of the Microwave Devices and Standard Circuits Group in DEP Central Engineering. Mr. Schach is a Member of the IRE, PGMTT, PGED, and Sigma Tau.

A. J. SCHWARTZ received his BEE from City College of New York in 1948 and his MSEE from Rutgers University in 1952. From 1948-1950 he was employed at the Signal Corps Engineering Laboratories, Fort Monmouth, N.J. From 1951-1953, after promotion to Project Engineer there, he was in charge of a group in development of r-f and microwave components. He came to RCA in 1954, and engaged in application and standardization work on microwave tubes and components. In 1957-1959, after promotion to Group Leader of the Electron Devices Activity for DEP, he was in charge of a group responsible for consultation and standardization in electron-tube and semiconductor-device applications. In November 1959, he was promoted to Manager of the DEP Component Standards Activity. His responsibilities now include application and standardization efforts on all types of electronic and electromechanical components and devices.

I. K. Munson

B. H. Rosen

S. Schach

A. J. Schwartz

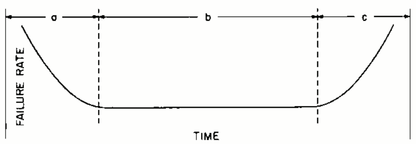


Fig. 4—Failure rate vs. operating time.

able in terms of high reliability; many such parts result from major part-improvement programs carried on to maximize reliability. In addition, Central Engineering provided an abridged version of the DEP Standards manual which specifies parts and materials specifically selected for the high-reliability project and recommended wherever a "contractual standard" part is not suitable.

Design activities were furnished copies of both standard parts manuals. It was their responsibility to select parts wherever possible based on items listed in these documents.

Use of Nonstandard Parts

Where a suitable standard part was not available, a *Nonstandard Parts Procedure* (NSP) was established. The design engineer submits a Nonstandard Parts Request to the Standard Parts Working Group. Request forms include an outline of the component characteristics needed in the particular application, description of the nearest standard part, and specific reasons why the standard part could not be utilized.

Upon receipt of the NSP request from design, the individual component specialist in the Parts Working Group becomes responsible for selection of a part to meet the design requirement. In reaching a decision as to whether or not an existing part is available to meet all requirements, consideration is given to: 1) circuit requirements, 2) failure rate of the part, 3) total failure rate contribution to the system (part failure-rate-time quantity used), 4) specific reliability reasons why the particular part was selected, and 5) previous history relative to performance, availability, and quantity produced.

Fig. 5—Universal life-test rack for any type of component. Power-distribution panel at top allows modular expansion to any number of racks needed.

Such information is documented for each non-standard part utilized. This data, together with NSP information, constitute the basis for issuing RCA approval for each nonstandard part. Close coordination is always maintained with the design activities.

In addition to selecting the best part for each application, it is essential to prepare suitable procurement documents; parts under RCA control require suitable RCA drawings. Because of high reliability requirements, special consideration is given to specification requirements for quality assurance and acceptance tests. Accelerated life tests reduce the required test samples and time required for qualification approval, and continuous sampling plans are utilized wherever applicable. Finally, to insure product control, screening tests are specified to cull out units susceptible to known failure modes.

Verification Test Program

As a double-check on the individual component specialist's choice of nonstandard parts, a verification test program was set up to ferret out unknown weaknesses or failure modes of selected parts. Tests are run at high stress levels to induce failures, which are then analyzed for cause. This information is fed back to the vendor for corrective action. It is also incorporated in the formal specification, to insure that the vendor has taken corrective action and that tests will support the predicted failure rate and verify our selection of parts.

Parts Matrix

A parts matrix was established and maintained at all times during the program, to determine the effect of parts on the over-all system reliability. Essentially, the matrix summarizes parts usage per system on a part-type basis. It provides information on quantity used, failure rate per part, and total contribution to the failure rate for each part-type. The total contribution of all part types provides an overall estimate for the system failure rate; Table I shows the format and type of information in the parts matrix.

PART PRECONDITIONING: BURN-IN

Component burn-in tests are used extensively on high-reliability programs to assure the required equipment reliability. Commitments require an average component failure rate of approximately 0.001%/1000 hr, with some as low as 0.0001%/1000 hr. Thus, only one failure out of 1 million parts operating for 1000 hours is tolerable on certain components. In order to achieve such goals and maximize effectiveness of burn-in methods, it is essential to start with the best components available.

TABLE I—PARTS MATRIX

Part Type	*Quantity Per System, N*	*Part Failure Rate, λ (%/1000 hrs)*	*Part Failure Rate Per System, Nλ (%/1000 hrs)*
C_1	150,000	0.0001	15
C_2	16,796	0.004	67
C_3	6,237	0.0035	22
R_1	200,000	0.0002	40
R_2	112,382	0.0001	11
R_3	3,545	0.0007	3
Q_1	128,000	0.001	128
Q_2	2,090	0.003	6
Q_3	1,850	0.001	2
CR_1	139,920	0.0003	40
CR_2	2,535	0.002	5
CR_3	2,188	0.01	22
CR_4	906	0.007	6
TOTALS	766,449		367

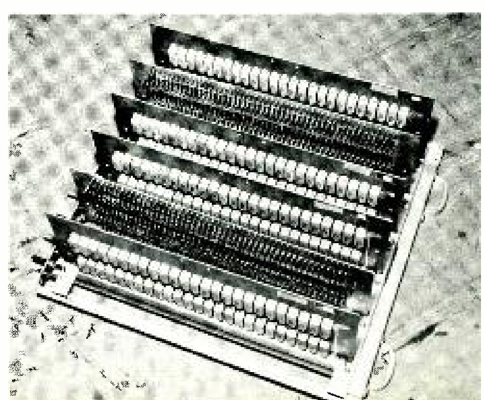
System Mean Time Between Failure = $10^5/367 = 272$ hours

General Concept

Although the described parts program does help accomplish high reliability, such low failure rates are needed that even the best the state-of-the-art can offer is still not good enough. Therefore, the burn-in procedure has been a practical approach in weeding out the few potential failures. The concept of component burn-in is based on the ability to detect and weed out *sports,* units which meet initial parameter limits, but behave abnormally such that they are potential reliability risks.

The system used is based on experience gained at RCA and other organizations, such as Bell Telephone Laboratories and Autonetics. A typical failure-rate-versus-time curve looks something like that shown in Fig. 4. Area *a* is the early failure region, sometimes called debugging time. Area *b* is the normal useful life of a part, and area *c* is the wear-out curve. For successful burn-in, it is assumed that 1) the early failure time is much less than the useful life of the equipment, 2) constant or decreasing failure rate is experienced over the useful life of the equipment, and 3) the

Fig. 6—Reusable transistor-socket component board.



wear-out period starts much much later than the useful life of the equipment.

Bell Laboratories have successfully used burn-in procedures for extremely high-reliability systems; an example is their transatlantic cable installation built about 20 years ago. Nearly five times as many tubes as eventually needed were made with the best materials and fabrication techniques known —and then placed on burn-in life tests for approximately 5000 hours. Initial and periodic measurements were made during the life test; only the most stable tubes were used in the cable installation which has experienced no failures to date. This performance is considered close to the ultimate in burn-in techniques, but was required and justified for economical maintenance. It costs about 2 million dollars to repair the cable.

DEP Methods

Similar effort has been successfully accomplished on other types of parts and for other systems. Therefore, it was decided to burn-in all parts which would benefit from preconditioning (i.e., that would exhibit early failures) and which have a wear-out life far in excess of the expected useful life of the equipment. By those criteria, about 90 percent of all of the parts used in a system should be burned-in before assembly in equipment module boards, and all other parts must be checked at least for initial parameters prior to assembly.

In determining the necessary burn-in stress conditions, there is considerable difference of opinion. For example, some state that burn-in should be at maximum ratings or higher to reduce burn-in time; however, severe tests may damage or degrade good units, and the mode of failure of the parts might be different because of the overly high stress.

It was decided to "burn-in" at conditions simulating actual operational use. Fortunately, use conditions for carefully designed, high-reliability equipments are generally from 10 to 40 percent of rated conditions, which is not so mild as to be meaningless nor severe enough to damage good parts. The duration of the burn-in is a compromise between realistic production schedules and the ultra-conservative burn-in time of perhaps 5000 hours. Most early failures and significant parameter degradations occur before 500 hours, a limit chosen for all preconditioned parts with one exception: 250 hours is sufficient for dipped mica capacitors.

Defining Failures

Once the stress level and duration is fixed, the next problem is to define a failure; i.e., which parts should be removed as sports or as reliability risks. First, all units not meeting initial parameter limits are removed from further consideration. Work is now going on relative to defining possible degradation failures. For example, how much change should be permitted and which parameters should be monitored to detect potential failure? In the case of transistors, leakage current, current gain, and breakdown voltage were considered the most sensitive indicators of reliability. However, several problems occur. For example, if we set a 50-percent change as the degradation limit in any of these parameters, difficulty may be experienced on some units which run initially about 0.1-μa leakage current. Obviously, a 50-percent increase in leakage current to 0.15 μa is insignificant. However, a 50-percent decrease in current gain from 50 to 25 (for these same units) is almost catastrophic. Similarly, a 49-percent change in all these parameters may be more serious than a 2:1 change in just one parameter, even though all are still within the 50-percent degradation limit. Advanced work is underway on optimum choice of degradation limits.

Burn-In Advantages

In evaluating burn-in testing, there are three very important advantages not previously mentioned that provide better data to improve our reliability predictions. One is the development of a significant amount of failure-rate data at actual controlled use conditions; previously, most available failure-rate data was based on extrapolation from rated or accelerated conditions.

Burn-in also provides an opportunity to determine weaknesses of components and what causes them to fail. A comprehensive failure-mode study program is essential to the obtaining of high reliability, since knowing failure modes permits information feedback to the vendor for corrective action, and for inclusion in procurement documents.

Finally, burn-in stabilizes component parameters; many well-designed components exhibit a large initial change in parameters and then level out to a stable value. The time for this initial change is approximately equal to the debugging time. As a result, burn-in substantially reduces the number of production failures occurring in fabrication module testing, and system testing.

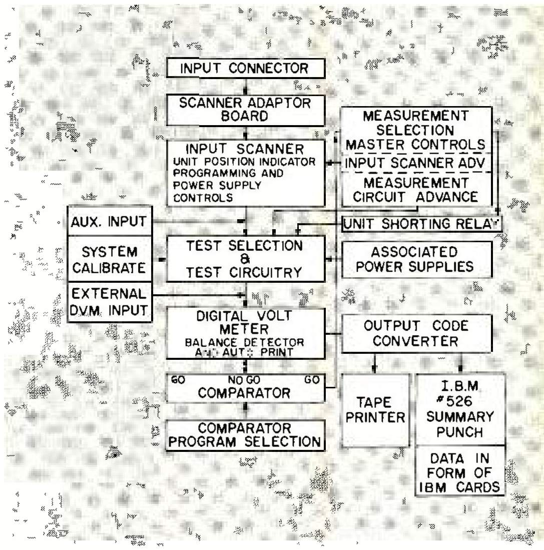


Fig. 7—General layout of fully-automatic test sets.

PART PRECONDITIONING FACILITIES

A test center was established to handle component burn-in for approximately 60,000 parts per month. In this specified test area, the humidity can be regulated, and the ambient temperature controlled to 25°C ±3°. An environment closely simulating the expected ambient conditions of the actual equipment is maintained. To prevent over-stressing the parts in the event of an air-conditioning failure, a thermostatic control is utilized to shut off all power to the test center when the ambient temperature exceeds 28°C.

To achieve the required voltage and power stresses, a universal life-test rack and power distribution panel was de-

Fig. 8—Automatic transistor test set.

signed to handle any type of component; transistors, diodes, capacitors, or resistors (see Fig. 5). Six sets of equally spaced cradle slides accommodate six component trays which are electrically connected by rack-and-panel connectors consisting of five giant banana plugs which mate with five banana jacks mounted on the copper bus bars.

The trays themselves are designed to handle a specific component class, i.e., transistors, diodes, capacitors, or resistors. Wiring is by printed circuit boards. Each board handles up to 200 components without damage to the individual units. Various body diameters (up to 1.2 inch), various component mounting centers (0.5 to 3.8 inches) can be accommodated, dependent upon the size of the component. Thus, a resistor rack with six trays and six component boards per tray, could burn-in 14,400 resistors when the component size permits 200 units per board. Printed-circuit component boards, while individually relatively inexpensive compared to the cost of units being tested, still involve a substantial total expenditure, since they can be used only once. To circumvent this problem for transistors, DEP Central Engineering designed a reuseable transistor-socket component board (see Fig. 6). It reduces over-all cost considerably; many boards have been used ten or more times without degradation or malfunction. Originally designed for TO-5 transistor cases, such boards have since been designed for several case sizes.

AUTOMATIC DIGITAL EQUIPMENT

A practical way to accumulate accurate data is by means of automatic digital equipment. Such equipment, with its inherent high accuracy, was employed for measurement of d-c and a-c voltages, voltage ratios, d-c and a-c currents, current ratios, resistances, and resistance deviations.

A typical digital test set (see Fig. 7) consists of these five basic sections.

1) *Input section:* A scanned, multiple input area to handle the 210-pin, printed-circuit board connector and an auxiliary single input. Modular handling techniques facilitate connections between the components in the component board and the points of scan input. Component selection is done at the control section.
2) *Measurement circuitry section:* A modular arrangement permitting plugging in of eight test modules, selected and programmed from the control section. Each measurement module contains a programmable means of establishing all test conditions designated for a particular measurement, and acceptable upper and lower limits.
3) *Control section:* Permits manual or automatic programming of tests and issues necessary operational commands to various sections of the equipment; this results in measurement-data collection on punched data cards. The master scanner controls the slave scanners, permitting selection of any consecutive group of components to determine whether the scanning system will test two or three terminal devices.
4) *Measurement section:* A 4-place digital multimeter and, when required, a 3-place deviation ohmmeter.
5) *Power supplies:* The necessary programmable and regulated constant-voltage or constant-current power supplies to supply the test measurement circuit modules.

The automatic equipment described above was designed to measure resistors, transistors (Fig. 8), and diodes.

COST EFFECTIVENESS

In view of the effort involved, what is the over-all cost effectiveness of the program? One of the basic reasons for imposing high-reliability requirements on parts for large weapon defense systems is to reduce high maintenance costs.

Consider an equipment involving a million parts per system. Assume the cost per maintenance operation is $1,500 (a realistic estimate). Table II shows the effect on maintenance, for this system assuming various average part failure rates.

Data in the first and last columns reveal two significant points: 1) Maintenance costs become astronomical and prohibitive in any practical sense when average part failure rate is permitted to approach 0.1%/1000 hr, and 2) on the other hand, we are approaching the point of diminishing returns as average part-failure rate decreases below 0.0001%/1000 hr.

In addition, cost trade-off information can be derived from the tabulated data. For example, it is generally expected that higher reliability devices are more expensive, but how much more can be profitably expended for such devices? Assume that the hypothetical 1-million-part system is to be operational for a minimum period of three years and that a choice is to be made between 0.01 and 0.001%/1000 hr. parts; it is noted that about 3.5 million dollars more per system ($3.5 per part) could be justifyably expended for the more reliable part. Beyond this point, the increased parts cost would surpass the savings due to reduced maintenance.

Thus far, cost effectiveness has been discussed with respect to the effect of average part failure rate on maintenance costs. Another consideration that should not be overlooked is the impact of an effective parts program on the basic equipment costs. Such considerations can be quite significant where high usage of individual part types is encountered. This proved to be the case in this DEP parts program. Because of the specialized component knowledge and experience available within Central Engineering, it was possible to select alternate parts for two high-usage applications. Substitutions at no sacrifice in reliability resulted in a reduction of 1½ million dollars per system, a savings of more than twice the cost of the entire parts program.

Additional cost savings should result from reduced production costs, since all parts will have been inspected for electrical parameters, preconditioned, and stabilized. Factory rejects, troubleshooting required during fabrication, and factory testing should be considerably reduced.

TABLE II—EFFECTS OF FAILURE RATE ON MAINTENANCE—HYPOTHETICAL SYSTEM

Average Part Failure Rate, λ (%/1,000 hrs)	*Total System Failure Rate, Nλ (%/1,000 hrs)*	*Mean Time Between Failures (hrs)*	*Maintenance Operations Per Year*	*Maintenance Cost Per Year ($ Thousands)*
0.0001	100	1,000	9	13.5
0.001	1,000	100	88	132
0.01	10,000	10	880	1,320
0.1	100,000	1	8,800	13,200

N = total parts in system, here 1 million.

CONCLUSION

Central Engineering has contributed very substantially toward the development of high-reliability systems by DEP; *first*, through the development of parts-reliability factors (now published as *Vol. 14, RCA Defense Standards*); *second*, through component parts application and standardization; *third*, through the development of improved reliability model techniques and, *now*, in development of programs and techniques for practical measurement of high-reliability levels for components and improved techniques for component selection.

The alert systems group takes advantage of these concepts to create a basis for new proposals more responsive to current and future Department of Defense requirements.

TOWARD BETTER DESIGN . . .
A New Concept in Military Electronic Consoles

by **W. C. MAC PHERSON**

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As the emphasis in modern warfare has shifted from offensive attack to defensive protection, the weapons of warfare have also undergone a basic concept change. Previously, combat weapons required high ratios of performance to volume and weight; the cost was in continuous operability. Such weapons could be taken off-line for extensive maintenance, and hours to weeks of operation were frequently supported by months to years of complete down-time for repairs. An example was the fighter and bomber aircraft of World War II.

The advent of surveillance radar brought about a change in emphasis in this ratio of operability to maintenance schedule. BMEWS, for example, must operate continuously, 24 hours per day, without over-all system-maintenance down-time. BMEWS and other current systems like the retaliatory weaponry of SAC have given rise to an organized endeavor to ensure continuous operability, generally referred to as *system reliability*.

To achieve this objective, the components of modern military surveillance systems have had to undergo a radical change. Transistors and diodes have replaced vacuum tubes and electromechanical devices in many applications to increase the reliability and reduce the power consumption. Molecular electronics promises even greater reliability with volume-weight and power reductions. However, even with such dramatic increases in component reliability, it is not and probably will not be possible, *to raise individual component reliability to a level sufficient to produce the required over-all system reliability*.

ROLE OF PACKAGING IN ACHIEVING SYSTEM RELIABILITY

Most current systems contain several techniques to offset this problem. One such technique is *subsystem redundancy*. By switching the operation to a stand-by subsystem, part of the equipment can be taken off-line for maintenance. Obviously, during this maintenance operation the security provided by an operable stand-by subsystem no longer exists, and in critical areas, there may be two or more operable stand-by subsystems. The number of such back up equipments is determined by several factors, some of which are:

1) frequency of maintenance required, a function of the individual component reliability
2) speed with which the faulty component can be located
3) ease of replacing the faulty component
4) importance of the subsystem to over-all system functioning.

Generally, the unit level of the subsystem which will be duplicated or triplicated depends on the same factors, plus the all-important cost considerations.

Electronic packaging has been greatly reoriented to reflect these changes in concept. Now, in addition, the necessary attention is being paid to the componentry and packaging of the *man-machine interface* (the operator console or operator station) which previously had undergone very few changes from World War II approaches.

Some significant improvements in the basic types of interface components had been made, such as the substitution of digital readouts for analog meters where accuracy is required (altimeters, radar range indicators, etc.), but generally the identical components which represented the state-of-the-art in 1940 have been all too commonly specified in man-machine interface equipment. Some of these components are edge-lighted plastic overlay panels, toggle switches, bullseye indicators, current and voltage meters (with accurately indexed scales), and separated indicator-operate pushbutton switches (which must be used conjunctively). The inherent maintenance requirements for these components, while sufficient in the 1940 to 1945 era of adequate down-time and relatively few items in each interface equipment, are completely outmoded in the multiple indicator-control panels of current continuous-duty systems.

A NEW MAN-MACHINE INTERFACE CONCEPT

Beginning with Atlas launch control and checkout and continuing in the BMEWS equipment, a new concept of man-machine interface design is under development. The primary emphasis is on increasing interface reliability through improving maintainability, and increasing operability through human-factors design flexibility. Cost has been assigned an important role in developing these new techniques for two reasons: 1) as the newer systems have increased in complexity, the number of man-machine interface signals, and therefore numbers of components, has greatly increased; and 2) attempts to improve rather than replace the techniques of 1940 indicated an exponential cost increase which the system could not afford.

An important restriction was that the new technique not be a drastic departure from the current state-of-the-art ability to instrument the conversion. Obviously, this was necessary to make use of this technique immediately applicable to current designs and to make a maximum use of reliability data on existing components. Basic approaches could, however, be designed to provide for item-by-item conversion to radically improved components.

Translucent Overlay Panels

In essence, the approach is in the use of totally flexible, translucent overlay panels, the front of which can be painted by several techniques to conform to almost any optimal human-factor arrangement. This panel is kept free from protrusions and supporting hardware to emphasize the operating components such as pushbuttons, knobs, etc. All status-indicator information is projected in the flush translucent windows with labeling in the otherwise opaque painted panel, thus eliminating all holes except for operated components. Extensive use of multiple-function components, such as multicolor illuminated pushbuttons, multicolor indicators, multiple message, or digit projectors, has greatly reduced front-panel area and thereby reduced operator visual work load. Of course, these applications must be confined to a relationship between signals for a given multiple-function component.

Hardware Mounting

Backing up this translucent overlay panel is a hardware and component mounting panel. In this approach, no elaborate disguises for mounting hardware are necessary and maximum freedom for replacement manipulation is allowed. Many available standard components require special mounting techniques, and this normally hidden mounting panel permits maximum simplicity in accomplishing these peculiar mounting problems. The net result is a consistently uniform external appearance without the usual expensive custom design and fabrication.

Improving Maintainability

The two independently mounted panels allow for maximum accessibility to least reliable components, i.e., the incandescent lamps. Where up to several thousand incandescent lamps are used on one control and indicator switching console, this high-speed maintainability is absolutely mandatory to complement subsystem reliability.

Generally, the life expectancy of the mechanical switches and relay or solid-state switching devices mounted behind the hardware panel exceeds the life of those components (incandescent lamps, etc.) mounted behind the overlay panel by several orders of magnitude; i.e., military standard basic switches at 1,000,000 operations and relays up to 9,000,000 operations, versus 500 to 1,000 hours of life from lamps.

Lamp test features have been removed from each indicator or illuminated switch, as was the general practice in the prior technique, and combined with the signal control relays to provide a collective lamp-test facility, usually by color. This is supplemented where possible by eliminating lamp test in the multiple-color indicators, which provide an always-illuminated condition for each indicator or illuminated control. This helps to maintain a consistent ambient panel brightness condition, easing operator fatigue and maintaining a constant power load to reduce regulation requirements. Use is made of color as operator stimulus, which is in many instances superior to brightness stimulus, e.g., lamp *on* or *off*, for gaining attention (e.g., a red, possibly flashing, indicator in an otherwise field of green). Lamp-testing several hundred to several thousand lamps by the former technique is much too costly in time. Also, the later technique tests signal circuits as well as lamps.

In the BMEWS equipment, considerable effort has been made to combine the mounting panel which contains the lamp sockets and/or mechanical switches with the chassis containing the relay or solid-state switches of the logic circuits in order to 1) reduce greatly intra-equipment or chassis wiring, and 2) make detailed fault-location a work-bench job instead of a difficult in-console job. Replacing the entire logic package, including signal lines, switches, intra-chassis wiring harness, and indicator-control devices for extensive fault location is mandatory where very high reliability requirements are imposed on the system. This approach was mandatory where cathode ray tubes are used as display components in conjunction with other indicator-control components.

In the Atlas launch control equipment, where the indicators and/or controls are more nearly a sensor-to-indicator application (e.g., the *standby status panel*) very little, if any, intercomponent logic is required. The effort has been to remove all components, except the man-machine interface components, to electronic equipment cabinets not physically located with the operator console. Also, this allows the console or display to continue operations with the remainder of the functioning equipment without interruption.

A SPECIFIC APPLICATION—THE BMEWS CONSOLETTE

The BMEWS consolette (Fig. 1) is an example of a specific application of the new concept. The upper section is an equipment status panel containing over 240 displayed signals in which all indicators are illuminated in one of three colors continuously (except the *test* indicator, which is double lamped for

Fig. 1a—BMEWS manual input and equipment-status consolette — front panels.

Fig. 1b—Control panel open (incandescent lamp maintenance position). Funnel shapes with white tops are push-button actuators; rectangular wells are plug-in digital read-outs.

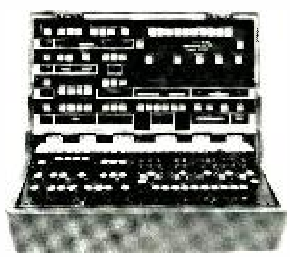

Fig. 1c—Control panel and component mounting panel open, showing wiring side of components for major maintenance.

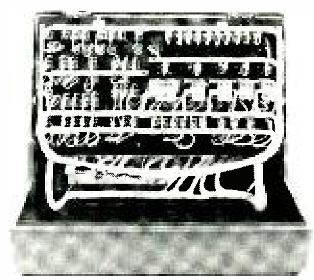

Fig. 1d—Status panel open (incandescent lamp maintenance position) showing three-color and single-color modules.

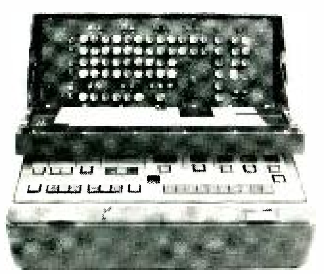

Fig. 1e—Rear view, cover in place.

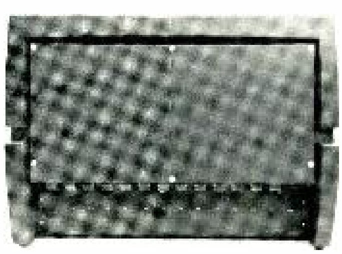

Fig. 1f—Rear view with cover removed. Thirteen 57-pin connectors connect this consolette to rack equipment.

increased reliability) thus eliminating a lamp test requirement. In the event that one window is unilluminated, the operator opens the overlay panel and replaces the associated three-lamp module (a 15° bayonet action). If this fails to restore the lighting of one lamp, i.e., one color, then maintenance of the circuits of the incoming signal is required. Since this panel contains only lamp sockets (which have been designed to exceed greatly the life of the equipment) and the intra-cabinet wiring harness, limited access to the hardware panel is provided through the removable cover plate on the rear of the cabinet.

The lower portion contains over 470 signal inputs and outputs and some of the logic switching. In this case, almost all of the logic switching is contained in the electromechanical digital readouts which act, in part, as a shift register for the external computer. The operator composes a binary coded message for the computer by manually inserting decimal numbers read from hard copy into the digital read-outs by means of the pushbuttons. After completing the manual input and proofreading the read-outs, he then operates the *insert* pushbutton which opens the line for the computer to pick up the message at its higher frequency and in its language. Therefore, in addition to the lamp replacement, these electromechanical read-outs are also replaceable between the panels.

Molding techniques have been used to package the consolette. Appearance and volume were important reasons for this approach, but of great equal importance was the cost factor. Conventional sheet metal fabrication with the necessary associated design and tooling to approximate the epoxy-resin, glass-reinforced, hand-layup molding would have cost approximately 5 to 7 times as much for the housing alone. An entirely new technology has resulted from work done on this unit which promises to reduce greatly design, drafting, and tooling costs in future electronic equipment packaging.

The design approach resulting from this unit offers the packaging designer novel flexibility and an earlier start before the specific equipment has been finalized. Utilizing the statistical findings of both the Atlas launch control and BMEWS programs, which amount to well over a billion dollars of electronic equipment, the following technique has been worked out.

IMPROVEMENTS IN DESIGN TECHNIQUES

There appears to be approximately ten to fifteen basic operator interface components which will handle 90 percent of the requirements. The front, or overlay, panel can be laid out by human-factors and design engineers using templates of these components with little difficulty. Since almost all of these components have now been normalized; i.e., designed and fabricated to mount and function similarly, operator-interface configuration can be defined as a relatively constant depth by the length and width developed in the template layout. Wiring can also be handled similarly as a flexible slab of uniform thickness. Terminal board and connector configuration can be treated in a similar manner as a part of the wiring plane.

Therefore, the interface electronic equipment can now be given certain limiting dimensions and physical relationships which can be described as the governing *inner-constants* of the equipment. Since these can be constructed with solid mock-ups like wood blocks, they can be arranged to provide maximum utility for fitting the anthropometric requirements of the operator-maintenance personnel, which can be termed the *outer constants*. This will then freeze the inner constants into a spacial relationship that can be used as the equipment configuration to be packaged.

One simple technique for handling this packaging for a molded shape is to coat the entire inner-constant mock-up with plaster and smooth the outside shape to the desired external configuration, making use of factors such as optimal shape-weight-strength relationship, molding limitations such as draft angle, and undercuts.

Since most of the electronic equipment housing dimensions are not critical except as they interplay upon each other, drawings need only contain critical dimensions for mounted hardware and a method of reproducibility for the shape. Since molded parts generally are best-suited to shapes which contain sufficient draft on individual parts and which have non-parallel, non-perpendicular planes, usually termed a *free-form* shape, templates are necessary to reflect mirror images about a centerline.

These templates then represent the optimum means of reproducibility. Therefore, irrespective of actual dimensions, and provided inner and outer constants are not jeopardized, dimensionally stable template-tracings can be used to reproduce the form. The grid-lock drafting technique, already in use to fabricate sheet metal parts (primarily to punch holes without dimensions) can be directly utilized. In fact, dimensioned prints have proven inadequate for free-form parts. As has been the case in grid-lock applications to date, costs of drafting and design seldom exceed 40 percent of conventional practices. The same technique has been successfully tried in the overlay and hardware panel, with similar results. The basic reason for these successes is that in research-and-development fabrication, a layout must be made anyway by a competent technician from the dimensioned prints, a process which is both time-consuming and subject to human error. This essentially is exactly the same as the result produced by the grid-lock drafting system.

SUMMARY

This entire approach of the dual-panel man-machine interface is a compatible stepping-stone, consistent with current technologies, from the hardware of the 1940's to the automated fabrication and to-some-extent-automated design and drafting of the future all-solid-state electronic equipments and displays. The most exciting immediate gain is, however, that costs can be reduced effectively such that price does not stand in the way of system optimization, as new developments allow improved reliability and man-machine relationships.

WILLIAM C. MacPHERSON received his BS in Industrial Design from Georgia Institute of Technology. He joined RCA in 1956 with the Human Engineering Group of TALOS Projects at Missile and Surface Radar, Moorestown, New Jersey. The transilluminated fiberglass polyester panel technique described in the article was developed by Mr. MacPherson for the Launcher Console of the TALOS Land Based Defense Unit in 1957. It was brought to fruition in the ATLAS Launch Control Consoles in 1958, which he also designed, and became the console panel standard for the BMEWS program, on which he participated as the senior member of the Industrial Design Factors Group from 1958 to 1960. He was transferred to WCM&SR in Van Nuys, California in April of 1960 where he participated in the experimental fabrication program which produced the consolette in the article and in directing the fabrication of the patterns.

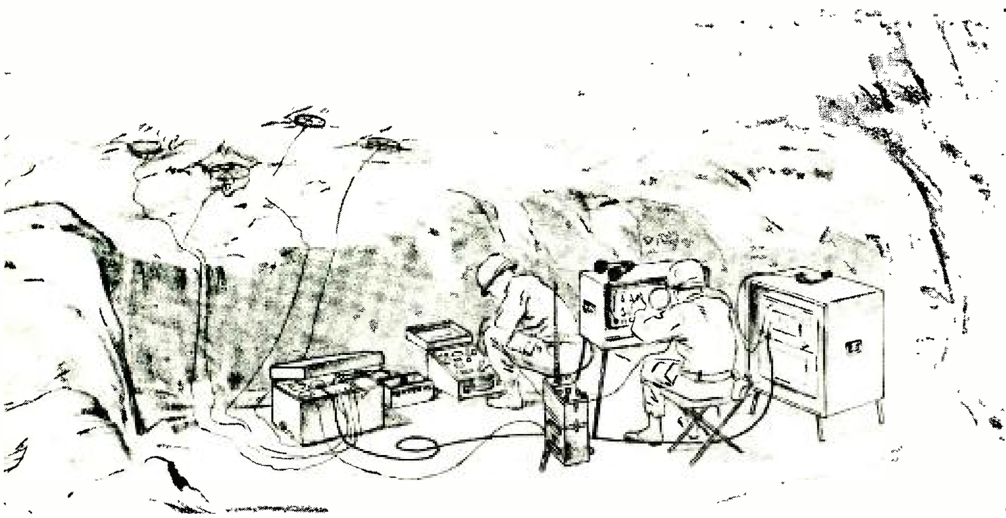

Fig. 1a—AN/TNS-5 azimuth measuring station in operation.

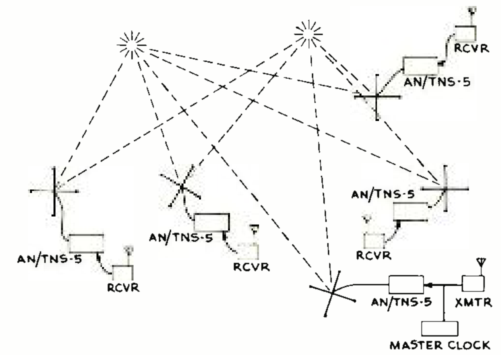

Fig. 1b—System configuration.

THE AN/TNS-5 ... A Modern Acoustic Missile-Launch Locator

by **R. M. CARRELL** *and* **R. RICHTER**
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ACOUSTIC TECHNIQUES have been used since World War I for the location of mortars and artillery emplacements. These acoustic locating systems have undergone a steady evolution in parallel with devices such as mortar-locating radars. The acoustic location system has a continuing place in modern ground warfare, since it will function under atmospheric conditions that blind radar.

Magnetic recording was first applied to acoustic ranging during World War II in a system which employed a drum to record the output of a microphone array distributed over a distance of many miles. Since the storage capacity of the drum was very limited, a forward observer triggered the recorder whenever he heard gunfire. This was hard on the observers, and some signals were missed. Another disadvantage of the system was that analysis of the recorded signals required a degree of mathematical skill not readily obtained.

In the early 1950's, a new acoustic technique was conceived. It is based on a number of independent *azimuth ranging stations* reporting azimuth fixes on target signals to a central plotting station. The targets are then located by triangulation (Fig. 1b). The azimuth ranging stations consist of a microphone array, a magnetic recorder, an oscilloscope, and a computer. The microphone signals are recorded continuously, even while previously recorded signals are being analyzed. The tape recorder provides means for measuring the relative times of arrival of the signals at the microphones by visually aligning the signals as seen on the oscilloscope. Shaft positions corresponding to time differences between the signals from opposite pairs of microphones are fed to the computer, which computes the azimuth of the incoming signal. In 1958, RCA began work for the U. S. Army Signal Research and Development Laboratory (USARDL) on equipment for instrumenting this systems concept. The equipment is designated the *Short Range Missile Launch Locator*, AN/TNS-5 (Fig. 1a).

AN/TNS-5 REQUIREMENTS

The principal requirements for the azimuth ranging stations of the AN/TNS-5 were:

- *Azimuth Accuracy*, ± 1 angular mil (0.06°)
- *Frequency Range*, 1 to 100 cps
- *Signal Threshold*, 0.01 dyne/cm^2 (36 db re 0.0002 dynes /cm^2)
- *Dynamic Range*, 60 db
- *Absolute Time Accuracy*, 0.1 second (long term), 0.01 second (short term)
- *Power Requirements*, 100 watts max. at 24 volts, d-c
- *Recording Time*, 4 hours (before erasure)
- *Monitoring*, aural or visual

In addition to these, the system had to require a minimum of operator skill.

SYSTEM OPERATION

The basic configuration of the system is shown in Figs. 1b and 2. An acoustic signal from a gun or missile is picked up by four condenser microphones located at the corners of a square, usually 300 meters on its diagonal (the array may vary from 50 to 600 meters across).

The microphone signals are recorded on individual tracks on a special magnetic tape, which has a photographically reproduced clock track on its base side. The clock track is optically sensed, and the pulses so generated are compared with a frequency standard to control the tape speed to 0.25 ips. The clock on the back of the tape thus becomes a highly accurate measure of the absolute time of arrival of the signals. This time of arrival is used to segregate azimuth readings obtained from different sites during multiple firings, so that when a triangulation plot is made, all fixes are on the same sound source. In addition to the four tracks recording the microphone signals, a skew-correction track is recorded near each edge of the tape. These are used to correct the display for tape skew during playback.

The microphone signals are reproduced by a scanning head rotating at 20 rps. The peripheral velocity is 40 ips, which transforms the recorded signal frequencies upward by 160 times to the range from 160 to 16,000 cps. During normal operation, the operator monitors the reproduced signals on a high-quality headset. When significant signals are heard, the operator stops the tape over the scanning head and then uses the oscilloscope for analysis.

The oscilloscope displays the four microphone signals on separate traces, which can be superimposed. The operator has two controls which move the dis-

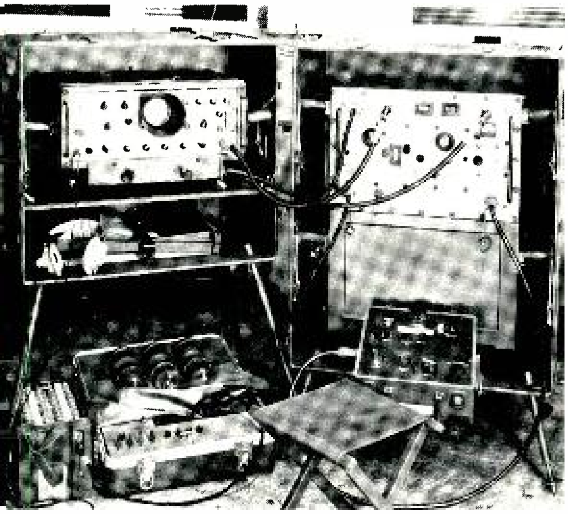


Fig. 2—System equipment.

played signals in pairs until they are coincident. When the alignment is complete, the computer calculates the azimuth of the incoming signals, plus a correction factor for the velocity of sound. The time of arrival of the signals is then read from the back of the tape.

During the analysis while the tape is stopped over the scanning head, the recording function continues, with the newly recorded tape forming a loop that is stored in a bin. After the analysis is complete, the stored tape is automatically removed from the bin, scanned for other signals, and reinserted in the bin. The tape is in the form of a continuous loop 300 feet long. A four-hour storage capacity is provided.

MAJOR COMPONENTS

The following discussion of the design and performance of the major components of the AN/TNS-5, highlights the way in which the performance-requirements were approached.

Microphones

The system accuracy tolerance of ± 1 angular mil requires that the time delays in all four record and reproduce channels be equal within 100 μsec or less. This time is equivalent to 0.07° at 1 cps, the lower frequency limit of the system. The response of the mircophones and amplifiers must, therefore, be controlled to much lower frequencies, to allow for component tolerances. In addition, the threshold noise level requirement of 0.01 dyne/cm^2 requires a sensitive microphone and low-noise preamplifiers.

Two microphones were developed for the project—a moving-coil type and a condenser type.

The moving-coil microphone has the response characteristic shown in Fig. 3. A model is shown in Fig. 4. This microphone has a novel center-suspended diaphragm which greatly reduces the tendency of the microphone enclosure to contribute acoustic stiffness to the moving system. The coil is wound on an aluminum form, which contributes a large amount of damping to the moving system. This damping is extremely stable. The response shown in the curve is accomplished without any equalization.

The condenser microphone has a performance curve shown in Fig. 5 and is illustrated in Fig. 6. The microphones have a sensitivity of 40 mv/dyne, and the diaphragms are resonated at 1000 cps.

Microphone Preamplifiers

An oscillator-bridge type preamplifier was developed for the condenser microphone. The oscillator-bridge approach was chosen as the best way to achieve the necessary low-frequency response and low noise level with the use of a transistorized circuit (Fig. 7). A crystal oscillator is used to generate a stable, low-noise signal for the bridge. The bridge is followed by two stages of amplification, a detector, and an emitter follower output stage for coupling to the line.

This preamplifier can be converted into a low-noise d-c amplifier by the substitution of a variable-capacity diode for the microphone in the bridge. The equivalent input noise of the microphone-preamplifier combination is below 0.01 dyne/cm^2 with both the condenser and moving-coil microphones.

The preamplifier is mounted on a printed circuit board 3 inches in diameter, which fits within the microphone case.

Record Amplifiers

In addition to providing the necessary current gain between the preamplifiers and the *record* heads, the record amplifiers incorporate an RC coupled Nuvistor stage for d-c isolation. The d-c drift of the transistor circuits is great enough to cause d-c biasing of the tape and a consequent increase in the reproduced noise level. The very-small low-frequency phase shift allowed requires that any RC coupling used must have a time constant of the order of 45 seconds to allow for component tolerances. A vacuum tube (Nuvistor) is used to achieve a 750-kilohm input impedance so that the coupling capacitor required is of a reasonable size. The Nuvistor has very stable characteristics and operates satisfactorily from a 20-volt plate supply, although the g_m is reduced from its nominal value. It is believed that this is the first military application of the Nuvistor.

Capstan Servo

The capstan servo is a pulse-sampling servo, similar to those used in the RCA Quadruplex Video Recorders. In essence, pulses derived from an ultrastable oscillator through a gating-type counter chain are compared in time with pulses from the optical track. The reference oscillator pulses trigger a trapezoidal pulse generator which produce pulses with a fast-rising, linear leading edge. This voltage is sampled by the pulse derived from the optical track. When the sample pulse occurs at the midpoint of the trapezoid slope, the error signal is zero. When the sampling pulse is early or late, a proportional error signal is generated. Since the slope of the trapezoid can be made very steep, this type of servo is very accurate. Rate sensitive circuits are possible by variations on this approach.

Fig. 3—Response characteristic, moving-coil microphone.

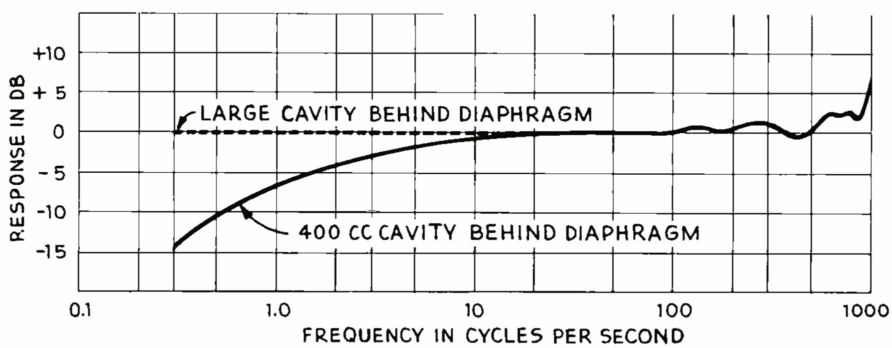
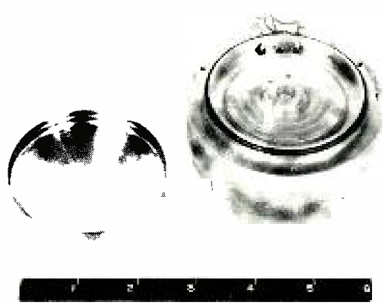


Fig. 4—Moving-coil microphone.



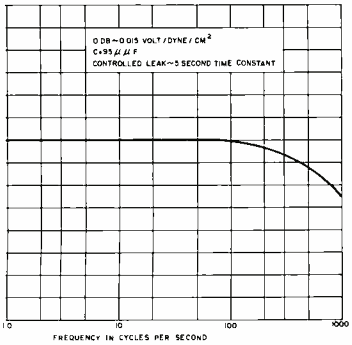


Fig. 5 — Over-all frequency-response of condenser microphone and oscillator-amplifier.

Fig. 6—Condenser microphone.

Capstan Drive

The capstan is driven through a gear train which is reliable. Gear drives are not common in tape recorders, since the wow and flutter generated by the teeth are difficult to control without using very costly gears. In the AN/TNS-5, wow and flutter are not of primary importance, since the essential information is time displacement, not spectrum content. This minimizes the effect of rapid speed variations due to the gear teeth, since the integrated time displacement is small.

Scanning Head Cluster

The recorded microphone signals are reproduced by a rotating scanning-head cluster which contains six head structures. The outer heads (tracks 1 and 6) have two active gaps each; the inner heads (tracks 2, 3, 4, 5) have one active gap each. All gaps are located in a plane parallel to and intersecting the axis of rotation of the cluster. The gaps of heads 2 and 4 are located on one side of the cluster and the gaps of heads 3 and 5 are located on the other side of the cluster. This results in a readout sequence as follows: *first-half revolution*, tracks 1, 2, 4, 6 read out; *second-half revolution*, tracks 1, 3, 5, 6 read out.

Tracks 1 and 6 contain the skew correction signals and must be read out on each half revolution. Tracks 2, 3, 4, 5 contain the microphone signals. Since the cluster rotates at 20 rps, each microphone signal is read out and displayed on the oscilloscope ten times per second. Placing heads 2 and 4 on the opposite side of the cluster from heads 3 and 5 simplifies the cluster design and minimizes the head speed required to obtain the above scanning rate. The cluster diameter is chosen so that the span of tape scanned is equivalent to 2 seconds of recording time; this is necessary to accommodate the largest microphone array used (600 meters). The peripheral velocity of the cluster is 40 ips, which is 160 times greater than the tape velocity during the recording.

Scanning Preamplifiers

The preamplifiers for the scanning heads are mounted in a drum which rotates with the scanning heads. This was done to maintain a 60-db signal-to-noise ratio after the noise contributed by the slip rings is added in. The noise figure required of the amplifier to meet the above specification approaches that of the best known low noise transistor.

Since the linear velocity of the magnetic tape relative to the scanning head is 160 times that of the tape velocity relative to the record head, the playback signals are transformed from the 1- to 100-cycle region to 160- to 16,000-cycle band. Alternating-current coupled amplifiers are, therefore, feasible.

The scanning head has a rising frequency response of 20 db per decade over the above frequency range. Thus 40 db of RC equalization is needed for the two-decade range. Since the equalization network would load the head, equalization must be added after the first stage. This means the first stage will have to handle a dynamic signal range of at least 100 db, the 40 db mentioned above, plus 60 db dynamic range. Also, no tuned circuits are permitted in the amplifier because of their effect on phase characteristics.

The amplifier developed has five transistor stages. A cluster of six amplifiers are mounted on a drum at the rear of the scanning head shaft (Fig. 8). Four are used for signal channels and two for skew correction channels. Special cards with a mechanically balanced layout are used to minimize unbalance during rotation.

The amplifier performance is as follows:

1) operates from a 100-millihenry head;
2) has 54 db of gain;
3) has a signal-to-noise ratio of 68 db referrenced to a 0.5-millivolt input signal when measured in a frequency band from 160 to 16,000 cycles;
4) compensated to operate between −20°C and +71°C;
5) rotation and microphonics degrade the signal-to-noise ratio by less than 1 db.

Tape

A special recording tape was developed for the AN/TNS-5 by Reeves Soundcraft under subcontract to RCA. This tape offered the simplest means for measuring the time of arrival of the signals at the center of the microphone array.

When the systems study on the AN/TNS-5 was started, it was assumed that the time of arrival would be recorded as a time code on the back of the tape, or that a 100-cps signal would be recorded on an extra track and the cycles counted on playback. Both of these approaches required very complex circuitry on playback.

There was not enough room on the

Fig. 7—Microphone preamplifier.

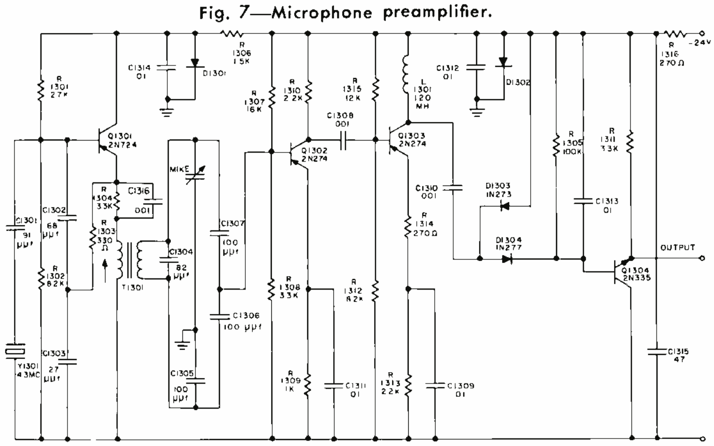
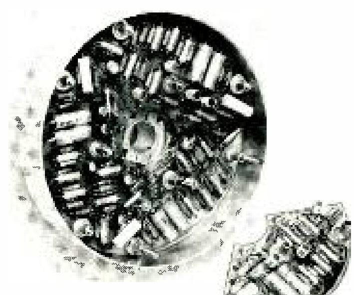


Fig. 8—Cluster of six amplifiers mounted on drum at rear of scanning-head shaft.



back of the tape for a timing code with centisecond resolution; besides that, the code had to be read with the tape stationary over the scanning head. A numerical readout was preferred to other schemes which generated an oscilloscope display requiring skilled interpretation.

The cycle-counting approach requires a method of discriminating between absolute motion of the tape and relative motion of the scanning head and the tape. Also, a six- or seven-digit counter was necessary, requiring a large number of transistors or tubes along with excessive power requirements. Further, the counter had to be reversible and operate over a wide range of input frequencies (which ruled out a mechanical counter).

It was finally decided to undertake the development of a tape with a precise clock track permanently marked on the base side as shown in (Fig. 9). This track is optically sensed and drives a servo which regulates the tape speed so that precisely ten tenth-second marks come by per second. The reference for the servo is a crystal oscillator accurate to 1 centisecond per day.

Any irregularities in the optical clock track will introduce error into the servo and cause irregular speed control, which in turn reduces the accuracy of the relative time measurement. Very rigid specifications on the accuracy of the clock track are necessary to maintain the system performance.

Fig. 9—Wide-line printed tape timing track.

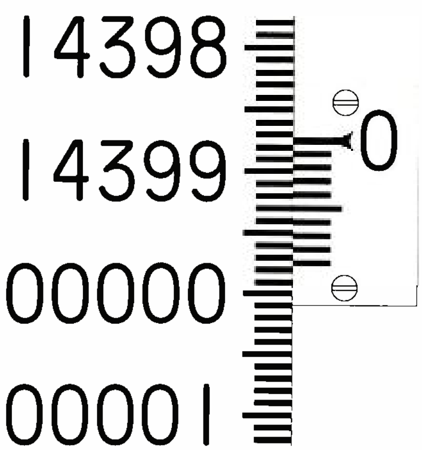
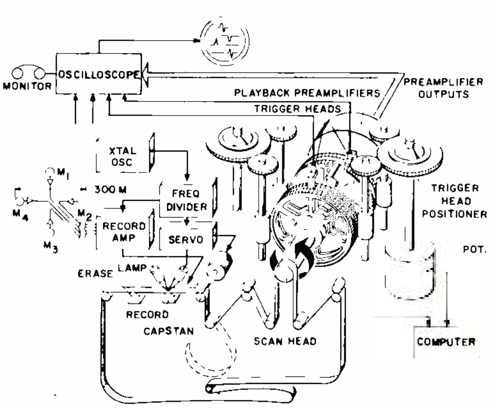


Fig. 10—AN/TNS-5 system.



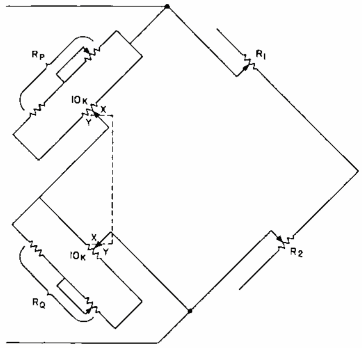


Fig. 11—Arctangent bridge of analog computer.

The clock track is specified this way: the distance between the leading edges of any two marks ½ inch apart must be within ±0.001 inch of the distance between any other marks ½ inch apart on any part of the tape.

Achievement of this accuracy is presently possible only by photographic means. The back of the tape is sensitized with a Diazo dye and then printed from a carefully prepared master. Silver halide sensitization is not suitable because of the hygroscopic properties of the emulsion. The tape width was set at 0.625-inch so that it is compatible with 16-mm motion-picture film equipment. The ¼-inch spacing between seconds marks is not compatible with motion-picture standards and required the construction of special equipment.

Many unforeseen difficulties were met and overcome in the development of this tape. The tape is unique, being the *first* combination of full-width magnetic recording with a high-resolution, optical recording.

Analyzer

The microphone signals are analyzed by measuring their relative position on the tape. This measurement is made by aligning the signal pulses as displayed on the oscilliscope. Each signal is displayed on a separate trace, triggered by a pulse from a movable pickup head located in the recorder-reproducer.

A schematic representation of the trigger heads is shown in Fig. 10. Four trigger heads are positioned by gears along the path of a magnetic trigger bar which rotates with the scanning cluster. Movement of the trigger heads changes the start time of a corresponding oscilloscope trace, and thereby the position of the gun signal on the screen. When the gun signals are aligned, the relative positions of the trigger heads correspond to the relative times of arrival of the signals at the microphone array. The time differences between the signals of diagonally opposite microphones are used to make the azimuth computation. These differences are sensed by precision potentiometers which are coupled to the movable trigger heads by accurate gear trains. Each gear train moves two heads in opposite directions. The potentiometers are connected to the computer bridge, as discussed below.

To meet the system accuracy requirements, the position of the pulses on the tape must be measured with a tolerance of the order of 100 microinches. Very precise gears, accurate trigger and sweep circuits, and electronic skew correction are required to obtain this accuracy.

Oscilloscope

In addition to displaying the gun signals, the oscilloscope package contains a number of other functions and serves as a master control for the system. The oscilloscope is shown in an azimuth measuring-station setup in Fig. 1a. Portions of the oscilloscope are outlined below.

Visual playback presentation of the recorded microphone signals is provided by a 3-inch single-gun cathode ray tube. The cathode ray tube, of the 3WP type, containing a special low-power (0.25-watt) filament design, is used with sequential switching circuitry to provide a four-trace display. Each trace represents one signal channel. The switching circuits are triggered by two fixed magnetic heads arranged to set up the oscilloscope to properly display each microphone signal.

As the reproduce head gap for a particular channel just comes in contact with the magnetic tape, the following operations are performed:

1) vertical trace position is set up;
2) proper movable trigger head is connected to circuitry that initiates the sweep;
3) correct microphone channel is connected to the vertical amplifier; and
4) correction for the position of the horizontal trace is set up in response to the skew correction signal.

The above operations set up the display on the cathode ray tube so that gun signals from the four microphones are displayed on four separate traces.

To facilitate alignment of the played-back signals, the following features have been incorporated into the design of the oscilloscope:

1) facilities to superimpose traces 1 and 3, traces 2 and 4, and traces 1, 2, 3, and 4;

2) individual gain controls for each channel;
3) one master attenuator for all channels;
4) variable passband by means of switchable filters; and
5) remote-control operation of the movable trigger heads.

All the basic scope controls are also available, such as intensity, focus, and horizontal and vertical positioning.

A *transistorized power converter* operating from a common 24-volt nickel-cadmium battery provides all operating voltages. The battery itself has no taps. The highest voltage generated by the converter is 1500 volts, which is used for the cathode ray tube ultor. Power dissipation for the converter is approximately 7 watts, while the rest of the oscilloscope circuitry dissipates about 13 watts.

A *master oscillator* is incorporated into the oscilloscope package to maintain synchronization between stations to within 0.1 second over a 24-hour period. This is accomplished by a 1.31072-Mc oscillator with a stability of 1 part in 10^7 over a 24-hour period. The oscillator package is a 3-inch cube which contains a proportionally controlled oven. It uses approximately 6 watts of power. The 1.31072-Mc frequency is divided down to 10 cps by means of a 17-stage binary counter. This 10 cycles is then used as the record capstan servo reference and as the recording source for the skew corrector circuitry.

Electronic skew correction has been incorporated into the oscilloscope, since tape skew would introduce error into the signal alignment and thus destroy the system accuracy. This is accomplished by recording 10-cps square waves on the outside tracks of the magnetic tape. On playback, the square waves are compared and any changes in their relative phase angles sets up an error voltage proportional to the tape skew angle. This error voltage is then divided into four voltages, each of which is used to correct the horizontal position of one of the traces. The reason for the voltage division is that a fixed skew angle introduces a different but proportional amount of timing error on each channel. A skew-track frequency of 10-cps allows for ±1.3° of tape-skew correction.

For *synchronization and calibration* of stations, radio or telephone facilities are utilized. A 2560-cps carrier obtained from the master station ultrastable oscillator is transmitted to all other stations. When a carrier is received, it is beat against the local ultrastable oscillator 2560-cps frequency to give a Lissajous pattern on the cathode ray tube. An adjustment is then made to lock the local oscillator in with the received carrier.

R. M. CARRELL received his BSEE from Iowa State University in 1949 and began work in microphone development at RCA in that year. He has participated in the development of several broadcast microphones and the AN/AIC-10 acoustical components. He has also functioned in a systems capacity in several magnetic recording projects, including the AN/TNS-5. He is currently involved in developing a new line of digital input/output equipment for military and commercial service.

R. RICHTER received his BSEE in 1952 from the University of Denver, and his MSEE in 1958 from Drexel Institute. He has nine years of experience in wired and wireless interphones, baseband amplifiers, hybrid circuitry, pulse circuitry and instrumentation equipment. He is currently Leader, Site Communications Engineering, in the SurfCom Digital Communications Group. He had Project responsibilities on the AN/TNS-5 program.

After all azimuth station oscillators are locked together, the 2560-cps carrier is modulated with a single-cycle transient generated by a switching operation. This transient signal is used to remotely start all record drives in synchronism. This same signal is then transmitted for simultaneous recording at all stations for a time calibration.

The radio or wire link also automatically provides voice communications when not being used for synchronization.

Computer

An analog computer (also shown in Fig. 2) is used to translate the trigger head positions into two numbers: the azimuth of the incoming signal, and the survey range correction factor (SRC).

The azimuth is computed from:

$$\theta = \arctan \frac{T_{1\text{-}3}}{T_{2\text{-}4}}$$

Where: θ is the azimuth, $T_{1\text{-}3}$ is the time difference between the signals at microphones 1 and 3, and $T_{2\text{-}4}$ is the time difference between the signals at microphones 2 and 4. The arctangent function is approximated to within ±0.5 angular mil by the transfer function:

$$\tan \theta = \frac{28x - x^2}{180 - 8x - x^2}$$

This equation is solved by a bridge-type computer using only linear potentiometers. In the bridge circuit shown in Fig. 11, R_1 and R_2 are the precision potentiometers coupled to the analyzer. During computation, the bridge is brought into balance by a servo which drives the 10K potentiometers. The computer calculates azimuth angles to 90° only; switches connected to the trigger heads set up a quadrant computation which is then added thru a differential to the azimuth reading. For alignment, R_p and R_q are used. The major advantage of this type of computer is that a wide variety of functions can be closely approximated by various combinations of linear potentiometers and shunts. Tapped and nonlinear potentiometers are generally not required. In order to realize the accuracy inherent in the approach, however, the best potentiometers permitted by the state of the art are required.

The second function computed (SRC) expresses the velocity of sound over the array as a ratio with respect to a standard velocity of sound. The SRC factor is used during initial setups in the field to estimate the distance to a powder charge exploded in the center of an adjacent microphone array. The time difference between the acoustic impulse and one transmitted over a telephone or radio link is a measure of the distance. The velocity of sound must be accurately known when this measurement is made. The SRC factor is also used as a check during the alignment of pulses on the oscilloscope; if the pulses are incorrectly aligned, the SRC factor will differ from the average value for the day.

The SRC factor is given by:

$$\mathrm{SRC} = \frac{K}{\sqrt{T_{1\text{-}3}^2 + T_{2\text{-}4}^2}}$$

Where: SRC is the survey range correction factor, $T_{1\text{-}3}$ is the time difference between microphones 1 and 3, $T_{2\text{-}4}$ is the difference between microphones 2 and 4, and K is a scale factor. Tapped potentiometers are used to adapt the bridge to different sizes of microphone arrays.

ACKNOWLEDGEMENTS

The equipment described in this paper is the work of many groups within RCA. Those participating were drawn from the Site Communications and the Magnetic Recording Equipment groups of the DEP Surface Communications Division, and from the DEP Applied Research group. The computer was designed by the Frankford Arsenal. The project was sponsored by the U. S. Army Research and Development Laboratories on Contract DA-36-039-SC-75034.

A NEW DIGITAL SYSTEM FOR EDITING TV TAPE

This rapid, accurate system uses digital techniques to allow selection and viewing of portions of TV-tape recordings, and subsequent editing with single-frame accuracy. Originally developed for NBC, it has promise for the entire TV broadcast industry, as well as for special commercial and defense TV applications.

by

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TV TAPE USAGE has developed within the broadcast industry, and in closed-circuit TV applications, to a position similar to that of motion pictures. The TV tape recorder is no longer a device to be used only for recording TV programs; it is a production tool used extensively in the preparation, production, and broadcasting of TV presentations.

The producers, directors, and actors see the tape recorder as a means of achieving program perfection. Often, scenes or portions of scenes are recorded several times until desired results are obtained. The finished tape is then obtained by cutting and splicing these recordings. Such artistic requirements, in addition to the commercial requirements such as preparation and insertion of advertisements, and program timing, have over-burdened present tape-editing facilities.

SYSTEM CONCEPTS

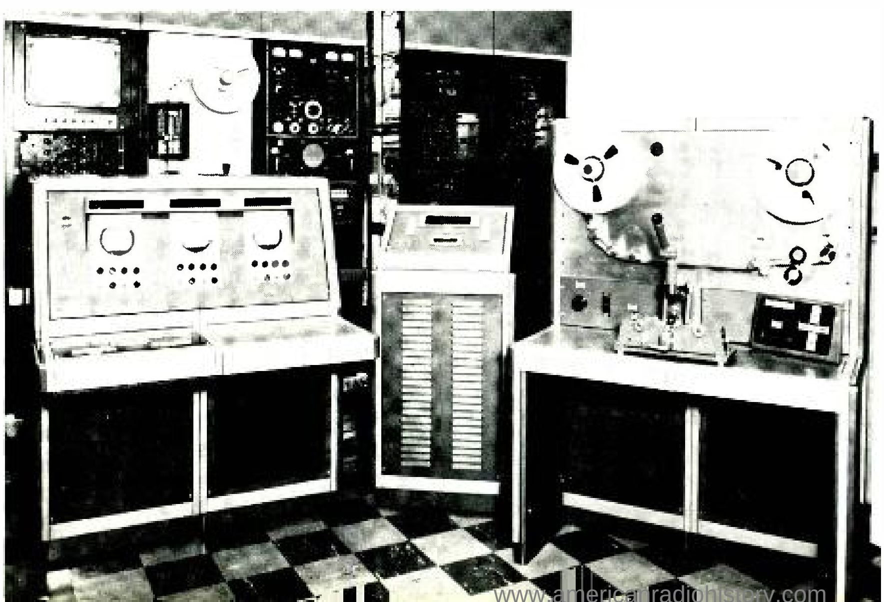
Recognizing this problem, a system was designed to simplify and speed-up tape editing operations. This system permits the editor to select, view, compare, and evaluate groups of "frames" on the tape and to edit with single-frame accuracy. When all the edit frames are determined, the tape recorder is no longer used. A specially designed console is used for locating the specified frames and splicing the tape.

While in motion-picture editing the film can be directly visually examined for editing, TV tape must, obviously, be observed through a monitor system. A general edit location based on video or audio content may be selected, but lacking is a method for locating the precise segment of the tape involved. To solve this in the digital system described herein, numbers are magnetically recorded on the TV tape to identify each frame and permit their selection and display for careful examination. Edit frames are thus quickly and accurately located for splicing. The resulting system is simple to operate. fast and accurate. No changes in the TV tape recorder are required to accommodate this equipment, and a minimum number of interconnections are needed.

THE EQUIPMENT

Three consoles (Fig. 1) comprise the system: 1) frame-number generator, 2) frame-selection-and-display console, and 3) tape-search-and-splice console. The frame-number generator has been designed so that it is easily moved and connected to any tape recorder. The frame-selection-and-display console is also movable and may be positioned as desired. The tape-search-and-splice console is self-contained and is not connected to the recorder; therefore, it may be set up and operated in any convenient location.

Fig. 1—Tape editing consoles.



FRAME NUMBER RECORDING

The frame-number generator generates the identification numbers that are recorded on the cue track of the video tape. The only connection to the number generator are a composite video or sync input from the recorder or a camera, and the frame number output to the recorder. The frames are identified in terms of minutes, seconds, and thirtieths of a second, up to a maximum of 99 minutes, 59 seconds, and 29 thirtieths of a second. Preselect switches on the control panel permit the setting of the initial frame number anywhere from zero time to the maximum time. The number display on the control panel shows the numbers as they are being recorded. Because of the physical displacement of the cue track head and the video head, an 18-frame displacement exists between a video frame and its related frame number.

The frame-identification numbers may be recorded during the preparation of an original tape, or they may be added later to a prerecorded tape.

EDIT FRAME SELECTION

The next step in the editing cycle is to play back the tape, observe the video information, and decide where editing is desired. The usefulness of the frame-selection-and-display console is clearly shown at this point in the edit cycle.

As shown in Fig. 1, the frame-selection-and-display console has three video-storage monitors and associated frame-number displays. The monitors use Tonotron storage tubes, which permit viewing of selected frames for up to five minutes.

In operation, as the video is being played back, discrete frames are sequentially displayed on the storage monitors. Each monitor displays a different frame. The interval between successive frames can be selected by the editor and may be 1, 5, 10, or 20 frames. A 10-frame interval is normally used during this phase of the operation.

The editor may also observe a standard monitor, and at any time, he may stop the sequencing of the storage monitors. This freezes the video frames on the storage monitors. Displayed above each monitor is the corresponding frame number. If the frame at which a splice is to be made is being displayed, or in the event the information displayed is adequate for a decision to be made, the frame number is noted and playback is resumed until the next edit location is reached. The above edit process is then repeated.

If the desired frame is not displayed and an accurate edit must be made for artistic or commercial purposes, the frame number closest to the area of the desired edit point is set into the frame selection switches on the control panel. A shorter frame interval, 1 frame or 5 frames, may also be selected at this time. The tape is rewound a short distance and restarted. As the preselected frames are played back by the recorder they are stored on successive storage monitors. In this way, a precise frame determined by the editor may be selected as the edit point. After this phase of the editing cycle is completed, all edit frames are noted in terms of their frame numbers.

TAPE SPLICING

The splice function is performed on the tape-search-and-splice console. This unit consists of a tape transport with circuitry necessary for reading the digital frame numbers and the capability of searching for and stopping at any selected frame.

In operation, the first edit frame number is entered into the frame-selection switches. Numbers are read from the tape and when coincidence is obtained between the number on the tape and the number in the frame-select switches, the tape stops. The desired frame is displaced 18 frames from the number. A pointer on the tape transport indicates this frame position and an edit pulse on the control track then determines the precise location for tape splicing. The procedure is repeated for the remaining edit frames.

FRAME NUMBER GENERATOR

Fig. 2 is a block diagram of the frame-number generator. A sync separator circuit provides vertical sync pulses from the composite video. Since a video frame contains one sync pulse for each of its two interlaced fields, only one of these sync pulses has to be counted for frame number generation. In this system, the odd field pulse was chosen.

The sync pulses are counted in a binary-coded decimal counter operating in the 8-4-2-1 code. This simplifies decoding of the numbers so that they may be displayed during recording and playback. Twenty-one binary bits are required to represent the entire range of frame numbers.

After each sync pulse, the number in the counter is transferred nondestructively and in parallel into a shift register that operates as a parallel-to-serial converter. A 21-bit pulse burst generator is then triggered and shifts the number serially out of the shift register into a tone burst gate. A 4-kc oscillator is enabled when a binary zero is shifted out of the shift register, and an 8-kc oscillator is enabled when a binary one is shifted out. By this method, a series of sine-wave bursts representing the frame numbers is obtained and recorded on the video tape by the cue-track record head. Fig. 3 shows a typical tone burst representation of a frame number. By using sine-wave bursts, the system becomes relatively immune to random-noise pulses which may occur during recording or playback of the frame numbers.

Preset switches are also included so the counter may start from any desired initial number.

VIDEO-DISPLAY-AND-FRAME-SELECTION CONSOLE

A block diagram of the video-display-and-frame-selection console is shown in Fig. 4. To view a particular frame, its identifying number is entered into the frame number selector switches. Playback is started and the 4-kc and 8-kc bursts which comprise the frame numbers are read from the cue track. These are amplified and demodulated to provide pulses suitable for driving the other circuits in the system. The demodulated numbers are then fed into a 21-bit shift register and a synchronizing circuit.

The numbers in the shift register are constantly compared with the number entered into the frame selector switches; when equality is obtained, a sequencer circuit is enabled. The sequencer gates the selected video frame to one of the storage monitors, and two additional frames are gated to the other two storage monitors. Separation between stored frames may be chosen to be at 1-, 5-, 10-, or 20-frame intervals. Simultaneously with the display of the selected frames, the frame numbers are transferred from the shift register to binary-

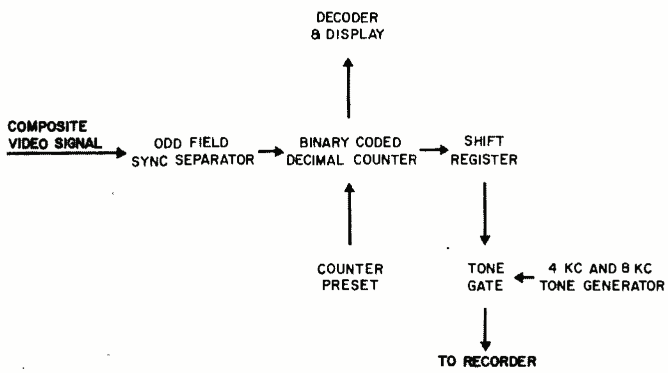


Fig. 2—Frame-number generator.

WILLIAM J. HANEMAN received his BEE degree from the Polytechnic Institute of Brooklyn in 1951 and his MS degree from Purdue University in 1955, all in Electrical Engineering. In 1951, he joined the Airborne Instruments Laboratories where he designed moving target indicator circuitry for use in radar systems. From 1952 to 1954, he served with the U. S. Army at Aberdeen Proving Grounds, Maryland, performing systems tests on anti-aircraft fire control systems and maintaining a digital computer. In 1955, he joined the RCA Laboratories and in 1958, Mr. Haneman transferred to the Astro-Electronics Division of RCA, where he participated in the development of the Tiros ground station. Mr. Haneman is a member of Eta Kappa Nu, Sigma Xi, and the IRE.

HARVEY OSTROW received the BEE and MEE degrees from the City College of New York in 1954 and 1961, respectively. He joined RCA in 1954 and has been associated with the Semiconductor Division, RCA Laboratories, and Patent Operations. At the Astro-Electronics Division, which he joined in 1959, he has worked on the TIROS satellite system and on digital logic circuit design problems. He is presently working on the design of television cameras for satellite applications.

coded-decimal to decimal decoders, and the proper frame numbers are displayed over the selected frames.

In another mode of operation, the storage monitors may sequentially display single frames spaced at 1-, 5-, 10-, or 20-frame intervals by disabling the comparison circuits and simply using the sequencer circuits to continuously gate individual frames to the storage monitors.

TAPE-SEARCH UNIT

The tape-search unit (Fig. 5) has four modes of operation: manual slow, manual fast, search, and variable speed control. The variable speed control bypasses all logic circuitry and provides continuous control of tape speed and direction. In the two slow modes of operation, speed control is provided by a capstan drive. In the high-speed mode, speed control is obtained by a reel drive servo.

Digital information is read from the cue track and demodulated by the appropriate circuits, i.e. low or high-speed demodulators. The output of the demodulator is fed to the shift register and to the synchronizing circuits. The synchronizing circuits detect the end of a frame number and trigger the logic circuits. In the two manual modes, the synchronizing circuits transfer the data in the shift register to the display circuitry. The direction of tape movement in the manual modes is set by two indicator-switches on the control panel.

To search for a particular frame, the desired frame number is set into the frame selection switches, the search button is depressed and the tape moves in the direction set by the direction control circuits. After a frame number is read into the shift register the synchronizing circuits initiate a direction comparison. When the comparison is completed, a direction command signal is sent to the direction control circuits which establish the correct direction of tape movement to find the selected frame. This direction comparison is made for each frame number. The tape is stopped when the number in the shift register agrees bit for bit with the number in the frame selection switches.

The mechanism for stopping the tape accurately is a stepping motor used for the capstan drive. When this motor is de-energized it exerts a holding torque which keeps the tape from moving. The tape is marked and the clear switch is depressed, which releases the tape so that the splice may be made.

SUMMARY

In the preceding description, emphasis was placed on editing as a function of video information. Realizing that video-tape editing has varied requirements in which any one or a combination of items may require critical editing, it is worth emphasizing here, that this system need not be limited to editing solely on the basis of video. The *freeze* feature of the system, which permits the freezing of video and number displays, may also be used to locate audio edit points by freezing the number display at the desired audio transition. The system is also compatible with a double system of recording with separate tapes for video and audio.

The frame numbers may be recorded on several tapes at one time if duplicate tapes are being recorded. The splicing of the duplicate tapes is a mechanical operation once the edit frame numbers have been determined from the original. It is unnecessary to play back the duplicate tapes; they may be spliced directly on the tape search unit.

This editing system is very flexible and can handle editing from the simplest to the most complex with no system modifications. When the tape recorder art permits electronic editing, the frame numbers will be most useful in synchronizing tape machines and switching video signals at the exact frames.

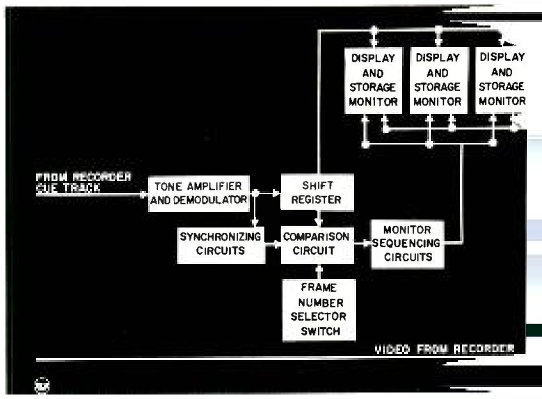


Fig. 4—Video display and frame selection.

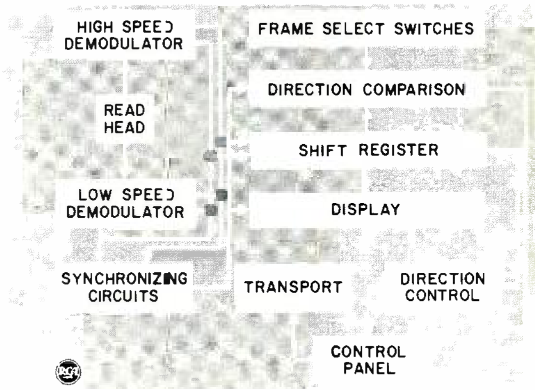
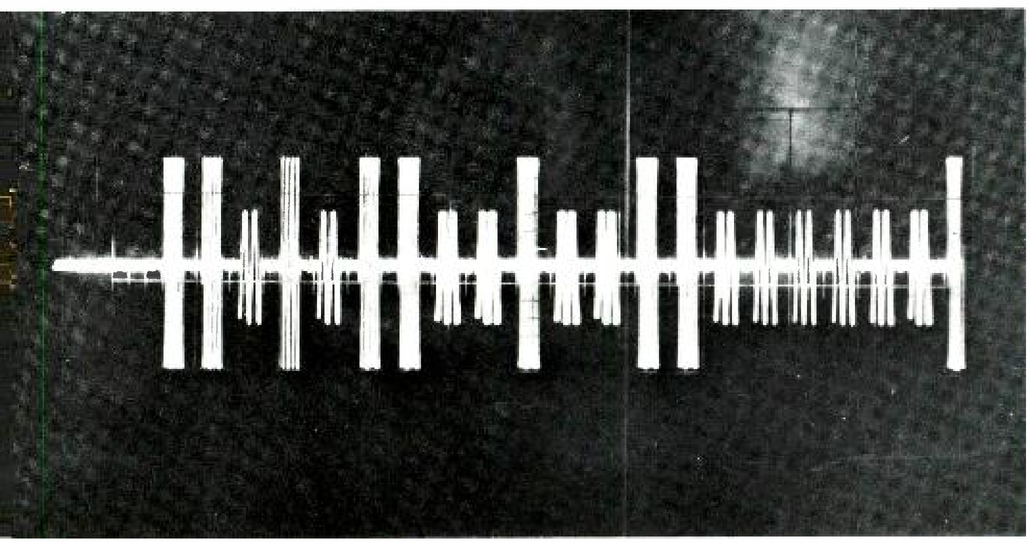


Fig. 5—Tape search.

Fig. 3—Frame-number—tone-burst representation.



THE DEE CONCEPT . . . A Family of Test Systems

by **D. B. DOBSON and L. L. WOLFF**

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DEP, Camden, N. J.

The Oct.-Nov. 1960 issue of the RCA ENGINEER contained an article on the RCA Digital Evaluation Equipment (DEE), the outgrowth of Ordnance Corps program for test-equipment standardization. Since then, DEP System Support engineers have advanced another step, with an integrated product line of automatic all-purpose test systems.

THE OPEN-END DESIGN of the DEE family of test systems makes it possible to instrument an electronic test system with only those stimulus, measurement, and control building blocks *actually required*. Electronic building blocks, of available designs, can quickly be added, substituted, or removed, without modifying the basic DEE configuration.

Each system in the DEE family can be building-block expanded to handle additional test tasks or increased work flow. Thus, DEE does not suffer the frequent test-equipment obsolescence normally accompanying changes in test requirements. Further, extensive R&D effort is not required to assemble any given DEE test system. This whole concept ensures moderate initial capital investment and expansion costs. The family consists of four classes of equipment (Figs. 1-4), and uses FIELDATA code as program language.

PROGRAMMED SEMI-AUTOMATIC DEE

This lowest-cost system will process tests programmed on punched paper or mylar tape (Fig. 1). It includes a low-speed paper tape reader, a control and display panel, and monitor-adapter equipment for the units to be tested. Control circuitry is composed of control elements, a data register, an instruction decoder, a switching register, and a decoder. The system utilizes the user's existing stimulus and measurement equipment, and test-result printer.

Operating from programmed tape, the system selects test points and measurement functions, routes stimuli to the appropriate input terminals, and displays or prints out test results.

The operator compares results with listed standards. If the test result is acceptable, the operator initiates the next test by pushing a button. If unacceptable, the operator stops the test and disconnects the unit under test for repair. Fault location and troubleshooting is simplified by observing the test result on the display panel.

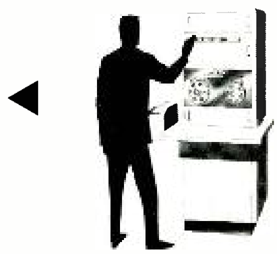
Production-line testing of standard electronic units or components is an ideal application for the Programmed Semi-automatic DEE. It may also be used profitably in component grading and selection processes.

PROGRAMMED AUTOMATIC DEE

To accelerate test processes, automation is featured in the Programmed Automatic DEE (Fig. 2). This system minimizes operator participation during critical test phases, reducing human errors and the requirement for highly-skilled operators.

The system uses a perforated-tape reader to perform programmed test routines. Three hundred test programs (equal to 13 diagnostic routines or 88 acceptance tests) can be stored on a 10-inch tape reel. Tape access time is

Fig. 1—Programmed Semi-automatic DEE.



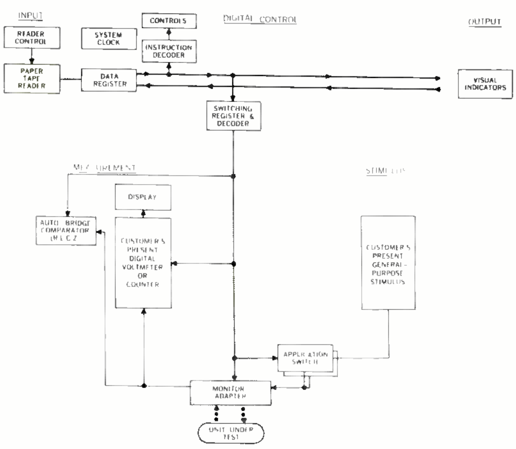
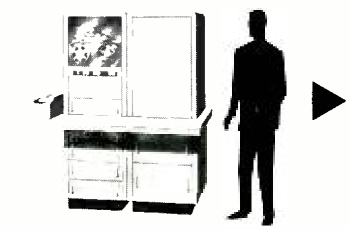


Fig. 2—Programmed Automatic DEE.



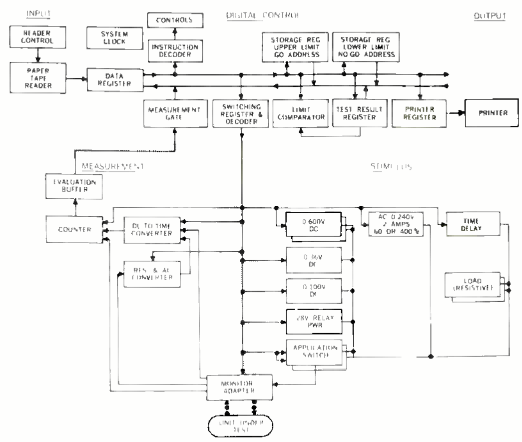
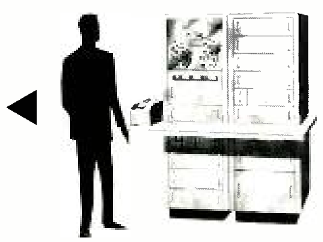


Fig. 3—High-Speed Automatic DEE.



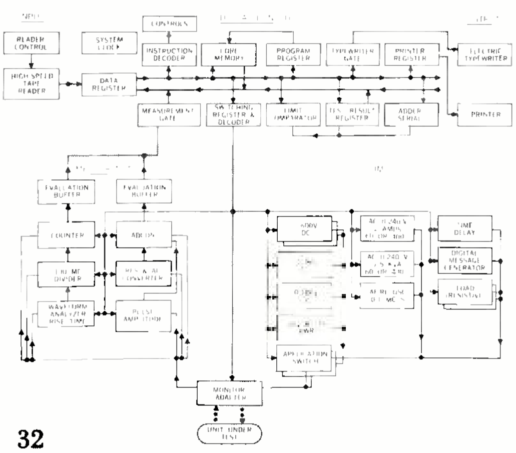
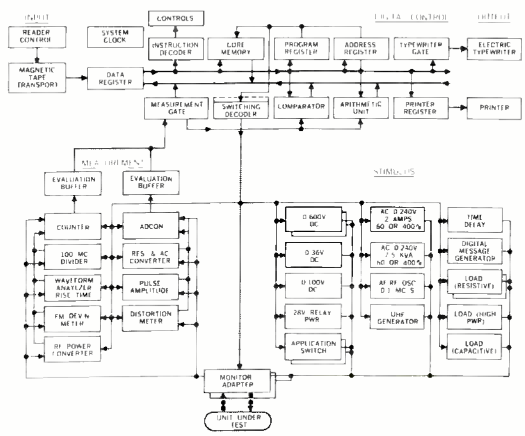


Fig. 4—Computer-Controlled DEE.



15 seconds. Approximately 12 reels are required to test a complete radar system.

The system automatically selects the signal monitoring points and measurement functions; compares measured values with stored test limits; adjusts stimuli to proper settings; turns them on and off at appropriate times; and routes their outputs to the correct input terminals of the unit under test. It then displays and prints out a record of each measurement, together with the *hi*, *go*, or *low* symbol and the test number.

System operation is automatic until an out-of-limit test result occurs. Fault isolation is then performed in step-by-step diagnostic programs, contained on tape. Acceptance and diagnostic tests are the most suitable uses for the Programmed Automatic DEE. In addition, the system may be adapted to production test and field checkout, where the variety of units to be tested is limited and time permits manual exchange of test-program tapes.

HIGH-SPEED AUTOMATIC DEE

This system uses general-purpose digital elements to control test routines. stimulus application, and test-result processing (Fig. 3). A high-speed paper tape reader. which is utilized in conjunction with a buffer memory, performs automatic test-limit comparisons. test-program search. and fault-isolation routines. Besides the analog stimuli, the systems employs a digital message generator for the checkout of digital devices, (e.g.. air-borne computers). Variable-pulse-width circuitry is incorporated to use as a radar pulse generator.

The most advantageous application for the High-Speed Automatic DEE is a production and quality-control system (repetitive tests at high speeds). The system can also be used as a test-equipment satellite, under the control of an available general-purpose computer.

COMPUTER-CONTROLLED DEE

The heart of the Computer-Controlled DEE is a general-purpose processor handling large quantities of test data, programs, and fault-isolation routines at high speeds (Fig. 4). Test instructions and programs, stored on magnetic tape, can be entered or changed by paper tape prepared by an electric typewriter. Computer operations are performed by an arithmetic unit from data stored in a high-speed, random-access core memory. A fast-response waveform analyzer replaces the customary oscilloscope; this causes the pulse rise time, amplitude, width, over and undershoot, and slope and tilt linearity values to be printed out on the electric typewriter.

The Computer-Controlled DEE handles the most complex testing, diagnostic, and test-data-processing tasks encountered in production testing, field checkout, depot maintenance, and R&D evaluation. The control portion may serve also as a master station for a group of test-equipment satellites.

DEE INTERFACE CONVERTER

In facilities which already have general-purpose computer, the DEE stimulus and measurement equipment can time-share such a data processor via the DEE Interface Converter (Fig. 5). This converter extends the high-speed arithmetic and programming ability of any existing general-purpose digital computer to the performance of test processes. preparation of test programs. and numerical analysis of test results for evaluation of reliability data.

The converter changes the test data into compatible general-purpose-computer language. A timing and status generator synchronizes the measurement and stimulus sections with the data-processor speed. Instructions from the computer pass through the format control in the converter and then enter a switching buffer and decoder. This unit then sequences the application of the various DEE stimuli to the units under test. The performance of the units under test is evaluated by the equipment in the measurements section, and the results are fed to the format control and parity insertion circuit of the converter. From there, the test result leaves as the standard computer word to the input register of the computer.

Where such a data processor has the additional capability of automatic program interrupt, it may be used to control the operation of several DEE test stations.

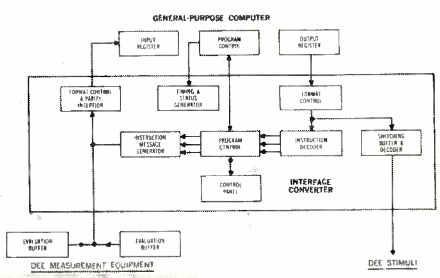
SUMMARY

The underlying test principle permitting the modular design of the DEE family was the development of the concept of a basic control system that could contain input equipment, arithmetic and comparison equipment, program control, and switching control.

The information bus is the prime factor in the ability to successfully modularize computer functions. It provides a two-way communication path for the digital signals throughout the controller system. The information bus links the tape reader with the data register, instruction register, and parity check circuit in the program control subsystem. It also interconnects the arithmetic and comparison subsystem. the switching-control subsystem. and when required. the memory subsystem. Similarly, the information bus links the peripheral equipment.

Figs. 1 to 4 also illustrate the basic growth pattern possible by the simple addition of functional modules to make test systems of any desired size.

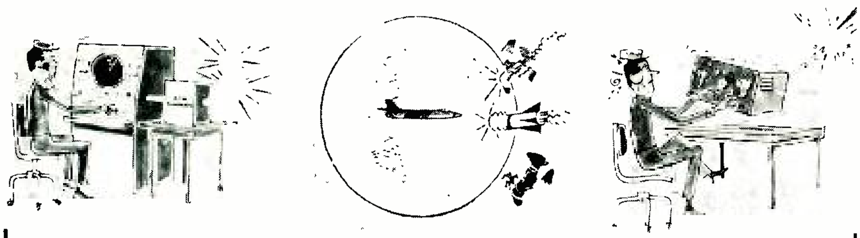
Fig. 5—DEE Interface Convertor.



L. L. Wolff, left, and D. B. Dobson.

DAVID B. DOBSON received the BEE from Rensselaer Polytechnic Institute. At the Signal Corps Engineering Laboratories, Ft. Monmouth, N. J., he participated in the development of high-powered audio amplifying systems. Subsequently, he was appointed the Electronics Member of the Army Psychological Warfare Board, where he engaged in the application of electronic equipment to psychological warfare. Upon joining RCA, he was first engaged in the production follow of fire-control radars. Later, he was assigned as Project Engineer for the maintenance engineering aspects of the MA-10 (AN/ASG-14) radar for the F-104, and was responsible for the design, construction, and delivery of two complete sets of USAF Depot Test Equipment for the radar. He next was responsible for the ASTRA Production and Depot Test Equipment design and development. With the formation of Systems Support Engineering, he became engaged in the application engineering of RCA systems-support products to new areas, with responsibilities for successful contract performance. He is a Member of the IRE, the AIEE, and the Society of American Military Engineers, and has presented and published papers on many aspects of systems support.

LARRY L. WOLFF received his BSME degree in 1939 from Prague University, and spent the following three years as a junior engineer designing heavy machinery. He served in World War II as an Engineer and Intelligence Officer in Europe and the Pacific theatres of war. After the war, he was a technical advisor and interrogator at the Nuremberg Trials. After serving again in the Korean War, he joined the Burroughs Corporation Research Center in 1955 and became supervisor of technical publications. With RCA since 1959, he has been assigned as publications engineer to the Systems Support Area of the Aerospace Communications and Controls Division in Camden, New Jersey.



Electromagnetic warfare is an inherently complex field that includes **reconnaissance** (electronic intelligence, ELINT: and communications intelligence, COMINT), **countermeasures** (ECM), and **counter-countermeasures** (ECCM). Development of systems and equipment for these requires knowledge of many fields, e.g., communications, radio navigation, radar, missile systems, military tactics. ECCM for countering an enemy's ECM must be considered by groups designing radar, communication, or navigation systems. ELINT or COMINT is an important part of intelligence gathering and analysis. ECM is very complex, with varying requirements for land, sea, and air weapons. DEP is presently conducting electromagnetic-warfare programs in the Aerospace Communications and Controls Division, the Surface Communications Division, and the West Coast Missile and Surface Radar Division. Programs involving a specific technique are usually carried out in one Division; more-complex efforts may frequently involve more than one Division.

ELECTROMAGNETIC WARFARE

by **D. K. GILBERTSON**
Advanced Systems and Techniques
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The Aerospace Communications and Controls Division has been active for several years in operations analysis related to electromagnetic warfare and in development of advanced countermeasures (ECM) and counter-countermeasures (ECCM) equipment. This has involved both a variety of contracts and a significant portion of ACC's Advanced Research and Development effort. This work is backed by the broad capability of RCA in directly related fields such as high-power transmitting tubes, low-noise receiving tubes, heavy ground radars, data-link and spread-spectrum secure communications, data processing, airborne interceptor radars, and ECM receivers, jammers, transponders and decoys.

The primary aim of ACC in this work is to develop system concepts and equipment to increase U. S. military capabilities to:

1) collect intelligence concerning the enemy electromagnetic capabilities through electronic intelligence (ElInt) and communications intelligence (ComInt),
2) degrade the effectiveness of enemy offensive and defensive weapons through active and passive ECM techniques, and
3) immunize our own electromagnetic capabilities through appropriate ECCM techniques.

PRESENT ROLE

The capacity of any major nation to carry out military operations and to wage war has grown more and more dependent upon electronic devices. Strategic, tactical, and defensive air forces, field armies, and navies depend upon radars of many descriptions for search, intercept control and guidance of complex weapons. The various forms of communications networks provide an important link in the coordination of far-flung tactical and strategic forces. Disruption, confusion, and saturation of these information-gathering and -processing systems can cause serious degradation and even complete failure of military operations.

Any offensive weapon system which is intended to penetrate hostile air space should attempt to deny the defenders the information they need from their electromagnetic equipment. One technique is to screen, or cover up, the required intelligence. Another is to confuse or deceive the defenders by introducing misleading information into their data acquisition and processing systems. The penetrator will probably be capable of attempting one or both of the above countermeasures in order to increase its probability of target kill.

CURRENT ECM—MANNED BOMBERS

Manned bombers have both the need and the capacity to carry along a large amount of ECM equipment. They operate at relatively modest speeds and altitudes and are vulnerable to defensive weapons. Their probability of mission success may be significantly enhanced through the extensive employment of electronic warfare tactics.

Noise Jamming

This is the earliest used and most natural form of jamming. Noise-like energy is introduced into the victim radar's receiver with a power level sufficient to mask the true skin echo reflected by the penetrator. Current noise jammers employ mechanically tuned c-w magnetrons, amplitude-modulated to increase their r-f bandwidth. They are tuned to a particular frequency or swept over a range of frequencies in an attempt to jam a tuneable radar or a number of radars operating on different frequencies. They can cover the entire frequency range of interest with a series of separate transmitters.

The effectiveness of such a jammer is dependent upon the outcome of the power competition between the target echo signal and jammer noise within the radar receiver's bandwidth. The critical parameters for effectiveness are the total power capability of the transmitting tube, the number of transmitters in each frequency band, the antenna gain in the direction of the victim radar, and the spectral width of the jamming energy. If the jammer is to be swept in frequency, the sweep rate and sweep width must be carefully controlled to obtain optimum effectiveness. In addition to diluting its average power at a given frequency, a sweeping jammer is susceptible to certain ECCM which allow the victim radar to discriminate against the sweeping noise signal, while retaining the true echo signal.

Noise jammers now becoming operational employ carcinotron oscillators which are both frequency- and amplitude-modulated to provide a much wider bandwidth than can be achieved with the amplitude-modulated magnetron. These equipments, called barrage jammers, generate relatively wideband output energy with statistical properties approaching those of true thermal noise. They may be operated at various bandwidths with their center frequencies tuneable over a modest frequency range. In general, they are available only in certain frequency bands. In the remaining bands, jammers that employ low-level, channelized noise and driving high-power distributed amplifiers or traveling-wave-tube amplifiers may be used. In general, these transmitters are manually operated, based upon information obtained from surveillance receivers carried by the bombers.

Automatic receiver-transmitter systems are becoming available in some bands to provide noise jamming of tracking-radar signals in those bands. The transmitters are essentially the same as those above, but are able to respond much more rapidly to high-threat illuminations.

Highly advanced automatic noise jammers are currently in development which employ sophisticated receiver techniques and high-power traveling-wave-tube amplifiers, the details of which are classified.

Passive Reflectors

This category includes the various forms of chaff—single-unit dispensing, track-break, and delayed-opening chaff. Since these are relatively simple and inexpensive countermeasures, most manned bombers are well-equipped with the dispensers and stores needed to sow chaff corridors and conduct track-breaking operations against both surface and air-borne tracking radars. The critical parameters are: total chaff load, bloom rate, cloud echo cross-section, bundle dispensing rates, and frequency coverage.

Repeaters and Transponders

These equipments generally perform the functions of electronic track-break, confusion by false target generation, and simulation to make a small radar target look large. They are actually relatively recent developments which depend on deception rather than brute force to degrade the effectiveness of the defense weapons. Range-gate stealers and conical-scan inverters are common forms of the track-break devices employed against conventional interceptor pulse radars and surface-to-air missile-guidance pulse radars. Velocity-gate stealers, employing frequency-shift techniques, may be used against the more-advanced, coherent radars such as the pulsed-doppler and c-w doppler types. False-target generators are generally employed against ground surveillance radars to cause a series of target blips to appear instead of the lone skin echo. Counter-countermeasures required to defeat these equipments are much more subtle and depend to a large degree on human judgement for differentiating between normal target behavior and erratic target behavior.

Infrared Sources

These devices are employed to decoy or break the track of infrared gun-sights or homing missiles carried by fighter and interceptor aircraft. They generally take the form of high-intensity heat flares dropped from the bomber at the proper time during the interceptor attack run, or they may be forward-launched by decoy rockets to draw attackers away from the bomber itself. Air-to-air missiles such as the Sidewinder and Falcon infrared weapons carried by most USAF fighters and all-weather interceptors are extremely effective against jet-powered aircraft and pose a serious threat to a manned-bomber fleet. Thus it may be expected that infrared countermeasures would be given a high priority by operational commands when selecting their expendable stores inventories.

Decoys

Decoys have long been an attractive approach to the penetration aids problem, since they have the inherent ability to both saturate the defensive data-gathering and -processing systems, and dilute the effectiveness of the terminal kill mechanisms. If the decoys can adequately simulate the actual bomber in all measurable respects, the defence commander is faced with the almost impossible task of having to maintain track and commit weapons against every apparently valid target. These decoys may carry noncoherent or coherent electronic repeaters or transponders, chaff dispensers, infrared flares, or jamming transmitters. The degree of the sophistication of the payloads determines, of course, the degree to which they may be discriminated against by advanced signal-processing radars.

Surveillance Receivers and Threat Evaluation Devices

All penetrators employing countermeasures must be equipped with some sort of receiving system which provides the required intelligence for proper employment of the various modes available. These receivers may range from simple, wide-open crystal video devices that determine only that a tracking signal in a particular frequency band is illuminating the bomber, to extremely complex, all-band surveillance systems that supply instantaneous data on all illuminating signals to a special computer which automatically selects and initiates the optimum countermeasure mode. The effectiveness of any given complement of ECM equipment aboard a particular bomber is highly dependent upon the information environment in which the electronic-warfare operator must function.

DONALD K. GILBERTSON, received the BSEE in 1950 from the University of Rhode Island. A member of the US Naval Reserve since 1943, he served on active duty as an aviation Electronics Technician during World War II and the Korean War. He joined the DEP Airborne Systems Division in 1952 and for six years was engaged in the design, development, and flight testing of air-borne fire control systems. Since 1958, Mr. Gilbertson has served as group leader in the Advanced Systems and Techniques section of the Aerospace Communications and Controls Division. He is presently responsible for electronic warfare operations analysis and development of advanced ECM systems.

Absorbent or Controlled Emissivity Coatings

Progress has been made in recent years in the technology of reduction of radar cross-section and infrared emission characteristics of penetrating vehicles, although certainly not to the degree desired by the offensive weapon system planners. A major breakthrough in this area would give a significant advantage to the penetrator during an electromagnetic warfare competition.

ELECTRONIC WARFARE IN THE MISSILE AND SPACE ERA

As the intercontinental bomber becomes obsolescent, the capability for delivery of weapons of mass destruction will depend more and more upon powerful, long-range ICBM's carrying nuclear warheads. NIKE-ZEUS appears at present to be a leading contender for the role of anti-ICBM. Providing this weapon ever becomes fully operational, it will depend upon the BMEWS radars and additional acquisition radars located somewhat nearer to the defended area for early-warning and rough tracking data. It must also depend upon its own local radars for accurate tracking and firing data. These radars are vulnerable to countermeasures, particularly of the decoy type. It is to be expected that various forms of decoy objects will be employed to the greatest extent possible consistent with the payload capacity of the booster rocket itself. This cloud of radar reflecting objects is expected to cause severe discrimination problems for the ground tracking and guidance equipment. These problems may be solved by the evolution of special radar and data-processing techniques based upon studies of the electromagnetic radar signatures of space objects. Extensive experimental radar signature data is being collected and analyzed on project DAMP, (Down-range Anti-ballistic-missile Measurement Program) and project PRESS (Pacific Range Electromagnetic Signature Study).

It is also conceivable that nose-cone ECM may be employed just prior to re-entry to further degrade and confuse the defense. There are many severe problems to be solved before this could be accomplished—notably antenna designs which can withstand the extreme temperatures of re-entry.

Electronic warfare technology will play a vital role in the development and employment of future space weapon systems. The precise techniques used will, of course, be compatible with the most advanced and imaginative ECCM "fixes" that will be employed in this never-ending cat-and-mouse game.

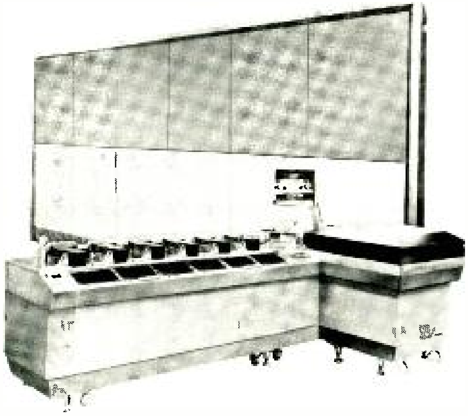

Fig. 2—Sample document used to show system feasibility.

Fig. 1—Electronic reading machine developed by DEP Applied Research. Top: recognition equipment and electronics. Bottom: paper-handling and scanning equipment.

ALL-ELECTRONIC READING MACHINE

by **S. KLEIN, Ldr.**

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THE RAPID ADVANCES in electronic-data-processing techniques have led to the conception of many sophisticated information-handling systems for both military and commercial applications. One frequent characteristic of such systems is that the raw input is in a natural language (alphanumeric) in many different formats; for example, varieties of typed or printed documents in English. Another is that a great volume of such input information must be handled. Sophisticated information-handling systems cannot realize their full potential unless such information inputs can be translated into digital computer language at a rate commensurate with the internal processing capabilities of the computer itself. Conventional methods are slow—i.e., an operator utilizing a manual keyboard. Thus, an *automatic reading machine* which can scan an ordinary printed document and produce a digital-coded computer input at electronic speeds is a vital link in such systems.

CRITERIA FOR READING MACHINES

Among the system applications that need this tool before the full capability of the digital computer can be economically realized are: 1) automatic language translation—e.g., Russian to English, 2) automatic abstracting and indexing of long documents—e.g., technical reports. 3) automatic document dissemination—determining distribution of material by scanning its content, 4) digital-communication system inputs, 5) automated accounting systems, and 6) automated billing systems—e.g., the reading of credit-card impressions and processing of invoices.

For such applications, an automatic reading machine must be able to handle ordinary printed or typewritten material in a variety of character styles and sizes (fonts), as well as a multitude of document formats. At the same time, it must maintain its high reading rate. For these reasons, the versatility and speed of electronic scanning is highly desirable, when combined with a character-recognition technique sophisticated enough to read arbitrary fonts.

The machine described herein was developed and constructed by DEP Applied Research to show the feasibility of high-speed electronic reading of a number of standard styles of typography. Previous reading-machine designs have ordinarily handled only a single type font, often, in fact one especially designed to optimize reading characteristics. The Applied Research feasibility model incorporates the basic characteristics needed for automated accounting and handled an alphabet of 16 characters. This feasibility model has proven the ability of the system to be readily extended to reading of full alphabets in varying typography styles, with great accuracy in practical, high speed applications. In addition, since it can handle ordinary typewritten material, it becomes practical for big computer installations to replace with typewriters the large number of code-generation machines such as flexowriters.

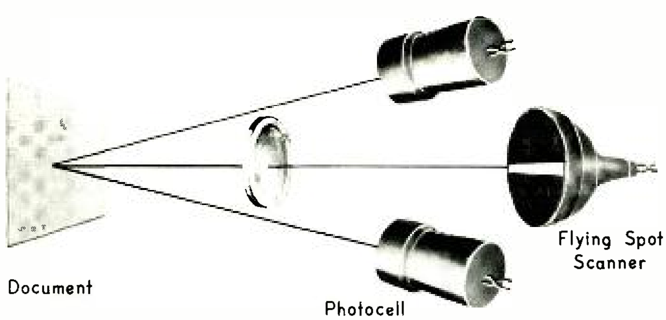
APPLIED RESEARCH'S READING MACHINE

The reading machine performs all of the functions necessary for an "off-line" document reader, that is, paper handling, character recognition, encoding of characters in computer language, and the recording of the digital code on magnetic tape for computer input. Except for paper handling, the machine's operation is completely electronic. The position of the lines and characters are located by means of electronic search of the page with the flying spot scanner. Recognition is by optical correlation. The basic memory of the machine is a photographic plate; this plate may be changed in order to recognize any arbitrary font.

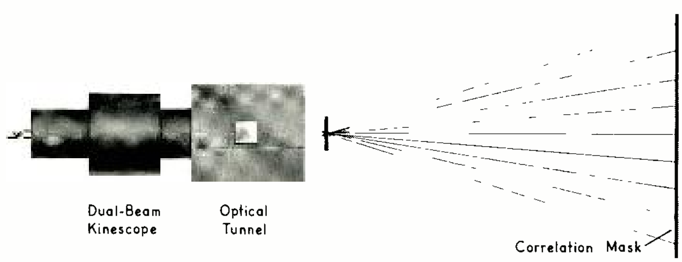
The electronic reading machine consists of two units (Fig. 1). The reading head, which houses the flying-spot-scanner pickup, is an integral part of a commercial check-sorting equipment. The recognition apparatus, search and centering logic, encoder and buffer circuitry, and associated power supplies are housed in standard RCA 501 computer racks. The search and centering logic, together with all other circuitry except the deflection power amplifiers, is transistorized on 501 computer plug-in boards.

The feasibility machine reads two lines of print having a maximum of 30

Fig. 3—Functions of the reading machine.



a. Documents are fed to the scanner unit. Characters in each line are scanned, one by one, by a feed-back-controlled flying-spot scanner that executes subroutines of search, center, and raster-scan for each character.



b. Optical correlator memory consists of an appropriate alphabet in a square array on a photographic plate. Unknown character is displayed on a kinescope. An optical tunnel simultaneously compares the unknown-character image with each of the characters of the alphabet array.

total characters (Fig. 2). The documents are presented by the paper handler to the reading head at a rate of 6¼ per second, and are stationary during a 100-msec reading period. All of the characters on the documents are individually read, recognized, and encoded during the 100-msec period that the document remains stationary. The "alphabet" for the accounting feasibility model consisted of 16 characters (ten numerals, *A*, *B*, period, dash, comma, and asterisk). For recognition, the machine simultaneously compares an unknown character with a memory plate containing all the alphabet characters (in this feasibility scheme, 16). To do this in the allotted time, the machine must, and does, recognize 500 characters per second. At this rate, the analog recognition process performs an operation that is equivalent to making about 10 million decisions per second by digital techniques.

SYSTEM OPERATION

The input to the reading machine is a printed alphanumeric character, the output is a digital code. In transcribing the printed character into computer language, the reading machine performs four basic functions (Fig. 3): a) scanning, b) optical correlation, c) identification, and d) encoding.

Scanning

The first electronic function is that of converting the unknown printed character into a video signal for presentation on a dual-beam kinescope. The major components of the scanning head, (Fig. 4) are photocells and a flying-spot scanner equipped with digital deflection circuits.

The scanning spot on a 5AUP24 cathode-ray tube is imaged onto the document by a high-quality photographic lens. The light reflected from the document is measured by two symmetrically-placed phototubes. The resulting signal is amplified and sent to the search and centering logic circuitry, which programs movement of the spot. The movement of the spot, although preprogrammed to some extent, is completely asynchronous, i.e., what it does next is determined by the signals detected in the video output of the phototubes.

The search and centering logic, which operates on the output of the phototubes, 1) locates the lines of text, 2) accurately locates the horizontal and vertical position of each character, and 3) takes an accurately centered "picture" of each character, which is used in the optical cross-correlator to identify the character. This picture consists of 30 vertical scans by the flying spot scanner with simultaneous display of the character on the faceplate of a dual-beam kinescope in the recognition cabinet. Following identification of the character by the recognition circuitry, the search for the next character begins.

Fig. 5 illustrates the video output of the phototubes as the scanning spot goes through a complete cycle on one document. The search-and centering logic centers each character separately. Hence, the scan patterns for the punctuation marks are centered lower than those for the alphanumeric characters.

Optical Correlation

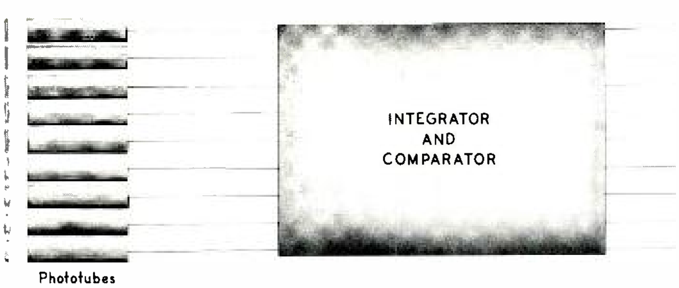
Identification of a character is achieved through the instantaneous parallel comparison of the unknown character with a large optical storage matrix. Comparing a character *simultaneously with many stored characters* permits much higher processing speeds than those attainable by serial methods.

TV techniques are used to present the unknown character for comparison as a clean, integral image registered with photographic memory matrix. The image of the character "read" by the flying spot scanner is displayed on the face of a dual-beam kinescope having a resolution of 1200 picture elements.

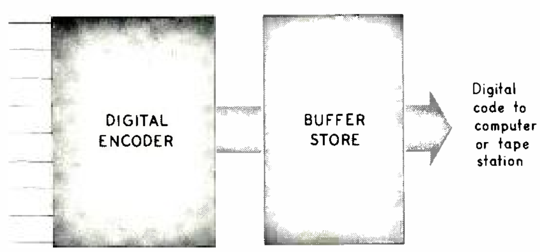
Parallel comparison is achieved with a unique optical tunnel, a four-sided array of flat mirrors permanently bonded to retain precise optical dimensions (Figs. 6, 7). Fig. 7a shows how positive and negative objects presented simultaneously by the dual-beam kinescope are simply inverted by a lens on the image plane. The optical tunnel, when placed between the lens and the image plane, produces multiple reflections of the image passing through it. Each reflection inverts the image either horizontally or vertically, or both. Hence, the optical tunnel projects a multiplicity of images in a symmetrical array onto the correlation mask.

This array of multiple images of the unknown character is registered against an array of characters stored on the

S. KLEIN received his BSEE from Drexel Institute of Technology in 1949 and immediately joined the Advanced Development Group of RCA's Home Instrument Division. He worked on the development of uhf receivers until 1950, when he went to Manufacturers Engineering Equipment Corporation for five years. During that period, he developed wideband video amplifiers, sweep generators (50-kc to 200-Mc range), tristimulus colorimeters and glossmeters, pulse height analyzers for the AEC, an ultraviolet recording absorption analyzer, and a multipoint recording system. Returning to RCA in 1955, Mr. Klein joined the DEP Airborne Systems Division and worked on the development of a wide-gated aquisition tracking system. In 1957 he was made Leader of the Synchronizer Group responsible for the synchronizer display and range tracker for the ASTRA fire control system (CF-105 aircraft). Mr. Klein's more recent work has included work on the design and development of an infrared image display device, and on character-recognition circuitry for the electronic reading machine. Mr. Klein is presently an Engineering Leader in Applied Research. He is a member of the IRE and Eta Kappa Nu.



c. Light from the unknown character on the display kinescope is transmitted through each character position in the photographic memory plate. This light is a measure of the correlation with the unknown character. An array of phototubes, one for each character in the alphabet array, measures these correlations. Tube receiving the minimum light identifies the character.



d. Each character in the alphabet array is assigned a digital code. Small sequences of these codes are stored in a buffer to facilitate readout to the computer or a tape station. These operations are carried out by conventional techniques.

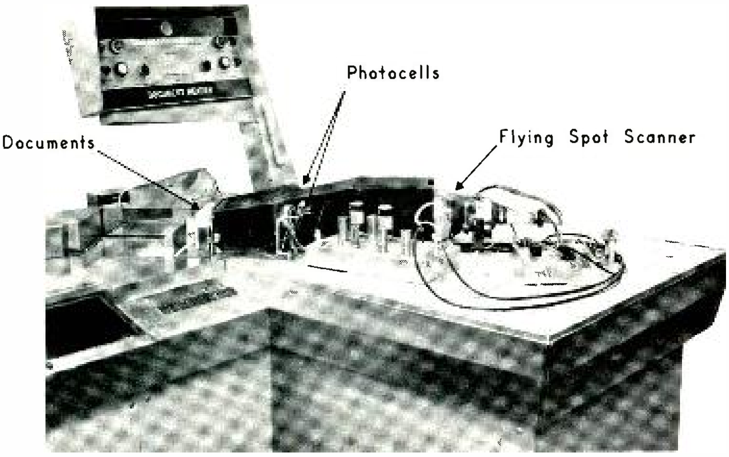


Fig. 4—Electronic scanning head.

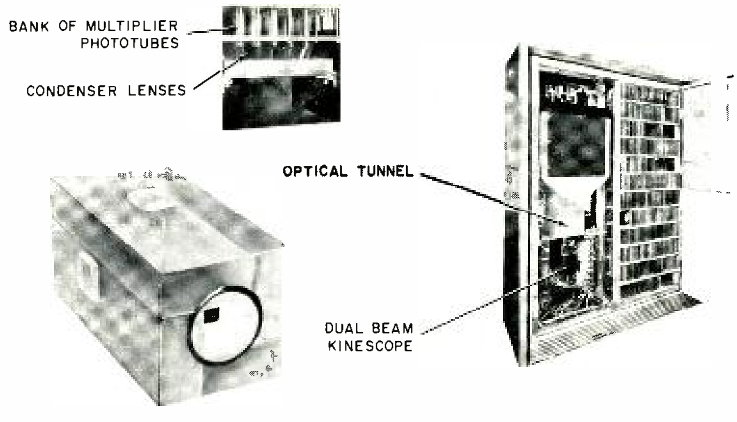


Fig. 6—Components of optical correlator.

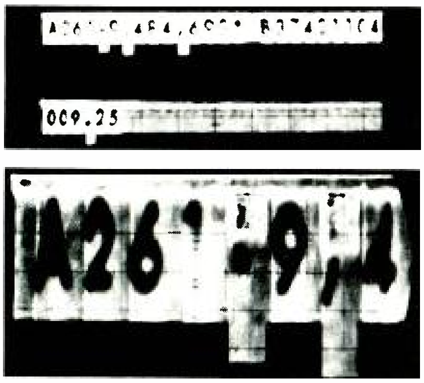


Fig. 5—Video output, demonstrating centering technique.

correlation mask. The mask is a transparency containing negative and positive representations of all the possible characters; thus, the stored character which is geometrically identical to the projected image passes no light. Fig. 8 shows a comparison mask for 25 characters and an array of *R*'s as projected by the optical tunnel. Also illustrated is the perfect match of the projected *R* (positive and negative images) with the *R*'s on the comparison mask. Note the null at the position where the *R* is on the mask. At all other positions on the mask, the stored images pass various amounts of light because they do not geometrically match the projected image. Such light is analogous to noise.

The recognition process is thus a true mathematical cross-correlation between the presented character and the stored version of it on the mask. The required integration of the correlation output over the area of the character mask is carried out in electrical integrators associated with each multiplier phototube. Fig. 9 depicts the correlation ratios as viewed at the output of the phototube-integrator combination associated with the numeral *4* as read from the document shown in Fig. 2. The oscilloscope recording shows the relative light outputs of each character on the mask when scanned in sequence as the numeral *4* is projected against them. The signal-to-noise ratio for the numeral *4* is approximately 3 to 1.

Identification

At the end of a character presentation cycle, there is a short interval for identifying the best null among the outputs of the phototubes. All of the integrator levels are simultaneously compared against a ramp. The first coincidence detected represents the best match and is therefore the character to be read out. An adjustable criterion for accurate recognition is provided in the machine, i.e., the null must be substantially lower than the channel having the next lowest amount of light. If this criterion is not met, a signal is generated which inhibits the encoding of the character and a reject symbol is encoded in its place.

Encoding

Each character in the document is encoded in the standard RCA 501 digital code and is stored in a buffer. During the time that this document is moved out of the reading area, the digital information is transferred out of the buffer and recorded on magnetic tape.

FUTURE CAPABILITIES

The Applied Research reading machine is an outstanding technical development for document input because: 1) the use of a photographic matrix mask for memory allows conversion from one font to another in a very short time at a minimal expense, 2) electronic page scan, and automatic line and character location have been successfully demonstrated, 3) the high resolution in this system has demonstrated an accuracy of one error per one million characters, reading a standard commercial font under dynamic conditions, 4) the machine has the potential of reading multiple fonts simultaneously with as many as 289 characters per correlation unit.

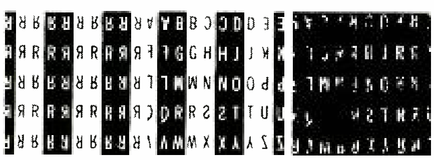


Fig. 8—Parallel pattern recognition. a. (left) Image array. b. (center) Comparison mask. c. (right) Recognition; note null at position of R.

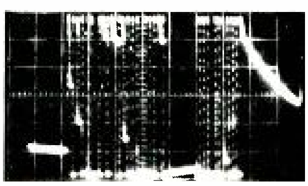


Fig. 9—Correlation ratios.

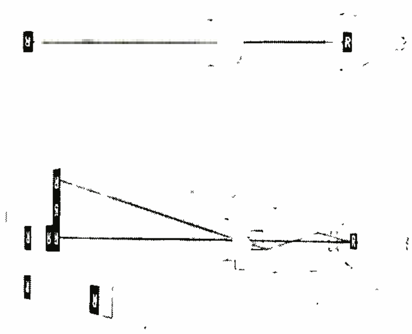


Fig. 7—a. (top) Simple image of kinescope display. b. (bottom) Multiple image using optical tunnel.

It would be shortsighted to suggest that the optical tunnel recognition technique is the ultimate reading machine technique. It is highly probable that an ultimate technique will be a form of feature abstract; that is, recognizing the invariant geometry of characters in a manner similar to the human recognition process, rather than character-by-character "reading."

Today's computer input requirements cannot, however, wait for tomorrow's techniques. Optical correlation is a *practical technique* ready to satisfy the needs of many present day systems. In addition, the electronic search and scan developed for use with the optical tunnel will be an invaluable base for this synthesis of the ultimate reading machine, when such methods as feature abstracting methods become a reality.

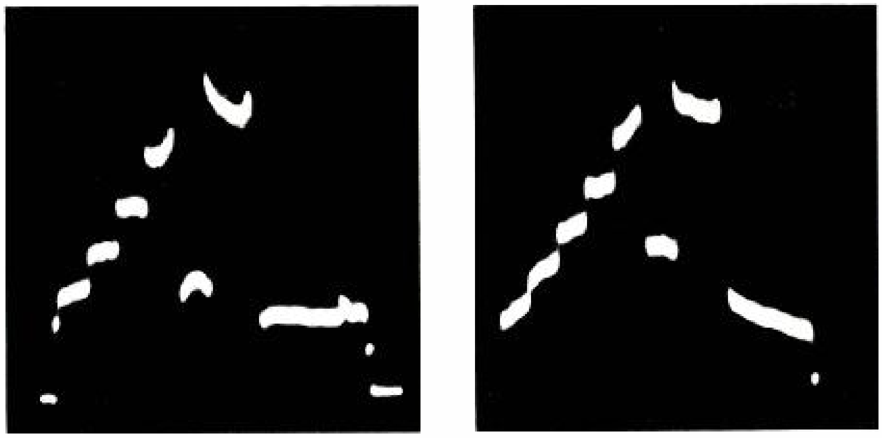


Fig. 1—Left: a) Oscillograph photo of the signal developed by an image orthicon showing the enhancement of boundaries between areas of different contrast. Right: b) Oscillograph photo of the signal developed by an image orthicon showing changes in waveform caused by a dirty optical system. (Note reduction in boundary enhancement)

PICTURE CHARACTERISTICS OF IMAGE ORTHICONS AND VIDICONS

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Discussed here are the differences in the nature of the pictures generated by an image orthicon and vidicon. A main point is that the picture generated by the image orthicon is uniquely suited to the TV system. It produces a picture that can appear to have a higher contrast than the actual contrast of the image on the face of the receiver, because the character of the picture complements two important characteristics of the human eye.

IT IS HIGHLY UNLIKELY that the vidicon as it is now known will generally replace the image orthicon as a studio broadcast-TV camera tube because vidicons and image orthicons are entirely different breeds of camera tubes. The image orthicon produces a different type of picture than the vidicon, in spite of the similarity of the normally accepted criteria for picture reproduction and fidelity of both the image orthicon and the vidicon—criteria such as resolution, sensitivity, signal-to-noise ratio and lag characteristics.[1]

IMAGE-ORTHICON BLACK BORDER

Anyone with even a small amount of experience in the TV industry realizes that the image orthicon is capable of producing a black border (sometimes called a black halo) around a brightly illuminated object. There has long been a running battle between purists and practical men concerning the desirability of operating image orthicons so that this black border is produced. Although purists endeavor to make a picture that is an accurate reproduction of the scene, practical men consider it expedient to open up the lens as far as possible to produce a "snappy" picture without regard to accuracy of reproduction of the scene. If either of these views is carried to the extreme of course, the final result is not the best that can be achieved.

CHARACTERISTICS OF THE EYE

A simple test of the capabilities and reaction characteristics of the human eye illustrates the principles described here. If you look through an outside window from a reasonable distance inside a room on a bright day, the window frame and drapes are practically indiscernible to your eye, whereas the wall and other furniture in the room several feet from the window can be seen clearly. Or, if you gaze at a young lady across a table in a restaurant having subdued lighting and a candle in the middle of the table, you can not easily discern the color of her eyes or readily make out features of the center of her face, although her hair and ears are very clear to you. These tests illustrate that the eye loses its sensitivity close to a bright object surrounded by a dark border.

THE EYE AND THE IMAGE-ORTHICON PICTURE

The image orthicon tends to behave in a similar manner under conditions of very high contrast, although viewers are not usually disturbed because their eyes and brains have been trained to interpret this effect as a normal consequence of high contrast in a scene. Therefore, except to engineers concerned with the trajectories of electrons inside the image section of an image orthicon, or to photographers concerned with the accuracy of film reproduction, an image orthicon picture with a *moderate* amount of black borders around a brightly illuminated object is satisfactory as far as entertainment or esthetic value is concerned.

The significance of this black-border effect becomes more pronounced under viewing conditions less well-controlled than the viewing conditions in the television studio control room. The actual picture-tube contrast range on a typical home receiver is probably in the order of 10 to 1, instead of a much higher value that can be achieved under very well-controlled conditions. When a TV picture has black borders, therefore, the eye recognizes the effect as high contrast, although the actual contrast may be well below the desirable contrast of a well-ordered TV system.

IMAGE ORTHICON ENHANCEMENT OF A TRANSITION

In addition to these psychological factors, there are measurable characteristics of the image-orthicon picture which contribute to the impression of a better television picture, including the high contrast obtained at the boundary of brightly illuminated objects. When the image orthicon is operated so that the highlights are even slightly above the knee of the light-transfer characteristics, the borders are accentuated, as shown in Fig. 1 a. Besides merely accentuating borders and giving the appearance of higher contrast, this characteristic actually compensates for some of the built-in aberrations of the television electro-optical system.

Fig. 1 b shows an oscillogram of the step pattern produced by the same image-orthicon tube and camera used in Fig. 1 a when the center of the lens was fogged by a thumb print. Although a dirty thumb print on a lens is not typical of TV practice, it illustrates a type of degradation of an image that can occur as a result of unclean optics and multiple reflections in the face plates of both the camera tubes and the picture tube, and between the safety glass in front of a picture tube and the tube itself. This effect has been noted by people who make TV picture recordings. Their experience over the years has been that a TV picture recording from an image-orthicon picture should be made with the image orthicon exposed to a higher light level than would normally be required for direct transmission. The light scattering or halation in the recording tube, the camera lens, and the film itself are then being compensated by the action of the image-orthicon tube.

THE EYE AND SHARP TRANSITIONS

The eye judges contrast primarily by transitions of brightness and not by the actual brightness differences of two different areas. In the logarithmic reflection charts of Fig. 2, there is a distinct difference in the brightness of the several steps of the pattern. The bottom step pattern of Fig. 2 shows the same step pattern with the sharp transition between two steps masked off. In this case, it is difficult for the eye to distinguish any difference in brightness values between the two steps. In other words, when the sharp transition is eliminated, the contrast range appears to be reduced as far as the eye is concerned. Therefore, enhancement or preservation of a transition or boundary apparently increases the contrast of a picture.

ADDITIONAL IMAGE ORTHICON CHARACTERISTICS

There are additional features of the image orthicon which make it especially suitable as a TV broadcast camera tube, particularly in studios where the action is faster than the action on film. For example, the limiting action of the knee characteristic of the image orthicon imposes an absolute limit on the amount of signal produced from extremely bright highlight glints. A disadvantage of this characteristic, however, is that very brightly illuminated highlights tend to lose most of their detail as a result of the flattening of the light-transfer characteristic when the highlights are substantially above the knee.

Another feature of the image orthicon, which has been described elsewhere, is that over-exposure (operating with the highlights substantially above the knee of the light-transfer characteristic) improves its motion-capturing ability, or reduces its lag, as it is commonly called in the terminology of the TV industry.[1] Under these conditions, the apparent "shutter" speed can be substantially less than the frame rate of the television system.

An additional and very important aspect of the image orthicon is that all the effects mentioned can be minimized or almost entirely eliminated, if desired, by operating the image orthicon so that the highlights of the scene are on the substantially linear portion of the light-transfer characteristic. This operating practice is used in color-TV systems at the present time because distortions of light values cannot be tolerated. Such distortions vary in the different color channels and produce shifts of hue rather than simple modifications of the brightness of portions of the picture, as is the case in black-and-white TV.

VIDICON CHARACTERISTICS

The vidicon can produce a very accurate TV picture because its light-transfer characteristic is partially complementary to the square-law characteristic of the television picture tube. Consequently, it requires little or no signal correction (gamma correction). The good resolution and recent improvements in the sensitivity and lag of the vidicon have put this tube on a par with the image orthicon as far as these characteristics are concerned.

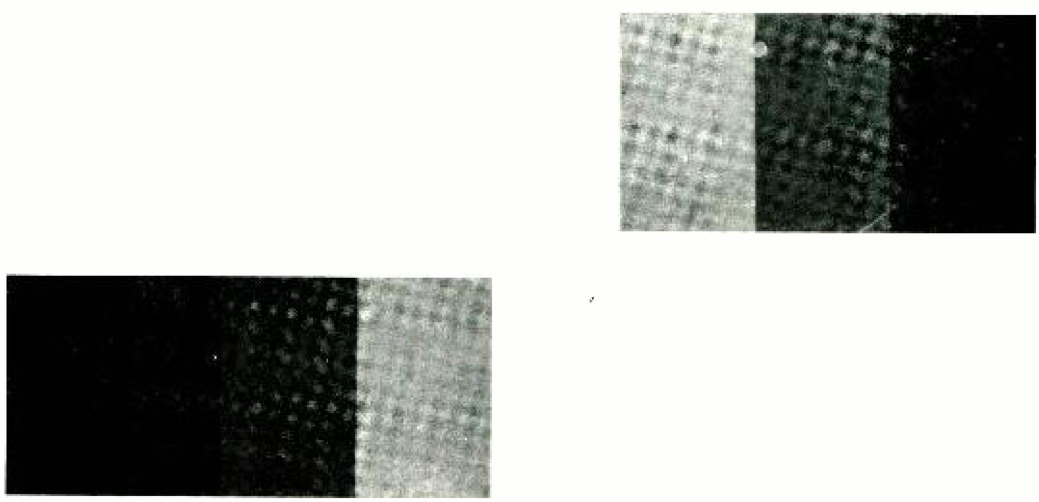
As a result, the vidicon can operate with normal television studio lighting and produce a picture that has electrical characteristics similar to that of an image-orthicon picture. Its signal-to-noise ratio is high, and its resolution can be somewhat greater than that of the image orthicon. If the performance of image orthicons and vidicons were judged only on the basis of a test pattern, the preference would usually be for the vidicon. When a vidicon is operated with a high focus field and high focus-electrode voltage, the picture is practically beyond reproach in the normal television broadcast channel. Under these operating conditions, resolution and uniformity of focus are much improved. Signal-to-noise ratio is in the 100-to-1 range, and detail response is about 50 percent at the cutoff of the TV frequency band.

However, the scene being reproduced may have a 100-to-1 contrast ratio. Although the vidicon can do a very good job of cramming a scene contrast range as great as 100 to 1 into the rather restricted contrast range of the TV system, the picture viewed on the TV set appears to have only the contrast of the TV set itself. As previously pointed out, this contrast range may be very low on the normally adjusted home television set, particularly when there is some additional light in the room. Even if the actual contrast range of the vidicon picture on the TV picture tube is equal to that which an image orthicon would produce, the contrast will appear to be lower because of the lack of black border or transition enhancement effect.

Some other aspects of the vidicon performance are generally superior to that of the image orthicon. For example, the uniformity of the signal output or sensitivity over the scanned area of the vidicon is very good. In addition, the background signal is extremely flat and free of undulations.

The basic differences between the character of the vidicon picture and that of the image orthicon picture are illustrated by the reproduction of a step function, as shown in Figs. 3 and 4. The photograph of an oscilloscope presentation of the vidicon signal waveform in Fig. 3 shows that there is a tendency for the dark level to anticipate the white

Fig. 2—Photograph of RETMA Logarythmic step chart. One transition on lower step chart is blocked off by a white card, showing the importance to the eye of the transition in evaluating contrast.



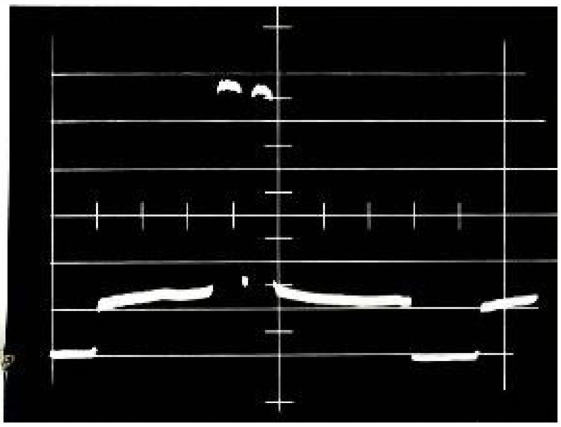


Fig. 3—Oscillograph photo of the signal developed by a vidicon, showing the loss of contrast of a transition and the reduction in contrast of small area blocks.

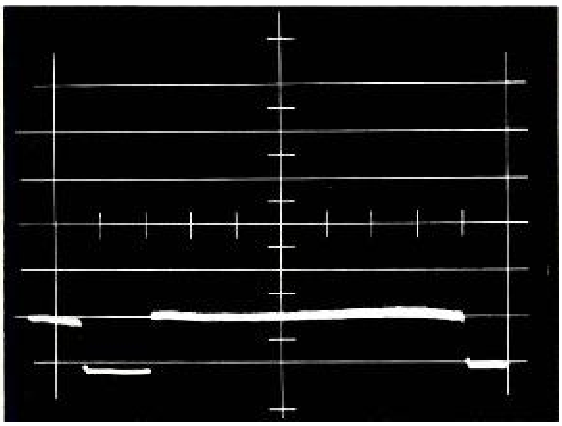


Fig. 4—Oscillograph photo of the signal developed by the vidicon of Fig. 3 with the light removed, showing extremely flat background.

step function. In addition, the small dark area in the middle has been lifted above the black level. Fig. 4 shows the same vidicon signal with the light turned off. These factors tend to reduce the contrast of sharp transitions or small dark objects and to produce a picture having an appearance of lower contrast than would be expected. Rather exhaustive tests have shown that this effect is primarily due to light scattering within the photoconductor of the vidicon. It is interesting that this scattering is more pronounced in the red portions of the spectrum than in the blue and green portions of the spectrum. This difference is, of course, due to the strong absorption of blue light in the photoconductor. The variation of this characteristic with different color of light was first noted when the vidicons were used in vidicon color cameras. In this instance, the black level of the vidicon signal in the red channel seemed to rise higher than that of the blue and green channels. In addition the red channel produced lower detail contrast. This effect has been minimized in recent versions of the vidicon, although it is still present to some extent.

Unlike the image orthicon, the vidicon has no abrupt limiting action. Therefore, its ability to handle very high contrast glints or reflections is not as good as that of the image orthicon. This problem is usually handled by using sufficient beam to discharge these highlight glints and then clipping the highlight signals elsewhere in the video system. This process has its limitations because only a limited amount of beam is available from the vidicon gun.

OBTAINING THE BEST PERFORMANCE FROM VIDICONS AND IMAGE ORTHICONS

When the characteristics and eccentricities of the different camera tubes are understood, it is a relatively simple matter to decide upon the proper operating conditions and precautions that must be taken to obtain the type of picture which is desired from a given camera tube.

For the image orthicon, it is probably desirable to operate with the highlights over the knee of the light-transfer characteristics to produce a slight dark halo around brightly illuminated objects. This of course, can be overdone to the point where the viewer becomes distressed upon seeing a black hat floating around a blond head, or when the lapels of a business suit begin to look as if they are black velvet on an evening dress coat. However, the use of this black halo should be carefully controlled and not be a result of careless over-exposure. Over-exposure may minimize adjustment of the camera on the scene, but it will not produce the best picture.

For careful control of the black-border characteristic, it is imperative that the lighting be strictly controlled or that the lens iris be controlled by the camera operator. When the vidicon tube is used in broadcast pickup, the optical system must be both clean and of good quality; otherwise, there is a greater tendency for the blacks to anticipate a white transient, as shown in Figs. 1 and 3. When the vidicon is used in black-and-white film pickup, some improvement can be made by use of a filter in the optical path to eliminate the red light coming from the projector. Lighting conditions for the vidicon must be controlled so that no extreme highlights are presented; otherwise, the video operator will be unable to handle the picture because of insufficient beam to handle the highlights.

When both live camera scenes and film inserts are to be used on a TV production, many problems arise. A proper understanding of the characteristics and capabilities of both vidicons and image orthicons helps to offset the frustration of a technical director when he attempts to combine image-orthicon and vidicon pictures in a single production. In this instance it might be wise to close the lens of the image orthicon down to the point where the black halo is essentially eliminated. To obtain a proper balance of tonal values between the two signal sources under these conditions, it may then be necessary to add a little black stretch in the image-orthicon signal or delete some of the additional gamma correction in the vidicon amplifiers.

SUMMARY

Both vidicons and image orthicons will probably be around for a long time because each serves a particular purpose and each has unique characteristics which make it desirable for certain types of broadcast service. In the industrial field, where accurate transmission of information is more important than the impact of the picture on the viewer, other criteria will determine the tube to be used. In TV broadcast use, however, the intelligent director will make full use of the advantages offered by both vidicons and image-orthicon tubes.

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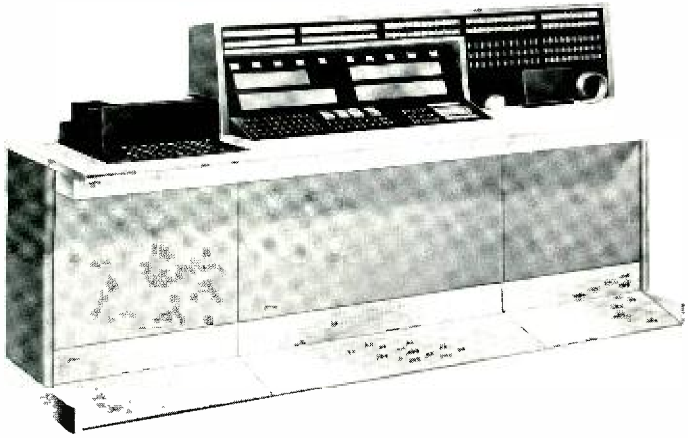
ROBERT G. NEUHAUSER joined RCA at Lancaster as a co-op engineering student, alternating work with study from 1946 to 1949. He received the BS degree in EE from Drexel Institute of Technology in 1949 and joined the cathode-ray tube development group at Lancaster. In 1950 he was assigned to the camera, oscillograph and storage tube development activity. Since 1953 he has been Engineering Leader in charge of camera tube and TV oscillograph tube design.



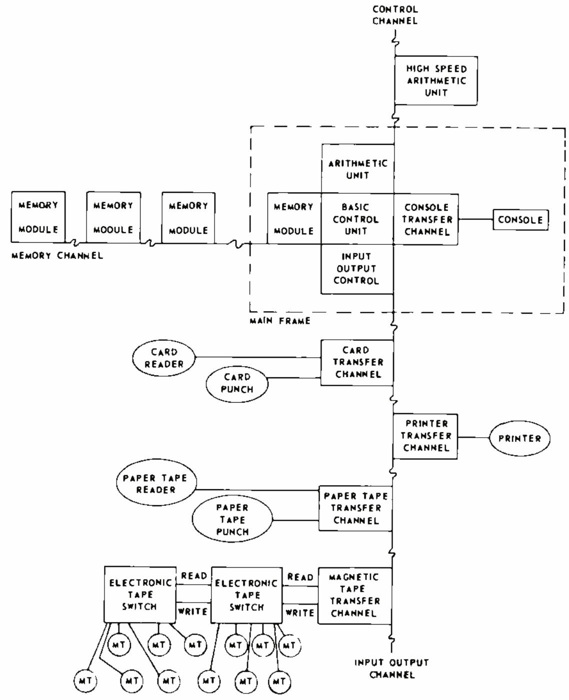


Fig. 1—A console design for the RCA 601; at right, an RCA 601 system diagram.

THE RCA 601 . . . Speed and Flexibility in a Large-Scale System

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One of the differences found among computer systems is whether emphasis is on word orientation or on character orientation. Pertinent design considerations not only include memory depth, but also capability for handling symbol-controlled operations and relative speeds of word and character operations. Emphasis placed on either word or character orientation tends to dictate a principal area of effective application. An important objective of the RCA 601 System is to perform efficiently over a very wide application base and economically combine the speed of parallel word processing with the logical flexibility of variable character operations.

The RCA 601 System is a generic name which, properly speaking, refers to a class of systems. This is due to a very generalized design approach, which will be illustrated by the RCA 601 System logic-design description. Specific elements have been selected from numerous possibilities to constitute the presently offered product line. The objective here is far from academic in that this approach provides, first, an exceptional ability for custom-fitting of system elements for a specific user; second, it tends to delay the inevitable onset of obsolescence by permitting revision of systems elements to increase performance or modify the system.

SYSTEM DESIGN

The RCA 601 System (Fig. 1) stresses a generalized system logic design in the computer. The main-frame is a fast processing unit with a 1.5-microsecond memory. Its design features provisions for uniting other system elements into an integrated system by means of standard interfaces. A unique modular packaging concept is used for these system elements to allow efficient and flexible system combinations.

The all-solid-state elements of the computer system include a main-frame processing unit, memory units, an arithmetic unit, and transfer channels. The main-frame processing unit includes a 56-bit-word memory module, a fast basic arithmetic unit, an input-output control, and a console transfer channel. Facilities for operating any combination of other elements comprising a single system are provided by three channels — the memory channel, the control channel, and the input-output channel.

Additional memory modules via the memory channel are available to operate as asynchronous, independent units. In the RCA 601 System, *asynchronism* means that the occurrence of an event begins upon fulfillment of a set of machine status requirements, and terminates as soon as its own requirements are fulfilled. A high-speed arithmetic unit can be added via the control channel to comprise an expanded computer. This unit operates at higher speeds than the main-frame arithmetic unit, and performs full-word—binary and decimal—floating-point arithmetic.

Remaining elements consist of transfer channels, which are links to peripheral devices via the input-output channel. Peripheral devices are available in card readers and punches, high-speed printers, paper tape readers and punches, and magnetic tapes. Flexible combinations of these devices within very broad constraints may be selected to operate on-line with the system. Two sets of tape stations are native to the RCA 601 System, providing the choice of 100-kc or 180-kc decimal-digit nominal transfer rates.

HARDWARE FEATURES

The generalized system logic design includes unique features such as elementary operation mechanization, an asynchronous control system, a generalized arithmetic unit, transfer channel input-output control, and an asynchronous memory system.

A unique feature of the 601 system is the manner in which its instructions are implemented. Instructions are broken down into small component parts called *elementary operations*. A sequence of elementary operations constitutes the logical steps comprising a machine instruction; thus, the elementary operation corresponds to an instruction in much the same manner as an instruction corresponds to a routine. Instructions are performed by these elementary operation sequences one at a time. Thus, by simply changing or adding elementary operation sequences, the instruction complement may be added to or changed. This open-ended design of instruction complement enables the customer to adopt new techniques as needed.

Asynchronism in operation timing is a convenient tool for modular variability in which a configuration of system elements is not fixed. The control-system arithmetic unit, and data transmission employ this technique. To illustrate this feature, consider the successive elementary operations *transfer* and *set*. The *transfer* elementary operation calls for the transfer of the information from one specified register to another within the computer. The *set* elementary operation transfers data from a memory location into a specified register. As shown in an exaggerated form in Fig. 2, the transfer operation involves steps 1, 2, 3, and 4. The asynchronous aspect of the control system is illustrated between steps 1 and 2 and the occurrence of step 4. The transfer elementary operation terminates just after the data transmission (step 3) has started so that the next operation may begin. Thus, steps 5 and 6, which are the set up and memory addressing for the next set operation, overlap with the relatively long transmission. The asynchronous aspect of data transmission via the data busses is indicated by steps 3, 6, and 8. There is a unique detection circuit on the busses to detect echoes from the receiver register and terminate the transfer by the generation of a terminate pulse, *T*. In this way, data transmission time depends on the physical configuration of the source and sink involved. Note that steps 6 and 3 overlap in time because separate busses are involved; if the same bus is used then step 6 would be interlocked to prevent its initiation until the T signal is generated.

The RCA 601 System memory storage employs a word format, even though the data format is extremely flexible. The majority of data manipulation involves logic with certain arithmetic properties. An efficient and compact design is made by generalizing the basic arithmetic unit to include data-handling functions as well as arithmetic operations. Operands that can be manipulated may be in character, half-word, or word format. Wired-in arithmetic operations include the full range of *add, subtract, multiply, multiply and accumulate*, and *divide*, for fixed-point decimal operands and for the majority of fixed-point binary operands. By the addition of a high-speed arithmetic unit, basic system speeds of certain operations are increased and floating-point arithmetic is added to the instruction complement.

A further feature of the basic arithmetic unit design is its built-in ability to accommodate variable-size characters. Four different character lengths (3, 4, 6, and 8 bits) may be directly addressed and manipulated. A character-length register is used to designate the size of character in all character operations. This register can be loaded and reloaded with appropriate designators during a program by half-word set-register instructions. Operations other than character-handling operations are not affected by this register. The variable-size character-handling ability, together with the general symbol-recognition feature allows the RCA 601 System to handle a large variety of codes.

A block diagram of the basic arithmetic unit is shown in Fig. 3. The adder operation is an asynchronous circuit with respect to carry propagation. That is, as soon as the carry propagation subsides, the adder operation is terminated.

Peripheral devices in the RCA 601 System are handled by control buffer packages called *transfer channels*. These transfer channels work on-line with the input-output control of the main frame by an automatic *instruction-interrupt* technique. The input-output channel is a general, standardized interface. Thus, looking out from the input-output control, proper operation is maintained regardless of the number or the complement of the transfer channels in operation. This allows a generous flexibility in the makeup as well as the size of the input-output system. This transfer-channel concept, coupled with a general, all-purpose input-output instruction complement, makes an efficient and economical way of coping with future development of peripheral and custom devices. The transfer channels are logically complete for independent and simultaneous operation with the mainframe. Additions of transfer channels mean potential additions in amounts of simultaneity. The amount of simultaneity is automatically regulated by a built-in, artificial, simple calculation called *speed-weight*. The transfer-channel concept also makes it possible for the operating console to operate independently and communicate with the computer without having to stop operation.

A key feature in the RCA 601 System is the high-speed memory. Each 56-bit word is accessed in 0.9 microseconds; the complete address-read-write cycle is 1.5 microseconds. The memory operation is logically controlled and asynchronous. Separate commands to operate the three memory logical steps (address, read-out, and write-in) are directed from the control system. Thus, its operation is integrated with the control system. Overlapped operation is possible when more than one module is present. Generally three modes of operation can be accomplished: 1) address and read-out; 2) address and write-in; and 3) address, read-out, and write-in.

The design approach here is basically conservative. Commercially existing components and proven techniques were used for this advanced equipment design, rather than depending on the development of new components. The design objective was to make the cost competitive with presently available memory systems that are up to eight times slower. The design stresses were on cost, reliability, and simplicity, taking into account the expected mainte-

Fig. 2—Asynchronous operation and overlap.

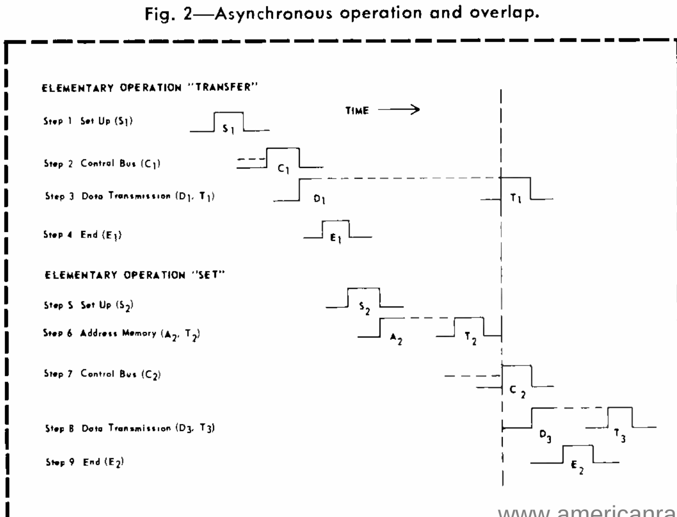
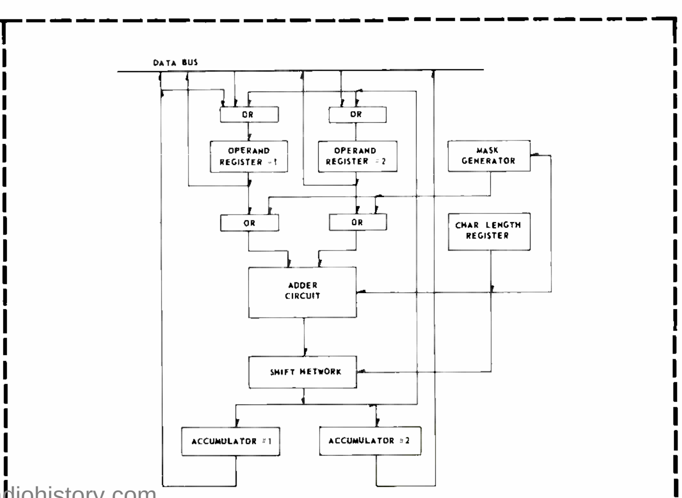


Fig. 3—Basic arithmetic unit.



nance problem. The storage elements are magnetic cores of 18-mil inside diameter, 30-mil outside diameter, and 10-mil thickness. This small size was chosen for performance as well as for packaging compactness. The circuit design simplifies the wiring complexity that is required in most present magnetic core memories.

The product design of high-speed computers must deal with problems arising from multitudes of short pulses with extremely fast rise times. In order not to affect proper performance of these high-speed circuits, wiring techniques become complex, particularly in the main-frame processor. High transistor packing density is specified in step with current techniques of component packaging.

Ready access directly to the internal construction means easier servicing with a minimum loss of costly computer time. A basic requirement achieved in the RCA 601 is that both the wiring side and the plug-in side may be opened for servicing without affecting the operating status of the computer. Means have been designed to make it easy to tap any point on this wiring for observation.

Transfer channels, additional memory units, and future expansion units are packaged in modules which are installed in universal racks. A unique channel-jumper cable technique threads through the entire system (Fig. 1).

PROGRAMMING FEATURES

One vogue in the majority of recently announced computing systems is the relative brevity of program statement contrasted to systems in common use. Factors contributing to these concise programs include powerful, well-integrated order codes, complex address-modification capability, flexible addressing, and variable instruction length.

Provision for variable-length data had been made in early electronic machines. The similar motivations of efficient memory utilization and the elimination of "filler" material have extended this to include, also, those bits in the memory that direct the control unit. In the RCA 601 System, *variable instruction length* means that instructions may be either 1, 2, 3 or 4 half-words in length. (Input-output instructions are the exception to this statement.) A unit data length in the RCA 601 System is either a word (or half-word) or a character. One of these, the half-word of 24 information bits, is the unit length for instructions.

Generally, an instruction half-word is an operation half-word that may have as many as three address half-words appended to it. A distinction has to be made between the number of addresses contained in an instruction and the number of addresses utilized as an integral part of the execution of an instruction. Each instruction type utilizes a fixed number of these address registers—e.g., a *move* will utilize two address registers, *multiply* utilizes three, a *do* instruction utilizes none at all. Frequently, those are the number of addresses written in that instruction.

However, the address registers utilized by an instruction have their contents augmented by one data-length unit. This value of the address register is often the appropriate value of the register for the operation of the next instruction. In particular, this occurs when the data of interest is stored in contiguous arrays in the memory. In such a case, when an address register contains the desired value, then that address need not be written in the program statement. Three bits termed *assumed bits* in the operation half-word of an instruction specify whether or not address half-words for each of three address registers are written following the operation half-word. Thus, a lesser or a greater number of addresses than used by the instruction may be written. When fewer addresses are used, the remaining addresses are said to be *assumed;* when additional addresses are used they merely cause the address registers to become loaded. The stepping of the address registers in conjunction with assumed addressing is really equivalent to automatic address modification by unity with, however, several advantages over address modifiers: no address modifiers are used up for this purpose; no time is lost to accomplish the address modification; no space is required in the program for the address; and no time is required to access the address.

Another place in which explicit addresses are not written occurs when the accumulator is being used in arithmetic operations. Again, three bits in the operation half-word specify whether any or all of the operands refer to the contents of the accumulator. Thus, a single half-word suffices to instruct the accumulator to double itself, an *add* instruction with all three addresses assumed and the accumulator specified as each of the operands. Fig. 4 illustrates some of these.

A unique and substantial addressing flexibility is incorporated in the address half-word. The 24 bits of this half-word, shown in Fig. 5, are divided as follows: an address part of 19 bits; 15 bits for addressing 2^{15} words; a 16th bit to address half-words; and 3 additional bits to address characters within the half-word. The 20th bit is used to designate

1 2 3	4	5	6 20	21	22 23 24
XXX	X	X	X .... X (15)	X	XXX
Address Modifier	Increment Address Modifier	Indirect Address	Word Address	Half-Word Address	Character Address or Control Bits of Indirect Addressing or Address Modification

Fig. 5—Address half-word.

Fig. 4—Assumed addressing and stepping of registers.

	OPERATION		ADDRESS A	ADDRESS B	ADDRESS C
EX. 1: $\sum_{i=1}^{n} a_i$	DO n	B ASSUMED	a_n	....	....
		C: ASSUMED			
IN CONSECUTIVE WORDS					
	ADD	A ASSUMED	.	...	....
		B: ACCUMULATOR			
		C ACCUMULATOR			
TOTAL PROGRAM: THREE HALF-WORDS					
EX. 2: $\sum_{i=1}^{n} a_i b_i$	DO n	C: ASSUMED	a_n	b_n	
	MULT/ACC	A: ASSUMED	..	...	...
		B: ASSUMED			
		C ACCUMULATOR			
TOTAL PROGRAM: FOUR HALF-WORDS					
EX. 3: a^n	DO n	A ASSUMED	...	....	..
		B: ASSUMED			
		C: ASSUMED			
	MULTIPLY	B: ACCUMULATOR	a	..	....
		C: ACCUMULATOR			
TOTAL PROGRAM: THREE HALF-WORDS					

Fig. 6—Control of indirect addressing and address modification.

BITS OF ADDRESS HALF-WORD	4	1	16	3
ADDRESS A:	AM1	I	B	d
ADDRESS B:	AM2	-	C	-
ADDRESS B+(AM1):	AM3	-	D	-

d PERMITS:

INDIRECT ADDRESS TO BE 1) B
OR 2) B+ (AM1)

DIRECT ADDRESS TO BE 1) C+ (AM1)
2) C+ (AM1) + (AM2)
OR 1) D+ (AM3)
2) D

MEMORY MODULE SIZE	8192 WORDS, 56 BITS EACH UP TO 4 MODULES	
OPERATION TIMES		MICROSECONDS
A + B → C, 1-WORD		6.6
ACCUMULATOR + B → ACCUMULATOR, 1-WORD DECIMAL		3.2
A + B → C, 1-WORD DECIMAL (NO ZEROS)		69.4
A → B, 10 WORDS		32.0
A → B, 6 6-BIT CHARACTERS		15.1
A → B, 6 4-BIT CHARACTERS		11.3
BRANCH		0.5
DO		1.5 to 3.0*
INSTRUCTION ACCESS AND INTERPRETATION TIMES		
ACCESS		2.5 to 6.5*
INDIRECT ADDRESSING		1.7
INDEXING		2.0 to 3.5*
INPUT-OUTPUT CONTROLS		
UP TO 16 SIMULTANEOUS INPUT-OUTPUT OPERATIONS		

* DEPENDS ON PROGRAM SEQUENCE

Fig. 7—Main-frame computer characteristics.

CARD:		
READ		600 CARDS PER MINUTE
PUNCH		100 CARDS PER MINUTE
PAPER TAPE:		
READ		1000 CHARACTERS PER SECOND
PUNCH		300 CHARACTERS PER SECOND
PRINTER:		
	120 CHARACTERS PER LINE,	600 LINES PER MINUTE
MAGNETIC TAPE:		
		180-KC DECIMAL DIGIT RATE
		100-KC DECIMAL DIGIT RATE
		50-KC DECIMAL DIGIT RATE

Fig. 8—Peripheral-device characteristics.

indirect addressing. The four remaining bits are used to address any of eight address modifiers.

Seven of the address modifiers are a full word in length, where the left half-word is the value part applied to an address when selected, and the right half-word is an increment part selectively added to the value part. This selectivity is gained by providing two addresses for each address modifier, one of which causes an automatic incrementing to take place. This accounts for the generous use of 4 bits to select eight address modifiers.

Applying both address modification and indirect addressing to an address would normally require an arbitrary order of precedence; however, in the RCA 601 System whenever an indirect address is specified, it selects another half-word in which is contained another address. Therefore, the three bits used for character addressing in this case, might be superfluous, but are used instead for the following:

1) to defer application of the address modifier with the indirect address to the direct address; this can permit dual address modification on the direct address;
2) to inhibit address modification on the direct level;
3) to inhibit subsequent indirect addressing.

Fig. 6 illustrates the possibilities with this octal digit for the case of only a single level of indirect addressing.

Indirect addressing and the flexible application of address modifiers provide considerable facility in working with the address lists. Lists of addresses can be generated by magnetic-tape–read instructions which list the addresses of special symbols (designated by the programmer) in memory, as well as the information itself. It is then possible to eliminate much data movement by utilizing the address lists.

Efficient data encoding is carried a step further in the character handling capability of the RCA 601 System. It has been mentioned that four different character sizes (lengths of 3, 4, 6, and 8 bits) may be directly addressed and manipulated. Thus, sequences of decimal digits are normally handled in 4-bit characters, alphanumeric data in 6-bit characters, providing efficient tape and memory storage.

The RCA 601 System features sets of indicators to provide a parallel decision making ability concurrently with the running program. Conditions sensed include: arithmetic underflow and overflow; error conditions; unsuccessful scanning operation; result positive, negative, or zero; and a binary indicator specifying such information as whether a logical connective yielded zero. A programmer-set mask is associated with each indicator to permit or inhibit an automatic branch whenever the condition is encountered. This feature permits minimizing the length of repetitve loops by eliminating, each time, explicit sensing for rare conditions.

When one of these automatic jumps does occur, storing of relevant registers takes place automatically, assuring ability to restore the status of the machine whenever control is returned to the interrupted point. In particular, one of the conditions which will cause an automatic jump to occur is the termination of an input-output operation. The format of an input-output instruction differs from the rest of the order code, being up to five half-words in length. One of the address half-words contains an address to which control is to be transferred when the operation is complete. This permits an effective multi-programming scheme, where linkages between programs occur such as to permit maintenance of input-output rates.

SUMMARY

Figs. 7 and 8 present a brief description of the characteristics and representative times of the current RCA 603 Computer in the RCA 601 System — actually a powerful, large-scale *class* of systems providing speed and great flexibility over a very wide base of applications.

A. T. LING is a graduate of Massachusetts Institute of Technology where he was awarded the BS in Mechanical Engineering in 1950, MS in Mechanical Engineering in 1952, and Mechanical Engineer in 1955. Mr. Ling joined RCA in 1955 and worked at that time on the Bizmac system. In 1959 he was appointed Leader in an EDP Computer Control Group, and the following year received his present title of Manager, Machine Logic Engineering. While at MIT, Mr. Ling was a Teaching Assistant and a Research Assistant. After receiving his Master's degree in 1952, he joined the Philco Corporation as a Junior Engineer. During the year prior to joining RCA, 1954-55, he returned to MIT where he was a Research Assistant. He has worked with the Bizmac Sales Recorder System, the RCA 501, RCA 301, and RCA 601 systems. He is a member of Tau Beta Pi, Pi Tau Sigma, and Sigma Xi honorary societies.

K. KOZARSKY was graduated from the University of Michigan in 1951 with an MS in mathematics. Mr. Kozarsky joined RCA in 1957. From 1951 to 1955 he was a Mathematician at U. S. Naval Weapons Laboratory in Dahlgren, Virginia, working on mathematical programming and co-authoring NORC compiler and specifying computer systems. Later, he worked with the U. S. Army, Frankford Arsenal, Philadelphia, on the specifications and procurement of digital computers to perform field-artillery fire control. After joining RCA's EDP Division, he co-authored specifications for RCA 501 assembly system, and Systems Planning and Specifications for RCA 301 Universal Converter and RCA 601.

ENTERTAINMENT-TUBE MARKETING

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Market Planning
Entertainment Tube Products
Electron Tube Division
Harrison, N. J.

In the good old days of bad plumbing, smallpox epidemics, and 14-hour work days, a man made something that his neighbor wanted, delivered it in person, received the exchange value for the item, and died at the age of 42 from overwork.

Today, you try to anticipate what product some unseen customers across the nation may buy, manufacture a million of them while you juggle the manufacturing schedules for several hundred similar items, compete with others to sell your products without losing your shirt, and die at the age of 41 from a heart attack.

This, in a nut shell, is Marketing. Its organization and its basic characteristics are the result of an economy of overabundance dominated by the customer and served by the most advanced technology in the world.

BASIC PRINCIPLES

We design, manufacture, and sell electron tubes—and as an outgrowth of our associated skills, other products, such as electroluminescent panels. Does this make us any different from those who make and market lipstick, or generators, or frozen food? Not really. The rules that apply to all are classic:

1) We may influence the styles, the tastes, or the requirements of the market we serve—but we can survive only if our product answers the market's needs.
2) We may love to serve mankind—but we can stay in business only if we sell our product at a profit.
3) We may know just what the customer wants — but our success depends upon having the manufacturing skills and facilities to fabricate and deliver enough of the product on time and at a competitive price.
4) We may know our products are better than our competitors'—but unless the customer knows this, we are lost.
5) We may have just what the customer needs—but unless the customer knows we do and is motivated to do business with us, we might just as well fold our tents.

Answer the need, make a profit, have the facilities, make it better, motivate the customer.

These are the fundamentals. If you recognize their existence, then you are like the man who knows that there are 88 keys on the piano, but still has a long way to go before competing with Artur Rubinstein.

ORGANIZATION

The Receiving-Tube Marketing group provides a good example of the skillful team working within the Electron Tube Division. Its organizational structure represents the most current philosophy of Marketing administration.

Since its market is rather fluid, it seems appropriate that—like Neptune, the god of the sea and the watery elements—those charged with the responsibility of marketing receiving tubes approach their task armed with the trident or three-pronged staff of 1) *Product Coordination and Controls*, 2) *Merchandising*, and 3) *Product Planning*. Obviously, a fourth element—the *Sales* arm—is the one that ultimately comes into intimate contact with the market. However, this fourth element depends on the first three.

Product Coordination and Controls

This can be best compared to a juggler performing his act on a high wire without the comfort of a net 100 feet below. This group plans the production schedules for each factory, divides the product among its warehouses, and build its inventories of gray hair by trying to predict the demands of the market in order to avoid both product shortages and excessive inventories. It reports to management the outlook for tube sales, together with the status of production and inventory.

The group performs its tasks by providing a focal point for information from the equipment and distributor segments of the market, and from the facilities manufacturing industrial and entertainment receiving tubes and nuvistors.

In the course of a normal day, individuals within the Product Coordination and Controls group evaluate against their previous experiences rumors and reports from salesmen, field engineers, marketing personnel, trade associations, newspapers, and customers. The material received may deal with a wide variety of industrial factors, ranging from forecasts of automobile production to trends in the customers' evaluation of component reliability. The group studies sales penetration in various markets, factory performance, product quality, inventory, and special customer requirements. And, with an occasional side glance at a well-hidden crystal ball, it establishes for every type in the line an individual production and distribution schedule. When an extraordinary situation makes special demands upon product availability, the Product Coordination and Control group calls upon its familiarity with the conditions of the moment to find and deliver the right type to the right spot.

Merchandising

This group performs five significant services:

1) It establishes commercial policy to sell by.
2) It provides optimum pricing so

GEORGE J. JANOFF attended Dana College, majoring in Economics and English, and received the LL.B. degree from Rutgers University Law School in 1933. He was in private law practice until 1942, when he was employed by the War Department's Office of Censorship. He subsequently transferred to the Department of Labor, and was later loaned to the Office of the War Production Board. In 1944 he joined RCA in the Home Office Priorities Department in Camden. He returned to private law practice in 1945, and rejoined RCA as Priorities Administrator for the Electron Tube Division in 1951. Since 1952, he has been manager of various activities in the Receiving Tubes Operation, including contract administration, marketing services, promotion, merchandising, and market planning. He is presently Manager of Market Planning for Entertainment Tube Products of the Electron Tube Division in Harrison.

that tubes may be sold competitively and at a profit.

3) It directs the promotional and advertising efforts in order to stimulate sales interest.
4) It keeps a close watch over tube performance and reliability.
5) It provides liaison between the home office and the field on commercial matters.

Merchandising is a very small group in number. but it provides services of urgent importance to our Division. It views with great seriousness the professional responsibility it has to improve the business of the RCA Electron Tube Division. The Merchandising group feels strongly that Marketing is as much a profession as engineering, medicine, and law. As Marketing people, they also have codes and ethics, and they strive on a daily basis to measure up to the high standards of a professional group. This is a significant concept in the area of distribution.

When faced with a problem of poor performance in a tube. an engineer tries to find ways to overcome the problem. He does not try to bring the performance of all tubes down to the poorer level. In the same way, a serviceman calls upon his knowledge in the solution of a difficult situation. The Merchandising group utilizes some of the most advanced techniques of Marketing administration in order to evaluate the problems of competition whether domestic or foreign. Its considerations and its deliberations involve such factors as cost analysis, market research. engineering know-how. the motivating factors of advertising. communication techniques, and customer contacts.

To the technically oriented individual. the role of Advertising and Sales Promotion within the broad arena of Marketing to industry is usually an elusive subject. Engineers and technicians who design and make products that lose their identity as they are incorporated into such finished systems as refrigerators, TV sets, and automobiles tend to misinterpret the contributions made by the promotional people.

However. we have entered a period of competitive Marketing during which reputation, company image, and brand recognition will be as influential on the buying decision as product specifications. The motivational force of good promotional communication will grow as a survival factor in this period of abundance.

Our abundance is matched only by our technological skills. And although some may claim that our lives are cluttered and smothered by things and the diversions that keep us well protected from the disturbing inner self. nevertheless this high tide of products and productivity is a factor of life.

There are mixed blessings here. Viewed solely from the Marketing man's vantage point, this flood of goods and services which bathes us in luxury may engulf us completely unless consumption keeps pace with productivity.

No force can be regarded as of major historic importance unless it has developed its own characteristic institution. According to David Potter, Professor of American History at Yale, the institution that has been brought into being by the characteristic abundance of our economy is modern American advertising. As a tool of Marketing, advertising develops and guides consumer and industrial trends, develops a familiarity with products, brands. and companies. and thereby stimulates consumption.

Naturally, our receiving-tube advertising is directed at the distributors and servicemen who purchase tubes for renewal applications and at the manufacturers of electronic equipment. We use trade and industrial magazines and direct mail to announce significant developments and to promote the sale of our existing line of types. We are always trying to motivate prospects to think favorably about our brand. To some extent, we have accomplished this by creating an image of outstanding performance and reliability for our products. and a picture of constant alertness for our design and manufacturing groups. The results are encouraging. Year after year. independent brand-preference studies show that design engineers. distributors. and service technicians rank RCA receiving tubes first and far ahead of our nearest competitor.

Product Planning

Product Planning calls the shots for our receiving-tube line by choosing the kind of products we manufacture and market. A major contribution to our success. this activity guides the Division in its decisions concerning the introduction of new types. Part of its job is to evaluate suggestions for new designs that emanate from either our own engineering departments or the customer's. The planning group does this by determining the current potential of the development, including such factors as sales potential, probable profit, and the like. In order to make these evaluations effectively. Product Planning must have an excellent understanding of the technical pros and cons for a new tube design and the system for which the tube is developed.

In effect, then. Product Planning is the technically trained link between the demands of the market and the potentials of the Division. This link can only perform its function with the assistance and the professional counsel of its engineering groups in the design laboratories and in the field.

The astuteness with which the Product Planning group coordinates the requirements of the market with the commercial objectives and resources of the Division is a determining factor. then. in the success and reputation we enjoy.

ENGINEERING CONTRIBUTION

But how foolish we would be if we thought this was all! The engineer. for example, plays a big role in our marketing success. And I do not refer to the effects and influences of particular jobs. I speak rather of a broad subject that is the province of the many rather than the few. I refer to truly creative innovation.

Creative innovation! What a disturbing subject. Disturbing because it unsettles the old way of doing things. Disturbing because it introduces change. upheaval, the unfamiliar into the comfortable pattern of manufacturing and marketing. Disturbing because it is invariably associated with the individual who will not leave well enough alone, the revolutionary who clings to the vision of doing things better, the practical dreamer who cannot rest until he has reached the horizon, the creative engineer who finds satisfaction only when he makes innovation part of his job—whatever his job may be.

There's a simple rule in Marketing that says: the moment you stop moving forward your competitor is moving up on your rear. We cannot move forward without creative innovation. Once every 8 or 10 or 12 years, something startling happens in our end of the business—like the miniature tube, the television picture tube, or the nuvistor—and industry turns on the steam like a Jaguar cornering into the straightaway.

DALLAS R. ANDREWS majored in Mathematics and Physics at Ball State Teachers College at Muncie, Ind. He later studied Radio Engineering at Purdue University Extension at Indianapolis. He has been engaged in development engineering at RCA in various phases of magnetic and disc recording for the past fifteen years. He is presently in the Record Changer Engineering Group of the Radio & "Victrola" section of the Home Instruments Department. He is a member of Audio Engineering Society, Institute of Radio Engineers, The Franklin Institute, and American Society of Inventors.

Fig. 1a—Cartridge tape recorder, stereo version, cover off.

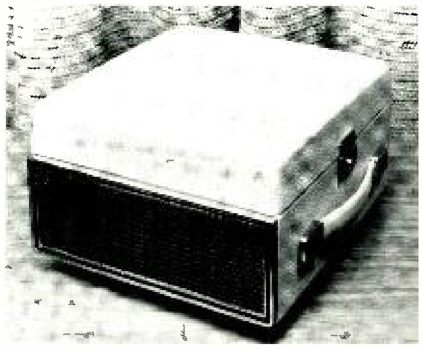


Fig. 1b—Cartridge tape recorder, with cover, weighs less than 12 pounds and measures 10 x 10 x 6 inches for easy portability.

J. A. TOURTELLOT studied at Columbia University and graduated in 1937 with an A.B. degree in Physics. From 1937 to 1939 he was engaged in his own private business and joined RCA in 1940. From 1940 to 1945, he was engaged in UHF, electromechanical modulators and "butterfly" circuits work for military applications. From 1945 to 1953 he was with the Philco Corporation, and upon his return to RCA in 1954 joined the Radio & "Victrola" Record Changer Design group. His work since then has been concentrated on phonograph pickups, motors, and record changers, and tape recorders.

A SIMPLIFIED CARTRIDGE TAPE RECORDER

by **D. R. ANDREWS**
and
J. A. TOURTELLOT
RCA Victor Home Instruments
Indianapolis, Indiana

A MAGNETIC TAPE RECORDER is usually considered to be the "Cadillac" of the recording industry, a position well deserved by its potential for superior quality of reproduction. It is generally used by those who demand the ultimate in performance, regardless of cost.

Since most quality tape recorders have been designed for this high-price market, sufficient effort has not been directed toward reducing the cost of their mechanism. Therefore, many people have the mistaken impression that a quality tape machine has to be much more expensive than a phonograph.

ESSENTIALS OF A TAPE RECORDER

The essential requisites of a tape mechanism are very similar to those of a disk record player. In both, a transducer produces electrical signals for the amplifier. A motor propels the tape or record past the transducer. Some means of speed reduction is necessary, and a speed change device is required if more than one speed is to be used.

There is only one basic difference in the operation of tape and disk reproducers: Tape operates at constant linear velocity past the head, while the linear velocity of a record groove past the pickup varies depending on the instantaneous distance of the groove from the center of the record. Some metering device such as capstan is used to provide this constant tape velocity and a second means is provided to wind the tape on the takeup hub. Of course, tape mechanism designs can be as elaborate as desired by providing footage counters, push button controls, automatic operation, etc.

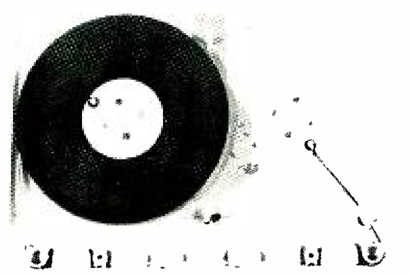


Fig. 1c—RCA coplanar tape cartridge, without cover (see text and Fig. 6).

Fig. 1d—RCA coplanar tape cartridge cover. (In this case, a prerecorded tape; a similar cartridge, blank, is used for recording.)

The trend toward complexity has been very prevalent among designers, thus leaving the mass market for a quality low-cost tape recorder practically untouched. The recent influx of foreign low cost products may alter this situation drastically.

A QUALITY RECORDER FOR THE MASS MARKET

RCA has recognized this potential market for some time, that a low-cost product must be provided with ease of operation and without compromise in quality of performance. To provide ease of operation, RCA developed the coplanar cartridge and associated automatic mechanisms, and also introduced the four-track recording system to the industry, using 3¾ ips to decrease the cost of the recording medium.[1-7]

Now, a tape mechanism and amplifier have been designed and packaged with input-output connections and speaker to provide a *low-cost* portable system in both monaural and monaural-stereo versions. Convenience of operation, small size, and flexibility of use are design keynotes (Figs. 1a-1d).

For high-fidelity reproduction, in stereo or monaural, its preamplifier output may be conveniently fed to an external high-fidelity amplifier-speaker system. Its self-contained amplifier-speaker system allows use as a recorder-playback package with power output and monaural speaker response equivalent to a high-quality table-model radio. Used in this way, stereo playback is achieved by feeding the second channel to any convenient external amplifier-speaker combination (e.g., TV, or radio). Provision is made for inputs from external microphone, tuner, or other program source.

Design Specifications

The following design objectives were met in every detail:

- *Size:* Small as a portable typewriter, 10 by 10 by 6 inches.
- *Weight:* Completely portable, less than 12 pounds.
- *Tape Speeds:* 3¾ ips for high fidelity, 1⅞ ips for maximum recording time.
- *Playing Time:* 1 hour stereo, 2 hours monaural at 3¾ ips; 2 hours stereo, 4 hours monaural at 1⅞ ips.
- *Audio Power Output:* Equivalent to table radio; 0.8 watts, monaural; 1.2 watts, stereo.
- *Frequency Response:* Full range, 50 to 15,000 cycles at 3¾ ips at preamp output, both record and playback.
- *Record Level Indicator:* Neon on leader model, Magic eye on deluxe version.
- *Signal/Hum:* 45 db at preamp outputs.
- *Wow and Flutter:* Good music quality, 0.4 percent peak.

Mechanism Drive System

The primary considerations for the design of the mechanism were low cost, light weight, and good-quality performance. A single-belt drive system was chosen for simplicity (Fig. 2). By using a compliant belt, all functions including capstan drive, takeup, rewind, and dual speed could be performed with one belt.

For normal operation (play or record) the belt runs in the path shown by the heavy lines on the sketch. During rewind, an idler lifts the belt off the takeup pulley and presses it into contact with the rewind pulley, as shown by the dotted lines. Two speeds are provided by using a stepped motor pulley. A wire loop is used to shift the belt onto the proper pulley size.

Normally, a *V* pulley is used to drive a round belt; however, any wobble of the pulley or weave of the belt will tend to cause the belt to climb the pulley flange or twist the belt. In either case, serious variations in speed may occur which produces wow or flutter in a record machine. If a flat-bottom pulley is used the belt

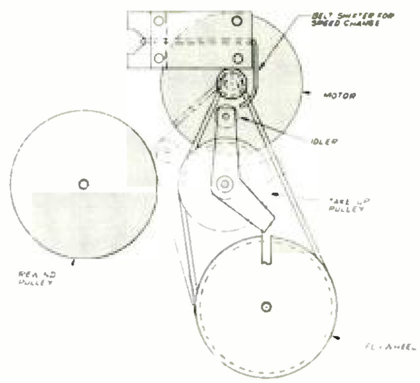


Fig. 2—Single-belt drive system.

tends to wander on the pulley. This problem was solved by a novel method: A round belt was used on flat-bottom pulleys, but the wandering was eliminated by placing a small groove in the center of the flat bottom of the motor pulley (Fig. 3). This groove, only about a fifth the width of the belt, tends to guide the round belt very similar to the manner a crowned pulley guides a flat belt.

Clutch

The takeup pulley has a simple built-in clutch (Fig. 4). It is merely a thin metal disk faced with oiled felt, which is pressed against the face of the pulley by a flat spring. A flat spring was chosen because it can provide very high torsional and very low lateral stiffness. The clutch tension may be adjusted by varying the distance the spring collar is placed on the takeup shaft before the setscrew is tightened.

Operating Control

A single three-position control operates both normal play-record and rewind (Fig. 5). Clockwise rotation of the control shaft from the neutral position moves an overcenter type of detent, latches the pressure roller against the capstan, turns on the power switch, and releases the brake on the pulley connected to the supply reel. Counterclockwise rotation operates a different overcenter type of detent to lift the belt from the takeup pulley and into engagement with the rewind pulley. This also turns on the power switch and releases the brake from the rewind pulley. Either operation may be stopped by returning the control to the neutral position, manually or automatically. The detent latching provides a release which may be tripped in a minimum of time with very little force. This permits the automatic-stop feature of the tape cartridge to be fully utilized.

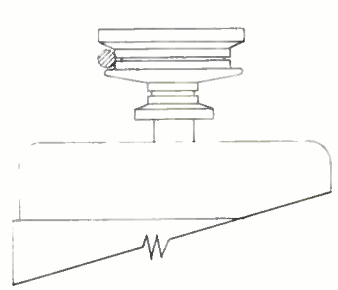


Fig. 3 — Flat-bottom motor pulley, showing groove to eliminate wandering of round belt.

Tape Cartridge

The machine uses the RCA tape cartridge (shown in Figs. 1c and 1d). It is of the coplanar type, having two hubs without flanges for reeling of the tape. Fig. 6 shows an expanded view of the cartridge parts. A polystyrene case encloses the tape. The tape is separated from the case by thin sheets of polyester film to reduce friction and decrease noise. A brake locks the hubs except when the cartridge is on the machine. The tape is fastened to the hubs to provide high tension when the supply reel is empty. Semicircular slots are provided

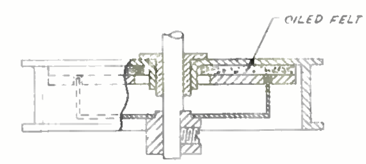


Fig. 4—Built-in clutch for take-up pulley.

for trip pins on the machine to sense the tape tension and operate automatic stopping. The trip pins, which protrude through the cartridge, are linked to the control mechanism so that excessive tension in the tape returns the control mechanism to the neutral, or off, position.

Cost Reduction

In order to reduce the cost of construction and still maintain proper operation, several new approaches were used. To provide constant speed comparatively free of wow and flutter, it is imperative that the capstan and its bearings be extremely accurate and smooth. This is usually controlled by careful custom grinding of the capstan and precision boring of the bearings in the motor board. In this machine, the capstan is not a custom-ground shaft but is a standard dowel pin used in tool-and-die work. These dowels are accurate within ±0.0001 inch, and the surface is ground to a microfinish. The flywheel is made on an automatic screw machine of cold-drawn steel, then shrink-fitted onto the dowel pin.

The capstan bearings are spherical,

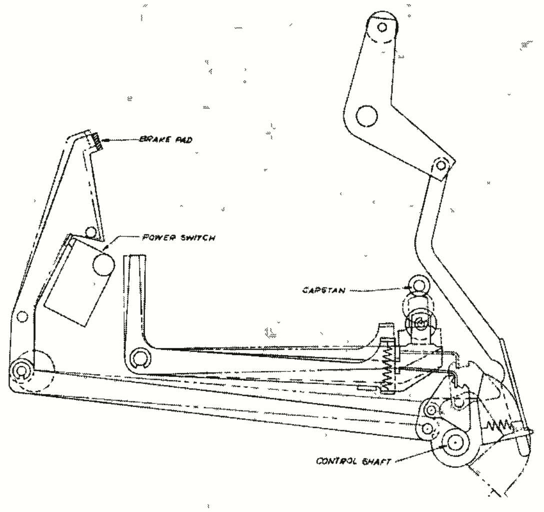
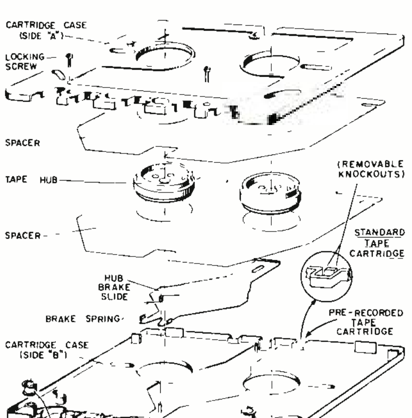


Fig. 5—Three-position control for play-record and rewind.

self-centering, and molded of sintered bronze. During assembly, a fixture is used to properly align the capstan with respect to the cartridge supports on the motorboard, while the clamps on the bearings are tightened. By these means, all the precision machining operations on the capstan and motorboard have been eliminated.

Functions were combined wherever possible. The left-hand trip lever, linked to the control mechanism, also operates the on-off switch and the brake for the supply reel (Fig. 7). An interlock prevents accidental erasure of prerecorded tapes. A mechanical latch prevents the record switch on the amplifier from rotating when prerecorded tape cartridges are on the machine. If a blank tape cartridge is inserted, a feeler pin at the back edge of the cartridge is moved, releasing the latch and permiting rotation of the record switch. This feeler is made of a single compliant steel wire which serves as lever, hinge, linkage, and return spring. The play-record switch on the amplifier is spring biased in the counterclockwise, or play, position. A latch on the mechanism holds the switch in the record position when rotated clockwise, if the machine is operating. When the control mechanism returns to its neutral position to stop the machine, the latch is released and the switch returns to the play position. This feature prevents accidental erasure of the newly recorded signal during rewinding. Interlock and latching is illustrated in Fig. 8.

Fig. 6—Expanded view of RCA coplanar cartridge (see Fig. 1c and 1d).



To insure proper tape guiding, the pressure roller must be parallel to the capstan to within a small fraction of 1°. Formerly, this has been done during assembly by bending the pressure-roller lever arm. Such a procedure was very time-consuming. A pressure-roller support arm has now been provided that is free to pivot in one plane and so be self-aligning.

Tape Heads

The use of a high-impedance record-play head, together with a vacuum-tube amplifier, results in good signal-to-amplifier-noise ratio and low system cost. The head is designed to be balanced for hum pickup and adequately shielded both for hum and crosstalk. The use of solid rather than laminated cores results in further cost reduction, without compromise of frequency response.

The double-gap erase head is economical of erase power, and provides entirely satisfactory erasure.

Amplifier

The design specifications adopted for this instrument require high-fidelity record and playback, with preamplifier output at approximately ½ volt, to allow connection to high-fidelity phonographs or other systems. This was achieved by the use of two high-mu triode stages per channel, with proper equalization. Type 12AX7 is suitable, but considerably better signal-to-hum performance can be obtained with the new 6EU7, without the necessity for a d-c heater supply. (Simplified circuit diagrams without switching are shown in Figs. 9 and 10.)

Since a portable instrument cannot readily be made to provide high-fidelity performance acoustically without adding considerably to size and weight, the design specifications were set up to provide power output and speaker response equal to table-model radios. This requirement is easily met by the use of a dual triode, type 6DR7, which has a low-mu section for power output and a high-mu section as a voltage amplifier.

To achieve minimum cost, the power supply uses a selenium half-wave rectifier. A power transformer allows chassis grounds to meet Underwriters requirements and minimizes hum problems.

For recording, sufficient gain is necessary to operate the high impedance tape head from a ceramic high-impedance microphone, the output voltage of which is only a few millivolts. In addition, the circuits must provide proper high-frequency pre-emphasis. With suitable choice of components and operating points, two stages (using the 6EU7) provide adequate gain and proper pre-emphasis.

Adequate bias and erase power are provided for both monaural and stereo by using the low-mu section of the 6DR7 as an oscillator at 75 kc. The use of the audio-output transformer as an r-f choke and split-capacitor tuning minimize switching complexity, and also allow use

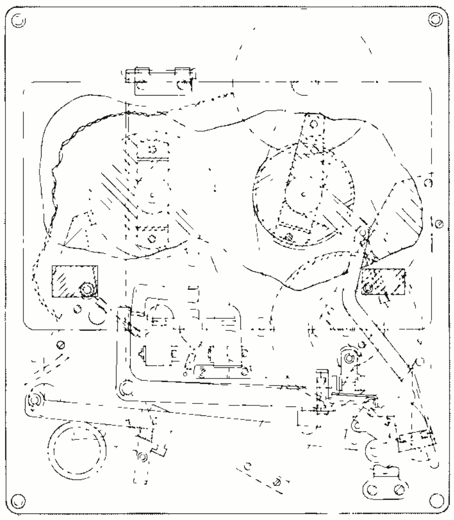


Fig. 7—Left-hand trip lever, linked to control mechanism, also operates on-off switch and supply-reel brake.

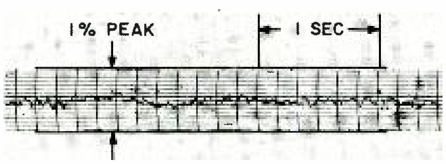
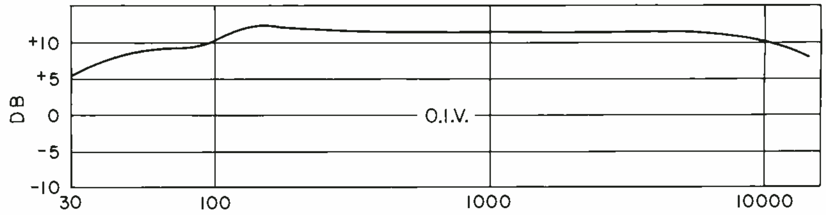


Fig. 11—Wow-gram, illustrating constancy of tape motion.



FREQUENCY RESPONSE FIGURE 12

Fig. 12—Frequency-response curve; 3¾ ips.

of a simple low-cost oscillator coil with no taps.

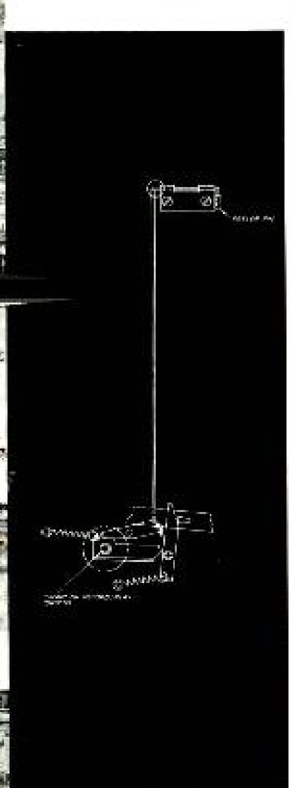
No adjustment is provided for bias current, since with a low-impedance oscillator, impedance variations of the record-play head cause compensating bias-current variations, tending to maintain proper bias flux in the head.

The neon recording-level indicator used in the monaural instrument presented a design problem. The firing level for these tubes is approximately 70 volts, while the voltage available at the output of the stage driving the tape head is only about 2 volts, and the high-mu section of the 6DR7 will not provide sufficient gain to fire the neon. In addition, a large 75-kc bias signal is superimposed on the audio. The design finally adopted uses RC networks in both the grid and plate circuits of the 6DR7 to filter out the 75-kc bias signal. The tube is biased close to cutoff with d-c voltage by connecting its cathode to a tap on the cathode resistor of the oscillator. The neon tube is connected in series with the plate of the 6DR7, and a shunt resistor controls the plate current so that firing occurs at the desired level. The firing of the neon is thus a combination of audio signal voltage and a signal-derived d-c plate-current variation in the 6DR7. Variation in firing level with random selection of neons, tubes, component variations, and line voltage does not exceed 6 db, so no adjustment is required.

The switching from play to record is straightforward. Of course, there may be many couplings and feedback paths which could cause undesired distortion and oscillations. The switch layout and choice of switching points in the circuit were carefully selected to minimize these problems. In addition, several chassis layouts were evaluated to minimize hum problems and to meet Underwriters requirements for operating temperatures of the various components.

The amplifier is made in two basic models, stereo and monaural. The monaural amplifier uses only two tubes, a 6EU7 as a preamplifier and a 6DR7 as audio output-bias oscillator and neon amplifier. A microphone jack, electrical input jack, and preamplifier output jack are provided. A switch is also provided to disable the speaker in the instrument when using the instrument to feed a high-fidelity system. The volume control in the instrument operates the stage between the electrical input and the preamp output jacks, so is effective when the instrument is feeding or being fed by an external amplifier or tuner.

The stereo amplifier has dual jacks and a ganged volume control. It uses a third tube, another 6EU7, to provide stereo recording and playback at preamplifier level. Stereo playback can be achieved either by connecting this preamplifier to a radio, TV, or phonograph to provide a second channel, or both preamplifiers may be connected to a high-fidelity stereo system. The record-level indicator used on the stereo amplifier is a 64GC/EM84. This tube is driven by the audio signals without integration, so faithfully displays instantaneous peak signals.



◀ Fig. 8—Interlock and latching.

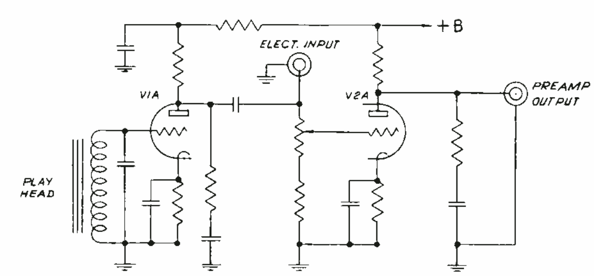


Fig. 9—Simplified preamp circuit (playback switching not shown).

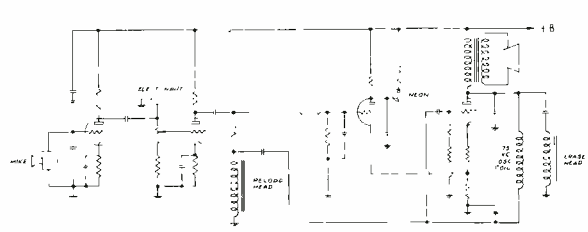


Fig. 10—Simplified record circuit (switching not shown).

CONCLUSION

The complete unit is a very versatile instrument. The size and weight have been reduced so even a child can carry it. The total weight including the microphone and accessories is less than twelve pounds. Fig. 11 shows a wow-gram illustrating the constancy of tape motion; Fig. 12 shows a frequency response curve of the playback system at 3¾ ips.

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THE BTH-250A ... New Ampliphase 250-kw AM Transmitter

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Early in 1956, RCA introduced a new line of 50-kw AM transmitters with the BTA-50G, using the so-called *Ampliphase* method of modulation, a method used in Europe and to some extent in the USA. The new transmitter had several advantages especially applicable for power ratings in excess of 10 kw. Its more attractive features were the reductions in size and cost achieved with ampliphase, compared to transmitters having conventional modulation methods. Consequently, when the BTH-250A transmitter with a carrier rating of 250 kw was proposed, ampliphase modulation appeared to be the logical choice. Final tests have justified this choice.

AMPLIPHASE-MODULATED R-F CIRCUITS

The principle of ampliphase modulation[1-4,7] is a system whereby a low-level carrier signal is split into two opposing vectors. These vectors are then modulated in antiphase at constant amplitude by the audio signal and amplified in separate channels to a high power level. Since only phase information is present, high-efficiency Class C amplification can be used, except in the driver stage (as will be described).

At the output of each channel the vectors are recombined; but now, because of the opposing phase information, they alternately aid and oppose each other in the common load so that AM modulation of the final output is produced. Each channel delivers half of the transmitter power to the load.

BASIC CONCEPTS OF THE BTH-250A

In the BTH-250A (Fig. 1), the oscillator circuit is temperature-controlled and is followed by a 5693 buffer amplifier which drives a phase-splitting LC network ($L_1 - C_1$) to divide the signal into vectors 180° apart. If this phase relationship were retained in the two channels, the carrier output at the antenna would be zero. In order to establish a carrier reference it is, therefore, necessary to advance the phase of one vector and retard the other so as to obtain a phase difference of approximately 135°. This is the function of the 5693 d-c shifter stage used in conjunction with the phasing network R_1 L_2 C_2. The network has the unique property that, if the reactance of L_2 and C_2 are chosen so that $X_L = 2X_C$, the impedance of the combination will be constant and equal to X_L, regardless of the value of R_1. If R_1 is then varied, only a change in phase will occur without amplitude variation of the applied carrier.

With the carrier reference maintained at a phase difference of 135°, it is now possible to phase-modulate each vector in accordance with the frequency and amplitude of the audio signal. If the amplitude of the phase excursion for 100-percent modulation is adjusted for a vector swing of ±22.5° in opposing directions, the angle will vary between 90° and 180°. In the common load the carrier current will then vary in amplitude between zero and about twice the carrier value. This phase modulation is accomplished in three cascaded 5693 stages, called a-c shifters, each of which shifts the phase ±7.5°. They are similar to the d-c shifter, except that resistor R_1 is replaced by a 5692 vacuum tube. Included in the a-c shifter combination is a diode limiter which prevents phase swings in excess of 22.5°. Two intermediate Class C amplifier stages (1614 and 4-250A) then raise the signal to the 4CX5000A driver level to be followed by the power-amplifier stage.

POWER AMPLIFIER

Probably the most important item in the design of a very-high-power transmitter is the final power-amplifier tube. It is, indeed, the heart of the circuitry, and other components must be designed to match it. When the BTH-250A design was started, the present RCA 6949 tube was a developmental model known as the A-2332C and had been used in a high-frequency transmitter[6] with good results in Class C operation at 500 kw. Consequently, two of these tubes were proposed to give an unmodulated carrier rating of 250 kw.

The 6949 is a water-cooled, shielded-grid, beam triode. Very-high power gain and low grid drive are possible because of the electron-optical construction. Radial compression seals are used so that r-f currents flow only on low-loss copper surfaces (seals are a common trouble source in high-power tubes). Neutralization is generally not required because of the shielded-grid construction. The filament is thoriated tungsten to reduce filament heating power to a relatively low value. Efficient cooling of the beam-forming cylinder, grid terminal, and plate is accomplished by distilled water. These features were necessary to effect a stable, trouble-free, economical transmitter.

Operating Conditions

The coaxial feeder from the antenna normally presents a resistance of 51 ohms to the transmitter terminals. This resistance is transformed to 20 ohms at the input of the harmonic filter and matching sections, designated L_5 L_6 L_7 C_8 in Fig. 1. Because of the presence of the opposing vector voltages across this constant resistance, each 6949 anode will see an equivalent variable resistance which changes between zero at the trough of modulation and four times the carrier value at the crest. At the same time, a reactive component will also be present. Since a vacuum tube is essentially a constant-voltage device, such a load would be unsuitable. If, now, a 90° matching network is inserted between each 6949 plate and L_5, three things are accomplished: first, the impedance is converted to a more satisfactory value; second, a suitable tank circuit is obtained; and third, if the r-f voltage is maintained constant at the 6949 plates, the r-f current in the termination will be constant, regardless of the manner in which the termination changes. Hence, the power will vary between zero and four times

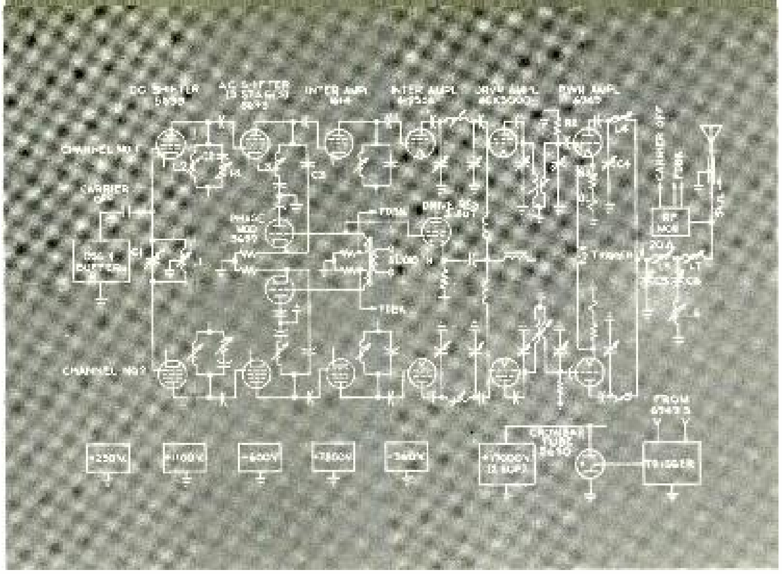

Fig. 1—Functional diagram, BTH-250A.

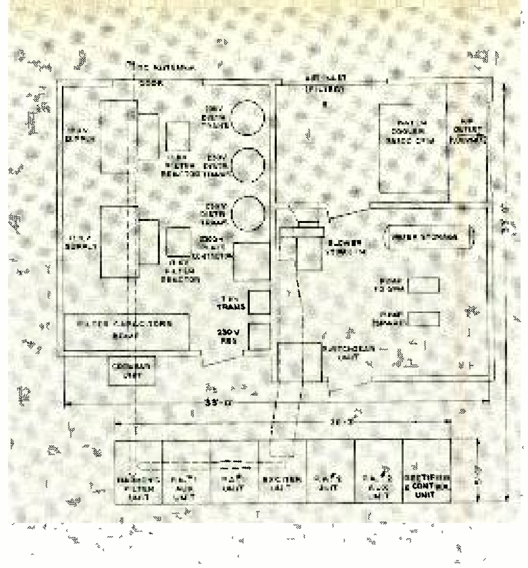

Fig. 2—Floor plan, BTH-250A.

the carrier value. This is the desired condition for 100-percent modulation.

The varying impedance with modulation in the 6949 plate circuits presents a problem in selecting the proper load Q, bias voltage, optimum efficiency, and correct grid drive to maintain constant voltage across the 90° matching sections.[1-6] It is sufficient to say here that the 4CX5000A driver tubes are normally grid-modulated to about 90 percent by the drive regulator tubes (three parallel 807's) to obtain a variable 6949 grid drive. In addition, r-f swamping resistors, a grid leak, inverse feedback, and a drive linearity corrector are used. This makes it possible to dynamically adjust the operating point of the 6949 power amplifiers so that at the crest of modulation, grid bias, and grid drive are increased from the carrier value. At the trough of modulation, bias is reduced and the drive almost cut off. Thus, the tubes will not be over-driven when the plate impedance is high. Furthermore, exact 180° displacement of the vectors at the trough of modulation is not necessary.

It was noted that the load impedance at each 6949 anode has a reactive component due to the presence of the output from the opposing channel. This component depends upon the instantaneous angle between the vectors and reduces the plate efficiency of the tube. It can be partly corrected by detuning the 90° networks to obtain unity power factor at one point on the modulation characteristic, generally at carrier level. The efficiency will then be a maximum for this point and drops off somewhat on either side. A compensated audio feedback voltage is obtained from the r-f monitor shown in Figure 1. This feedback is of considerable value in maintaining modulation linearity which is further enhanced by a linearity correction circuit in the phase modulator. It is desirable that the phase modulator be capable of swinging the phase to values greater than the nominal ±22.5° in order to compensate for phase retardation in the 6949 plate circuits at the modulation peaks.

Power Supplies

Each of the 6949 power amplifier anodes requires a maximum of 17,000 volts d-c at 17 amperes, which is supplied by two parallel "unitized" rectifiers. Reduced power operation with one rectifier is thus made possible. In the unitized construction, the plate transformer, the filament transformers, and the rectifier tubes are assembled as a unit in a single oil-filled housing. Six 857B rectifier tubes in a full-wave circuit are required with each unit. The 17,000-volt supplies, as well as a power supply rated at 7200 volts, 3 amperes for the 4CX5000A tubes, are attached directly to the 2300 volt source through a single plate contactor. Low-voltage plate, screen, grid, and filament supplies operate from a 2300-230 volt distribution transformer. In general, the primary voltage for low-power supplies is regulated. Power for the water cooler, pumps, and blower is also obtained from the distribution system, but is not regulated. Total 60-cycle power at 100-percent modulation is of the order of 700 kva.

CONTROL CIRCUITS

Standard transmitter safety practices were followed in the design of the control system for the BTH-250A. All doors of cabinets containing dangerous voltages are interlocked. Air- and water-cooling systems are monitored by pressure, flow, and temperature switches which remove power in case of a system failure. Relays and contactors to energize the power circuits are interlocked and sequenced so that human error in operating the equipment is minimized. In starting the transmitter, the operator has a choice of either manual step-by-step operation of all controls (except the main transmitter *start-stop* switch) in the *on* position. When this switch is closed, all parts of the control circuit are energized in automatic sequence.

One of the primary functions of a control system is to minimize or prevent damage to the transmitter when dangerous conditions exist, or when a breakdown occurs. Overload relays are used for this purpose in important parts of the vacuum tube circuits. They are connected in the control system so that the primary plate contactors in the transmitter open when trouble develops. The operator may make use of a notching relay which re-closes the plate contactors for three successive trials before finally opening the circuit. Branch feeders to the various parts of the transmitter are protected by circuit breakers having both magnetic (short-circuit) and thermal (overload) trip releases. When an antenna or transmission line fault occurs, a reflectometer circuit in the r-f monitor operates a relay to momentarily remove the r-f signal and thus interrupt the arc.

A common source of trouble is a power tube which has been operating normally and suddenly develops an internal flash-arc without any warning. Plate contactors under such conditions will open in 8 cycles or less, but this is still much too slow to prevent serious tube damage unless large limiting resistors are used in series with the anode supply. If the tube is not destroyed, it will probably require a slow reconditioning period before it can again be used at full power.

The BTH-250A transmitter uses a 5630 electronic crowbar ignitron[5] for interrupting internal flash-arcs in the 6949 power tubes. When a flash-arc occurs, the rise of voltage across R_3 in the 6949 cathode return actuates a

Fig. 3—Front line of 7 aluminum cabinets containing the r-f circuits.

trigger circuit. The trigger circuit, in turn, fires a 5630 ignitron which is connected in a hold-off condition across the 17,000-volt plate supplies. When this happens, the fault current in the 6949 tube is transferred to the ignitron, where it is dissipated until the plate contactors can open. It has been found possible to extinguish a flash-arc by this means in 5 to 10 μsec, a speed at which even fine wires show only small pits when short-circuited across large high-voltage power supplies. The early detection of a fault is very important if a crowbar tube is to be effective. Hence, rise time of the trigger voltage must be very fast. Furthermore, it is desirable to protect capacitors and other components by means of the crowbar. Triggering voltages should, therefore, be derived from a suitable point in the circuit so that the maximum protection is obtained.

HUM ELIMINATION

Hum and other noises on the carrier have been reduced to a low value by heavy filters in all d-c power supplies. Also, 240-cycle hum has been reduced by quarter-phasing the filaments of the channels with respect to each other. This was accomplished by operating them from a Scott-connected primary distribution transformer. A hum-bucking circuit and d-c filament supply are incorporated in the phase modulator to reduce 120-cycle hum. Predominant hum frequencies lie in the range from 60 to 600 cycles.

Table I—Test Data, BTH-250A at Station XERF

Frequency	*Audio Frequency Response (60% Mod.)*	*Harmonic Distortion (90% modulation)*	*Modulation Capability*
50 cps	+0.7 db	1.5%	100%
100 cps	+0.4 db	0.70%	100%
1,000 cps	0 db	0.60%	100%
7,500 cps	+0.8 db	1.75%	95%
10,000 cps	+0.9 db	3.00%	90%

Power Output (carrier at antenna): 250 kw
Frequency Stability: better than ±10 cycles
Carrier Shift (90% modulation): 2.5 to 3%
Noise Level (below 100% mod., 1000 cps): –56 db
Power Consumption (average program): 400 kw

BTH-250A CONSTRUCTION

Fig. 2 is a simplified floor plan of the BTH-250A transmitter. It shows the compact design of the equipment which is possible with the ampliphase system, while Fig. 3 indicates the front line of seven aluminum cabinets containing the main r-f circuits.

The *exciter* houses a crystal oscillator, an operating phase modulator and a switchable spare modulator, the drive regulator, and all amplifying stages up to and including the 4CX5000A tubes, for both channels. A combining capacitor C5, which terminates the 90° matching network, is part of the exciter.

The 6949 power amplifier stages are located in four cabinets termed *power amplifier* and *power-amplifier auxiliary, Channels 1 and 2.* These units also contain the input components of the 90° matching sections, conveniently placed so that connections may be made to the combining capacitor in the exciter. Associated water-cooling equipment is located in the power-amplifier auxiliaries.

Output power from the two channels is fed to a coaxial line of the exciter, and thence to the *harmonic filter* cabinet, which houses the output matching networks, second harmonic traps, and r-f monitor. A 51-ohm line from the antenna is brought into the transmitter at this point.

Low-voltage rectifiers and power circuits, and the control system switches and indicators are placed to the right of the power-amplifier No. 2 auxiliary unit. The 5630 ignitron crowbar tube and trigger circuits are located outside of the transformer vault which contains the oil-filled components. A pump room and water-cooler room contain the equipment for supplying approximately 60 gpm of distilled water to each 6949 power tube. Air-cooling for the rest of the transmitter is obtained from a 2200-cfm blower. It is interesting to note the simplified construction used in a present-day transmitter, as compared to designs common a number of years ago.

PERFORMANCE DATA

A BTH-250A Transmitter has been in operation on a frequency of 1570 kc at Station *XERF*, Villa Acuna, Coahilia, Mexico, for about two years. The transmitter is powered by a large 2300-volt Diesel engine generator, a power source having inherent regulation problems. Nevertheless, test data taken on the transmitter have shown very satisfactory performance (Table I). Listening tests have indicated that the transmitter has excellent quality and good area coverage.

An unusual feature is the rising characteristic of the frequency response curves at the extremes of the audio range. High level and similar modulation systems generally attenuate these frequencies.

SUMMARY

At this time, the market for transmitters with power ratings in excess of 50 kw is limited to countries outside the U.S. Performance standards required by the customer are, therefore, frequently not as strict as in this country. However, test data has shown (Table I) that performance equal to the best can be obtained. In addition, the system has some very outstanding advantages for power levels above 10 kw, as compared to previous high-level modulated Class C, or linear Class B system.

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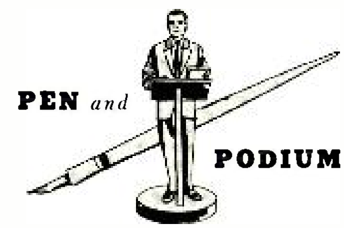
3. T. H. Price, "The Circuit Development of the Ampliphase Broadcasting Transmitter"; *Proc. Inst. of Elec. Engr., Part III*, Nov. 1954, P.391
4. J. Q. Lawson, "How the RCA Ampliphase 50 KW AM Transmitter Works"; *Broadcast News*, June, 1957, P.12
5. James O. Weldon, "A 600 Kilowatt High-Frequency Amplifier"; *IRE Transactions on Communications Systems*, Vol. CS-5, No. 1, March 1957, P.40
6. W. N. Parker and M. V. Hoover, "Gas Tubes Protect High-Power Transmitters"; *Electronics*, Jan. 1956, P.144
7. C. J. Starner, "Current High-Power AM Transmitter Design"; RCA Engineer, Vol. 3, No. 4, Feb.-Mar. 1958.



Based on Reports Received Over a Period of About Two Months

INDUSTRIAL ELECTRONIC PRODUCTS

Data Communications, Facilities, Techniques and Equipment for the EDP User
R. E. Montijo: San Diego Chapter of the ACM, November, 1960

Microsystem Computer Techniques
E. Luedicke and A. H. Medwin: Western Joint Computer Conference, Los Angeles, Calif., May 1961

Priority Interrupt in Control Computers
S. B. Dinman and R. W. Sonnenfeldt: *Control Engineering*, May issue 1961

A Standard for Positioning the Vacuum Guide in Transverse Track Video Tape Recorders
A. H. Lind: SMPTE Convention, Toronto, Canada, April 1961

Color Reproduction Techniques in Comparative Color Television
J. W. Wentworth: Maxwell Colour Centenary at the Royal Institution and the Imperial College, London, England, May 17, 1961

Tunnel-Diode Binary Counter Circuit
H. Ur: *Proceedings of the IRE*, June 1961

Experience with Stabilized Color Cameras
K. Sadashige and H. N. Kozanowski: 1st International Television Festival, Montreux, Switzerland, May 15, 1961

Transistors and TV Tape Recorders
A. H. Lind: 1st International Television Festival, Montreux, Switzerland, May 15, 1961

The Effect of SWR on Cross-Modulation on FM Multiplexed Signals
A. H. Bott: NAB Convention, Washington, D. C., May 9, 1961

Organization of a Kilomegacycle Computer
P. Warburton: 1961 Workshop on Kilomegacycle Computing Systems, Monterey, Calif., May 12-13, 1961

Fabrication Considerations in Kilomegacycle Computers
D. R. Crosby: 1961 Workshop on Kilomegacycle Computing Systems, Monterey, Calif., May 12-13, 1961

Directionality and Gain in Tunnel Diode Logic
H. Ur: 1961 Workshop on Kilomegacycle Computing Systems, Monterey, Calif., May 12-13, 1961

An Analysis of Transistor Turn-on Wait Times
D. B. Simmons: Thesis, June, 1961, University of Penna., Moore School of EE.

A Non-Destructive Read Tunnel Diode Memory
J. J. Hill: Thesis, June 1961, University of Penna., Moore School of EE.

Theoretical Analysis of Tunnel Diode Locked Pair Circuit
H. R. Kaupp: Thesis, June 1961, University of Penna., Moore School of EE.

A Survey of Asynchronous Principles
C. R. Jones, Thesis, June, 1961, University of Penna., Moore School of EE.

Evaluation of Systems Using Associative Memories
J. W. Ausley: Thesis, June 1961, University of Penna., Moore School of EE.

The Characteristics of Slot Radiators in Cylinders
H. J. Ghandour: Thesis, June 1961, University of Penna., Moore School of EE.

The Space Age and Civilian Products
T. A. Smith: 5th National Symposium on Product Engineering and Production, Philadelphia, Pa., June 15, 1961

Circuit Reliability, Frequency Utilization and Forecasting in the High Frequency Communications Band
J. H. Nelson: Ionospheric Research Conference for Aeronautical Research and Development of Nato, Naples, Italy, June 1961

DEFENSE ELECTRONIC PRODUCTS

Non-Linear Problems
G. Rodeman: University of Penna., Thesis, June 1961

Space Maintenance Training
T. Taylor, H. Matty and W. Sommer: *Space-Aeronautics R&D Handbook*, June 1961

Need for Standardized ATE
D. B. Dobson and L. Wolff: ASTC of AIEE, Philadelphia, June 26, 1961

General Design of ATE
J. Cecola: University of Penna., June 1961, Thesis

Allocations of Maintenance Functions in Systems of Spacecraft
H. Dordick: Operations Research Society, May 25-26, 1961

Modifying Vidicon Camera Chain for Slow-Scan Television Systems
F. F. Martin, C. T. Shelton: *Electronics*, June 9, 1961

Low-Frequency Microphone
J. R. Barger, A. L. Witchey and L. Weinreb: Acoustical Society of America, Philadelphia, May 1961

Digital Microelectronic System Problems and Potentials
A. H. Coleman: West Coast AIEE Convention, Los Angeles, May 14-15, 1961

A Miniature Universal Lightweight Military Microphone
E. D. Simshauser and R. M. Carrell: Acoustical Society of America, Phila., May 11-13, 1961

What Value Engineering Is Not
D. P. Simonton: *Standards Engineering*, April-May issue 1961

ECM in Orbital and Ballistics Vehicles
L. M. Perkins: NORAD ECM Conference, Ft. Bliss, Texas, May 16, 1961

An Integrated Airborne PCM Telemetry System
N. Aron, C. Granger and H. Slade: *Proceedings of the National Aerospace Electronics Conference*, Dayton, Ohio, May 10, 1961

Thermal Design Solutions for Micro-Modular Equipment
G. Rezek and P. K. Taylor: National Conference of IRE Prof. Group on Product Engineering and Production, Philadelphia, June 13, 1961

Digital Microelectronic System Problems and Potentials
A. Coleman: 5th National Conference, IRE Prof. Group on Product Engineering and Production, Philadelphia, June 14, 1961, IRE Transactions July 1961

A New Digital Communications System—Modified Diphase
Douglas, Aaronson and Messlener: Globecom V, 5th National Convention Military Engineering, June 26, 1961

Self-Verification Requirements and Techniques
J. Cohen and H. J. Kishi: 5th National Convention Military Engineers, June 26, 1961

Micro-Module and Ultra-Miniaturized Crystal Units
R. R. Bigler: 15th Annual Frequency Control Symposium, May 31, 1961

Synthesis and Design of a Global Communications System
J. B. Potts: 5th National Convention on Global Communications, Chicago, May 22, 1961

Alternate Routing Computer
A. Kritz and H. Roberts: 5th National Convention on Global Communications, Chicago, May 22, 1961

Nomographs for the Statistical Summation of Noise in Multihop Communications Systems
B. Sheffield: 5th National Convention on Global Communications, Chicago, May 22, 1961

Communication Error Rate Instrumentation System
Rabinowitz, Tepfer, Chewey and Wittman: 5th National Symposium on Global Communications, Chicago, May 22, 1961

Study of Intelligibility Improvement with Out-of-Phase Connections of Headphones
D. Greenberg: Acoustical Society of America, Philadelphia, May 1961

Deriving Operational Availability from Subsystem Maintainability and Reliability
Dr. I. H. Zagor: Published in book *Electronics Maintainability*, Vol. 3, of the Electronic Industries Association

ELECTRON TUBE DIVISION

Application of Nuvistors to Amateur Receivers
J. M. Filipczak: North Jersey Radio Club, Englewood, N. J., May 8, 1961

A Quick-Heating, Rugged, UHF Ceramic Pencil Triode for Missiles and Satellites
S. W. Bogaenko and O. H. Johnk, Jr.: IRE Military Electronics Convention, Washington, D. C., June 26-28, 1961 and published in IRE MIL-E-CON 1961 *Convention Record*

Suppression and Limiting of Undesired Signals in Traveling-Wave-Tube Amplifiers
H. J. Wolkstein: *RCA Review*, June 1961

Color TV—What It Is
R. E. Ritter: Corning Glass Works, Corning, N. Y., May 1, 1961

New Frontiers in TV Camera Tubes
R. G. Neuhauser: SMPTE Convention, Toronto, Canada, May 7-12, 1961

Vidicon Light-Transfer Characteristics and Film Reproduction
R. G. Neuhauser: SMPTE Convention, Toronto, Canada, May 7-12, 1961

DATES and DEADLINES

PROFESSIONAL MEETINGS AND CALLS FOR PAPERS

MEETINGS

Sept. 14-15, 1961: 9th Ann. Engineering Management Conf.; IRE-PGEM, AIEE, et al. *Prog. Info.:* H. M. O'Bryan, GTE Labs, 730 Third St., New York, N. Y.

Sept. 14-15, 1961: National IRE Conf. on Technical-Scientific Communications; IRE-PGEWS; Bellevue-Stratford, Phila., Pa. *Prog. Info.:* E. R. Jennings, RCA, Bldg. 2-8, Camden.

Sept. 20-21, 1961: Industrial Electronics Symp., IRE-PGIE, AIEE, ISA; Bradford Hotel, Boston, Mass. *Prog. Info.:* R. K. Jurgen, Sutton Pbl. Co., 172 S. Broadway, White Plains, N. Y.

Oct. 2-4, 1961: 7th Natl. Communications Symp., IRE-PGCS; Utica, N. Y. *Prog. Info.:* R. K. Walker, 34 Balton Rd., New Hartford, N. Y.

Oct. 2-6, 1961: 90th SMPTE Conv., Lake Placid Club, Lake Placid, N. Y. *Prog. Info.:* Dr. C. L. Graham, Eastman Kodak Co., Rochester, N. Y.

Oct. 9-11, 1961: Natl. Electronics Conf., IRE, AIEE, et al. Intl. Amphitheatre, Chicago, Ill. *Prog. Info.:* Dr. W. L. Firestone, Motorola, Inc., Chicago, Ill.

Oct. 9-13, 1961: 1961 Int. Conf. on Luminescence, Physics Dept., New York Univ. *Prog. Info.:* Dr. G. M. Spruch, Physics Dept., N. Y. Univ., New York 3, N. Y.

Oct. 11-13, 1961: Ann. Gaseous Electronics Conf.; APS Div. of Electron Physics; GE Res. Lab., Schenectady, N. Y. *Prog. Info.:* C. J. Gallagher, GE Res. Lab, P. O. Box 1088, Schenectady, N. Y.

Oct. 16-17, 1961: National Symposium on Engineering Writing and Speech, IRE-PGEWS, Kellog Center, Michigan State Univ., East Lansing, Mich. *Prog. Info.:* J. D. Chapline, Philco Corp., 3900 Welsh Rd., Willow Grove, Pa.

Oct. 23-25, 1961: East Coast Conf. on Aerospace & Navigational Electronics, IRE-PGANE; Lord Baltimore Hotel, Baltimore, Md. *Prog. Info.:* W. C. Vergara, Dir. Adv. Res. Dept., Bendix Radio, Towson 4, Md.

Oct. 26-28, 1961: 1961 Electron Devices Mtg., IRE-PGED, Sheraton-Park Hotel, Wash., D. C. *Prog. Info.:* Dr. I. M. Ross, Bell Telephone Labs, Rm. 2A-329, Murray Hill, N. J.

CALLS FOR PAPERS:

Nov. 24-25, 1961: American Physical Soc., U. of Chicago & Windermere Hotel, Chicago, Ill. *DEADLINE:* Abstr., **9/22/61** to K. K. Darrow, 538 W. 120 St., New York 27, N. Y.

Feb. 14-16, 1962: 1962 Intl. Solid-State Circuits Conf.; IRE, AIEE, Univ. of Penna.; Sheraton Hotel and Univ. of Penna., Philadelphia, Pa. *DEADLINE:* 300-500 wd. abstracts, **11/1/61** to R. B. Adler, Rm. C-237, MIT Lincoln Lab., Lexington, Mass.

Mar. 26-29, 1962: The 1962 IRE International Convention; Waldorf Astoria and N. Y. Coliseum, New York City. *DEADLINE:* (3 cys. each, 100-wd. abstract and 500-wd. summary) **10/20/61** to Dr. D. B. Sinclair, IRE Inc., 1 East 79th Street, New York 21, N. Y.

April 11-13, 1962: Sthwst. IRE Conf. & Elec. Show (SWIRECO), Rice Hotel, Houston, Tex. *DEADLINE:* Author and title of paper, **10/1/61;** abstract, **12/1/61** to Professor M. Graham, Rice Univ., Computer Project, Houston 1, Tex.

May 1-3, 1962: Spring Joint Computer Conf., IRE-PGEC, AIEE, ACM; Fairmont Hotel, San Francisco, Cal. *DEADLINE:* Papers, **11/10/61** to R. I. Tanaka, Lockheed Missiles & Space Co., 3251 Hanover St., Palo Alto, Cal. *Notify intent to submit ASAP.*

May 8-10, 1962: Electronic Components Conf.; IRE-PGCP, AIEE, EIA, WEMA; Washington, D. C. *DEADLINE:* 15 cys., 500-wd. abstract, **10/9/61** to H. Stone, Bell Telephone Lab., Murray Hill, N. J.

May 14-16, 1962: Natl. Aerospace Electronics Conf. (NAECON); IRE-PGANE, Dayton, O. *DEADLINE:* Abstracts, **1/5/62** to R. Nordlund, NAECON, 1414 E. Third, Dayton, O.

May 22-24, 1962: Natl. Microwave Theory & Techniques Symp., IRE-PGMTT, Boulder, Colo. *DEADLINE:* **12/18/61** to R. W. Beatty, NBS Boulder Labs, Boulder, Colo.

May 23-25, 1962: Natl. Telemetering Conf., IRE-PGSET, AIEE, IAS, ARS, ISA, Sheraton Park Hotel, Wash., D. C. *DEADLINE:* Approx. **11/15/61.** For info.: H. W. Royce, Martin Co., Baltimore, Md.

June 18-21, 1962: 4th US Natl. Congress of Applied Mechanics, US Natl. Comm. on Theoretical & Applied Mechanics. AIChE, AMS, APS, ASCE, ASME, IAS, SESA; U. of Calif., Berkeley, Calif. *DEADLINE:* Papers and abstracts, **1/1/62** to W. Goldsmith, Dept. of Applied Mechanics, U. of Cal., Berkeley 4, Cal.

June 25-30, 1962: Symposium on Electromagnetic Theory and Antennas; The Technical University of Denmark, Oster Voldgarde 10G, Copenhagen K., Denmark. *DEADLINE:* 1200-wd. summaries, **12/1/61** to H. Lottrup Knudsen, above address. (USSR expected to undertake two sessions.)

June 27-29, 1962: Joint Automatic Control Conf., IRE-PGAC, AIEE, ISA, ASME, AIChE; New York Univ., New York. *DEADLINE:* Abstr. **10/15/61,** papers **11/15/61** to Dr. H. J. Hornfeck, Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, O.

Aug. 21-24, 1962: Western Electronics Show and Conf. (WESCON), IRE, WEMA; L. A., Cal. *DEADLINE:* About **May, 1962.** For info.: WESCON, 1435 La Cienega Blvd., L. A., Cal.

Aug. 27-Sept. 1, 1962: 1962 Congress, Intl. Federation of Information Processing Societies (IFIPS); incl. IRE, ACM, AIEE; Munich, Germany. *DEADLINE:* 500-1000 wd. abstracts, **9/15/61;** complete ms. **3/1/62;** to Dr. E. L. Harder, Westinghouse Electric Corp., East Pittsburgh, Pa.

Be sure DEADLINES are met — consult your Technical Publications Administrator for lead time needed to obtain required RCA approvals.

Thermal Outgassing of Tube Materials
R. H. Collins and J. C. Turnbull: *Advances in Electron Tube Techniques 1960*, May 1961

New Design Methods for Obtaining 40g Vibrational Capability in Kilowatt-Class Tubes
J. J. Free: *Advances in Electron Tube Techniques 1960*, May 1961

Careers in Science and Engineering
R. H. Zachariason: Rotary Camp, Lancaster, Pa., June 20, 1961

A Radiotracer Test for Ultrasonic Cleaners
H. A. Stern: ASTM F-1 Meeting, Atlantic City, N. J., June 26-27, 1961

A Reproducible Test for Evaluating Ultrasonic Cleaning Equipment
E. L. Romero: ASTM F-1 Meeting, Atlantic City, N. J., June 26-27, 1961

Analysis of Noise in the Image Orthicon
B. H. Vine: *Journal of SMPTE*, June 1961

A Miniature-Package 2200-MC Parametric Amplifier Using a Varactor-Loaded Helix
C. L. Cuccia: Electronic Components Conference, San Francisco, Calif., May 1, 1961 and *Proceedings of ECC*, May 1961

The Helix Parametric Amplifier, A Wide-Band Miniature Solid-State Microwave Amplifier
C. L. Cuccia and K. K. N. Chang: *RCA Review*, June 1961

SEMICONDUCTOR AND MATERIALS DIVISION

Vapor Growth of Gallium Arsenide
R. L. Newman and N. Goldsmith: Electrochemical Society Semiconductor Symposium, Indianapolis, Ind., May 1-3, 1961

New Rechargeable Systems
G. S. Lozier: 15th Annual Power Sources Conference, Atlantic City, N. J., May 9-11, 1961

Capability and Characteristics of Microelements and Micromodules
B. V. Vonderschmitt: AIEE Los Angeles Section Meeting on Microminiaturization, Los Angeles, Calif., May 16-17, 1961

Emitter-Peaked Video Amplifiers
J. B. Fisher: *Electronics*, May 19, 1961 issue

A Diffusion Mask for Germanium
E. L. Jordan: *Journal of Electrochemical Society*, May 1961 issue

A Low-Cost Pre-Set Transistorized Counter
R. R. Painter and R. A. Christensen: *Semiconductor Products*, May 1961

An Ultra-Low-Distortion Transistorized Power Amplifier
C. F. Wheatley and H. M. Kleinman: IRE Symposium on Broadcast and Television Receivers, Chicago, Illinois, June 19-20, 1961

Production of Epitaxial Transistors
E. O. Johnson: International Conference on Semiconductor-Device Production Techniques, Rome, Italy, June 22, 1961

The Degradation of GaAs Tunnel Diodes
R. D. Gold and L. R. Weisberg: Solid-State Device Research Conference, Stanford University, California, June 26, 1961

Fuel Cells and Batteries
G. S. Lozier: *RCA Review*, June 1961

A New Concept in Transistor Converters
L. Plus and R. A. Santilli: *Semiconductor Products*, June 1961

RCA VICTOR COMPANY, LTD. MONTREAL

Five Years with a Physics Group in Canadian Industry
R. W. Jackson: Canadian Association of Physicists Congress, Montreal, June 9, 1961

Negative Resistance in Ideal P-I-N Junctions
R. J. McIntyre: Canadian Association of Psysicists Congress, Montreal, June 7, 1961

Launching Electromagnetic Waves into an Anisotropic Plasma, Bounded by a Flat Interface, for Arbitrary Angles of Incidence
K. A. Graf: Canadian Association of Physicists Congress, Montreal, June 9, 1961

Modulated Electron Beams for Plasma Diagnostics
T. W. Johnston: Canadian Association of Physicists Congress, Montreal, June 9, 1961

A Negative Ion Source for Electrical Propulsion
G. G. Cloutier: Canadian Association of Physicists Congress, Montreal, June 9, 1961

The Absorptivity Spectrum of a Uniform, Anisotropic Plasma Slab
I. P. French: Canadian Association of Physicists Congress, Montreal, June 9, 1961

The Status of Silicon Junction Nuclear Particle Detectors
R. L. Williams and P. P. Webb: Canadian Association of Physicists Congress, Montreal, June 9, 1961

Generalized Appleton-Hartree Equation for Any Degree of Ionization and Application to the Ionosphere
I. P. Shkarofsky: Canadian Association of Physicists Congress, Montreal, June 10, 1961

Field Separation of Optically Excited Carriers in a Silicon P-N Junction
R. L. Williams: Annual Meeting of the Royal Society of Canada Section III, Montreal, June 3-7, 1961

RCA LABORATORIES

Problems and Expectations to the Area of Artificial Intelligence
S. Amarel: Theoretical Chemistry Seminar, Princeton University, May 25, 1961

Tunnel Diodes as Microwave Devices
K. K. N. Chang: PGMIT & Electron Device Joint Meeting, Los Angeles, Calif., June 8, 1961

The Fundamental Reflectivity of Some Semi-Conductors with Zinc Blende Structure
M. Cardona: Conference on Semiconducting Compounds, Schenectady, N. Y., June 14-16, 1961

An Efficient Noise Immune Sync and AGC Circuit for Television Receivers
R. N. Rhodes and W. Dietz: IRE Spring Conference, Chicago, Illinois, June 19, 1961

Experimental Investigations of Ultra-Low Noise Traveling-Wave Tube Electron Guns: Beam Profiles and Limiting Perfeance Effects
J. Berghammer and J. M. Hanner: Conference on Electron Tube Research at Rensselaer Polytechnic Institute, Troy, N. Y., June 22, 1961

Experimental Investigation of Ultra-Low Noise Traveling-Wave Tube Electron Guns: Measurements of Noise Quantities S π and F
J. M. Hammer: Conference on Electron Tube Research at Rensselaer Polytechnic Institute, Troy, N. Y., June 22, 1961

Landau-Type Damping of Space-Charge Waves
J. Berghammer: Conference on Electron Tube Research at Rensselaer Polytechnic Institute, Troy, N. Y., June 22, 1961

Analysis of Double Stream Interactions in the Presence of a Finite Axial Magnetic Field
B. Vural: Conference on Electron Tube Research at Rensselaer Polytechnic Institute, Troy, N. Y., June 22, 1961

On the Acceptance of Slow Electrons at the Surface of Al_2O_3 and the Accurate Determination of the Insulator Surface Potential by the Beam Electrons
H. Heil: American Physical Society, Mexico City, Mexico, June 22-24, 1961

Use of Infrared Spectrometry for the Evaluation of Device Materials
J. I. Pankove: IRE Solid-State Devices Research Conference, Stanford University, Calif., June 26-28, 1961

Double Injection in Insulators
M. A. Lampert: IRE Solid-State Devices Research Conference, Stanford University, Calif., June 26-28, 1961

The Mass Spectrograph in Solids Analysis
J. R. Woolston: General Engineering Lecture Series, RCA Somerville, July 5, 1961

Image Processing Using Distributed Opto-Electronic Systems
E. C. Giaimo, H. O. Hook: IRE Solid-State Devices Research Conference, Stanford University, Calif., June 26-28, 1961

Evaporated Thin Film Triodes
P. K. Weimer: IRE Solid-State Devices Research Conference, Stanford University, Calif., June 26-28, 1961

Electronic Structure of Light Diatomic Molecules: Fluorine
A. Amith: Bell Laboratories, June 1961

A Mechanized Matching Procedure for Computer Aided Differential Diagnosis
V. K. Zworykin: 4th International Conference on Medical Electronics, July 16, 1961

A Miniaturized Hospital Telemetering System
V. K. Zworykin and F. L. Hatke: 4th International Conference on Medical Electronics, July 16, 1961

Photoconductivity, Recombination Processes and Space-Charge-Limited Currents
A. Rose: Summer School in Solid-State Physics, Univ. of Gent, Gent, Belgium, July 24-27, 1961

RCA VICTOR RECORD DIV.

Plastics in the Recording Arts
C. Martin: Society of Plastics Industry, Biannual Meeting, June 6, 1961, Commodore Hotel, N. Y.

RCA SERVICE CO.

On Scheduling Tasks with Associated Linear Loss Functions
A. Schild and I. J. Freedman: *Management Science*, Vol. 7, No. 3 April 1961

Radio Frequency Hazards
J. Roman: Third Nat'l R-F Symposium, Washington, D. C.

A Spectrophotometer Digital Output System
D. Hampel: Instrument Society of America, Conference on Automation, Toronto, Canada, June 8, 1961

Patents Granted TO RCA ENGINEERS

Based on Summaries Received over a period of about two months

NATIONAL BROADCASTING COMPANY

Television System
2,982,813—May 2, 1961; J. L. Hathaway

Television Systems
2,989,580—June 20, 1961; A. N. Goldsmith and R. C. Kennedy

INDUSTRIAL ELECTRONIC PRODUCTS

Pulse Generating Circuit Comprising Cascaded Shock-Excited Oscillators
2,989,706—June 20, 1961; I. I. Grasheim and S. V. Mormile

Rapid Film Acceleration Device
2,986,317—May 30, 1961; C. J. Mangiaracina

Magnetic Recording Cross-Talk Elimination
2,986,608—May 30, 1961; J. L. Pettus and M. Rettinger

Frequency Control System for FM Transmitter
2,986,631—May 30, 1961; R. S. Jose and F. E. Talmage (deceased)

Reversal Type Electroscopic Developer Powder
2,986,521—May 30, 1961; H. Wielicki

Miniature Reverberation Chamber System
2,986,228—May 30, 1961; M. Rettinger and C. N. Shipman

Composite Photography
2,985,063—May 23, 1961; F. L. Putzrath

Composite Photography
2,985,065—May 23, 1961; H. E. Haynes and F. L. Putzrath

Magnetic Recording and Reproducing Apparatus
2,985,395—May 23, 1961; J. J. Hoehn and F. B. Hills

Sorting Device
2,985,864—May 23, 1961; S. M. Fillebrown and H. P. Guerber

Magnetic Head Construction
2,984,709—May 16, 1961; M. Rettinger

Supporting Mechanism for Tape Reels
2,983,460—May 9, 1961; H. G. Wright

Tuning Means for Slot Radiator
2,983,919—May 9, 1961; M. S. O. Siukola

Memory System
2,988,731—June 13, 1961; Kam Li

Magnetic Memory Systems
2,988,734—June 13, 1961; A. G. Samusenko

HOME INSTRUMENTS

Crystal Oscillator with Reactance Tube Control Used in Color Television Receiving Apparatus
2,985,849—May 23, 1961; G. E. Kelly

Noise Cancelling Circuit for Television Receivers
2,989,589—June 20, 1961; L. P. Thomas, Jr. & C. W. Hoyt

Automatic Gain Control Systems
2,989,588—June 20, 1961; L. P. Thomas, Jr.

Color Television Receiver Fine Tuning Indication
2,990,447—June 27, 1961; J. Stark, Jr. and W. E. Lavender

ELECTRON TUBE DIVISION

Method of Making a Phosphor Screen and Screen Produced Thereby
2,982,669—May 2, 1961; J. F. Stewart

Heat Radiating Coatings
2,987,423—June 6, 1961; T. A. Sternberg

Photoconductive Pick-up Tube and Method of Manufacture
2,984,759—May 16, 1961; B. H. Vine

Electrode Support
2,982,878—May 2, 1961; E. M. Smith

Transition Device
2,982,927—May 2, 1961; A. C. Grimm and R. T. Schumacher

Pulsed Amplifiers with Pulsed Bias Control
2,983,882—May 9, 1961; M. V. Hoover

Three Tube Color Projection System with Skew Correction SKEW Correction
2,989,584—June 20, 1961; L. I. Mengle

DEFENSE ELECTRONIC PRODUCTS

Composite Photography
2,985,064—May 23, 1961; G. L. Dimmick

Sweep Circuit
2,984,788—May 16, 1961; M. Korff and H. M. Scott

Pulse Time Discriminator Circuit which Eliminates Transients Induced by Gating Pulses
2,983,873—May 9, 1961; A. I. Mintzer

Automatic Gain Control Circuit
2,987,679—June 6, 1961; W. G. Christiansen and Alvin B. Glenn

Transfluxor Counting Circuit
2,988,653—June 13, 1961; A. G. Samusenko

Moving Target Indication Radar Systems
2,989,742—June 20, 1961; M. C. Johnson and W. W. Weinstock

Time Discriminator
2,989,652—June 20, 1961; A. L. Hall

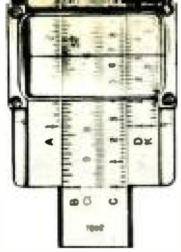
Control Systems
2,990,540—June 27, 1961; I. H. Sublette and L. W. Honens

Electrostatic Printing
2,990,279—June 27, 1961; J. A. Crumley, R. W. James & J. Shulman

Magnetic Memory with Non-Destructive Read-Out
2,988,730—June 13, 1961; N. S. Prywes

Method of Assembling a Matrix of Magnetic Cores
2,985,948—May 30, 1961; C. L. Peters

Mount for Ring Cores
2,983,886—May 9, 1961; C. H. Heckler, Jr.

Engineering  NEWS *and* HIGHLIGHTS

30 ENGINEERS EARN MS IN RCA GRADUATE STUDY PROGRAM

The engineers listed below have been awarded Masters Degrees through their participation in the RCA Graduate Study Program. In addition to their formal degree, all are honored at a special RCA dinner, and by presentation of a distinctive certificate. For a description of this program, which is sponsored by the operating Divisions and administered by the College Relations Activity, RCA Staff, Camden, see Vol. 5, No. 5, RCA ENGINEER *The Engineer and the Corporation: RCA Graduate Study Program.*

Charles Adomshick, SC & M, Somerville .. MSEE, Rutgers the State University, 6/7/61
Juan Amodei, RCA Labs., Princeton........ MSEE, University of Pennsylvania, 6/5/61
James Ausley, EDP, Pennsauken .... MSEE, University of Pennsylvania, 6/5/61
Wayne Austin, Electron Tube, Harrison .. MSEE, Rutgers the State University, 6/7/61
Robert Bell, DEP, Moorestown .... MSME, University of Pennsylvania, 6/5/61
Harold Blatter, RCA Labs., Princeton ...... MSEE, Rutgers the State University, 6/7/61
Norman Brennecke, DEP, Moorestown ..... MSEE, University of Pennsylvania, 6/5/61
James Christensen, DEP, Moorestown ...... MSEE, University of Pennsylvania, 6/5/61
Daniel Daly, RCA Labs., Princeton .... MSEE, Rutgers the State University, 6/7/61
Rene Dube, DEP, Moorestown .... MSEE, University of Pennsylvania, 6/5/61
Samuel Flateau, DEP, Camden .... MSEE, University of Pennsylvania, 6/5/61
James Hill, EDP, Pennsauken .... MSEE, University of Pennsylvania, 6/5/61
Charles Jones, EDP, Pennsauken .... MSEE, University of Pennsylvania, 6/5/61
Richard Josephs, RCA Labs., Princeton MS/Physics, University of Pennsylvania, 6/5/61
Robert Katz, RCA Labs., Princeton ...... MSEE, Rutgers the State University, 6/7/61
Herbert Kaupp, EDP, Pennsauken .... MSEE, University of Pennsylvania, 6/5/61
Richard McKrell, DEP, Moorestown .... MSME, University of Pennsylvania, 6/5/61
Robert Merkert, DEP, Camden .... MSEE, University of Pennsylvania, 6/5/61
Louis Napoli, RCA Labs., Princeton ...... MSEE, Rutgers the State University, 6/7/61
William Pehlert, DEP, Camden .... MSEE, University of Pennsylvania, 6/5/61
Joseph Perhach, DEP, Moorestown ... MS/Physics, University of Pennsylvania, 6/5/61
Philip Pressel, DEP, Moorestown .... MSME, University of Pennsylvania, 6/5/61
Charles Puckette, DEP, Moorestown .... MSEE, University of Pennsylvania, 6/5/61
Eli Reiter, DEP, Camden .... MSEE, University of Pennsylvania, 6/5/61
Glenn Rodeman, DEP, Camden .... MSEE, University of Pennsylvania, 6/5/61
Ralph Scott, DEP, Princeton .... MSME, University of Pennsylvania, 6/5/61
Dick Simmons, EDP, Pennsauken, ... MSEE, University of Pennsylvania, 6/5/61
James Whelan, DEP, Princeton .... MSEE, Princeton University, 6/13/61
Richard Williams, DEP, Moorestown ...... MSME, University of Pennsylvania, 6/5/61
Robert Williams, RCA Labs., Princeton .... MSEE, University of Pennsylvania, 6/5/61

STARAS AWARDED GUGGENHEIM FELLOWSHIP

Dr. Harold Staras, a Member of the RCA Laboratories Technical Staff, was recently awarded a Guggenheim Fellowship for one year beginning September 1, 1961, to undertake "studies of communications systems that utilize new modes of wave propagation." Dr. Staras has been associated with RCA since 1954 and has been engaged in research on propagation phenomena and communications theory. Dr. Staras will place emphasis in his study upon those communications systems which should prove of use to the newly emerging states in the world. He expects to center his studies in Israel.

WILDER RECEIVES LABS PH.D. STUDY AWARD

Joseph Wilder, Member of the Technical Staff of the Systems Research Laboratory, has been named the recipient of an RCA Laboratories *Doctoral Study Award* for the academic year 1961-62. Under this Award, Mr. Wilder will be given a leave of absence for the coming academic year to devote full time to graduate study in electrical engineering at the University of Pennsylvania. He will receive half salary during the period of leave, and RCA Laboratories will also pay the expenses of tuition, fees, and provide an allowance for books. A maximum of five RCA Labs employees can be selected for the program in a given year.

Two members of the research staff, **George Heilmeier** of the Electronic Research Laboratory and **Richard Ahrons** of the Systems Research Laboratory, recently completed their course work and doctoral examinations under the program. Mr. Heilmeier did his work in electrical engineering at Princeton University and Mr. Ahrons completed advanced studies in the same field at Brooklyn Polytechnic Institute.

NEW TEST FACILITY FOR TAPE

The Record Division's Magnetic Tape Plant has under construction an 1800-square-foot area for three-shift 100-percent testing of computer tape. This room closely controlled for humidity, temperature, and dust contamination, will also be used for audio, video, and instrumentation tape.

There will be eight 581 computer tape stations, a 381 computer tape station, audio-tape test consoles, and video tape test units. **J. Harrington** is coordinating the organization of this test center.—*M. L. Whitehurst*

MOVE TO MEADOWLANDS COMPLETED

The move of IEP's Communication Products Department from its old plant at Canonsburg, Pa., to its new plant at Meadowlands, Pa., was accomplished late in June 1961. This completes the relocation of that Department's administrative, engineering and production facilities under one roof. Manufactured there will be mobile communications, and audio and visual equipment.—*S. F. Dierk*

BORDOGNA AWARDED FELLOWSHIP

J. Bordogna, DEP Applied Research was awarded a University Fellowship at University of Pennsylvania for full time study toward his doctorate degree in Electrical Engineering during the 1961-62 academic year. He will continue the following year under a teaching fellowship to complete his thesis.—*W. Whittier*

DEGREES GRANTED

In addition to the Graduate Study Program degrees listed elsewhere on this page, the following RCA engineers and scientists received degrees in recent graduating ceremonies:

J. Carter, SCM, Needham .... BA, Bus. Admin., Northeastern Univ.
L. Arena, SCM, Needham .... Assoc., Elec., Northeastern Univ.
T. E. Yingst, ETD, Lancaster .... MS, Phys, Franklin & Marshall College
K. Strater, ETD, Harrison .... MSCE, Newark College of Engineering
H. F. Schellack, ETD, Harrison .... MSEE, Newark College of Engineering
BSME, Newark College of Engineering
R. McFarlane, ETD, Harrison .... BSME, Newark College of Engineering
R. T. Hansen, ETD, Harrison .... BSME, Newark College of Engineering
K. ReCorr, ETD, Harrison .... BA in Math, Rutgers University
S. H. Middings, ETD, Harrison .... MS, Rutgers State University of N.J.
J. P. McDonald, ETD, Harrison .... MSEE, Newark College of Engineering
R. K. Pearce, ETD, Harrison .... MS, Management Engineering,
Newark College of Engineering
A. B. Bodonyi, RCA Comm., IEP .... MSEE, Polytechnic Institute of Brooklyn
D. Douglas, SurfCom NY .... MEE, Polytechnic Institute of Brooklyn
E. A. Szukalski, DEP, Camden .... MSEE, Drexel Institute of Technology
J. A. Dodd, Jr., DEP, Camden .... MSME, Drexel Institute of Technology
R. R. Lorentzen, ETD, Harrison .... BSEE, Newark College of Engineering
E. Rose, ETD, Harrison .... BSEE, Newark College of Engineering
W. Johnson, ETD, Harrison .... BSME, Newark College of Engineering
H. Levine, ETD, Harrison .... MS, Newark College of Engineering
C. Christian, ETD, Harrison .... MS, Newark College of Engineering
D. Mamayek, ETD, Los Angeles .... BSEE, California Polytechnic Institute
Dr. J. Jarem, DEP-AMS, Princeton .... Ph.D., EE, Univ. of Pennsylvania
Dr. S. Spaulding, DEP-AED, Princeton .... Ph.D., Temple University
Dr. K. Fishbeck, DEP-AMS, Princeton .... Ph.D., Univ. of Pennsylvania
Dr. L. E. Matson, DEP-MDS, Moorestown .... Ph.D., Univ. of Pennsylvania

ENGINEERS IN NEW POSTS

In the new DEP Major Defense Systems Division, Moorestown, **D. B. Holmes,** General Manager, announces his staff as follows: **R. H. Baker,** Manager, BMEWS-United Kingdom; **H. W. Collar,** Manager, Systems Engineering; **C. J. Foskett,** Manager, Project Liaison (Bedford, Mass.); **J. J. Guidi,** Manager, Field Operations; **R. M. Harris,** Manager, Program Control & Subcontracting; **D. C. Koentizer,** Manager, Administration; **A. Mason,** Chief Engineer, Engineering Department; **O. L. Patterson,** Manager Advanced Systems Planning; **R. C. Shaffer,** Manager, BMEWS Operations; and **C. F. Thomas,** Manager, Marketing Department.

In DEP Communications and Aerospace, **W. G. Bain,** Vice President and General Manager, has named **R. M. Wilmotte** as Manager, RELAY Satellite Program.

In DEP Staff, **H. G. Munson** has joined the Advanced Military Systems Group, of which **Dr. N. I. Korman** is Director.

In Receiving Tube Operations, Entertainment Tube Products Dept., Electron Tube Division, **J. T. Cimorelli,** Mgr., Engineering, announces his staff as follows: **K. G. Bucklin,** Administrator, New Products Engineering; **R. F. Dunn,** Manager, Receiving Tube Development; **N. S. Freedman,** Manager, Chemical and Physical Laboratory; **E. C. Hughes, Jr.,** Manager, Commercial Engineering; **R. L. Klem,** Manager, Engineering Administration; **G. M. Rose,** Manager, Advanced Development; **W. H. Warren,** Manager, Product Assurance Engineering; **R. A. Wissolik,** Administrator, Special Engineering Assignments. Mr. Dunn's staff includes: **M. Bondy,** Manager, Receiving Tube Design, New Products; **W. A. Bruce,** Manager, Receiving Tube Test Engineering; **L. J. Caprarola,** Manager, Methods and Process Laboratory; **E. M. Troy,** Manager, Receiving Tube Design, Current Products; **G. Wolfe,** Manager, Engineering Standards.

In Princeton, **Dr. James Hillier,** Vice President, RCA Laboratories, announces the organization of the Laboratories as follows: **H. W. Leverenz,** Associate Director, RCA Laboratories; **A. A. Barco,** Director, Systems Research Laboratory; **A. N. Curtiss,** Manager, Administration; **J. S. Donal, Jr.,** Administrator, Special Programs; **R. S. Holmes,** Director, Project Pangloss; **J. A. McFadden, Jr.,** Administrator, Special Studies; **H. F. Olson,** Director, Acoustical and Electromechanical Research Laboratory; **C. E. Yates,** Counsel; **W. M. Webster,** Director, Electronic Research Laboratory; and **D. F. Schmit,** Senior RCA Representative, C-Stellarator Associates. Mr. Schmit serves part-time in the latter capacity; in his regular capacity of Vice President, Product Engineering, RCA Staff, he reports to **Dr. G. H. Brown,** Vice President, Engineering.

In the Electron Tube Division Microwave Tube Operations, **C. C. Simeral, Jr.,** Manager, Microwave Tube Operations, announces his staff to include: **W. E. Breen,** Mgr., Microwave Manufacturing; **H. L. Eberly,** Mgr., Special Products Manufacturing and Methods Development; **W. G. Hartzell,** Mgr., Microwave Operations Planning and Controls; and **H. K. Jenny,** Mgr., Microwave Engineering. Mr. Jenny's staff is: **P. R. Wakefield,** Mgr. Project Relay and Research and Development Liaison; **F. E. Vaccaro,** Mgr., Microwave Applied Research; and **M. Nowogrodzki,** Mgr., Product and Equipment Engineering. Under Mr. Nowogrodski are: **A. J. Biancculli,** Mgr., Microwave Equipment Design and Tube Development Lab; **E. J. Homer,** Mgr., Microwave Engineering Administration and Data Systems Development; **R. G. Talpey,** Mgr., Microwave Application and Test; and **H. J. Wolkstein,** Mgr., Microwave Design and Development. Mr. Biancculli has named **V. T. Valva** as Mgr., Microwave Development Lab. Mr. Talpey has announced **C. L. Cuccia** as Mgr., West Coast Microwave Engineering Lab.

A. L. HAMMERSCHMIDT NAMED CHIEF ENGINEER OF MOORESTOWN M & SR

A. L. Hammerschmidt has been named Chief Engineer, Engineering Department, of the DEP Moorestown Missile and Surface Radar Division, as announced by **S. N. Lev,** Vice President and General Manager. Mr. Hammerschmidt, who was formerly Vice President of Engineering and Facilities Administration of NBC, will be responsible for engineering development and design, and will establish all of the Division's engineering policies.

Mr. Hammerschmidt began his career with Station *WBNS*, Columbus, while earning his BSEE from Ohio State University. In 1941, Mr. Hammerschmidt joined NBC in New York as a television engineer. He held several positions of increasing importance until March 1952, when he was named Assistant Director, Color TV Systems Development.

In 1954, he was named Associate Director Technical Operations, NBC, and in 1955 was promoted to Vice President and Chief Engineer. In this position and in his most recent NBC post as Vice President, Engineering and Facilities Administration, he was responsible for the design, development, and installation of all NBC technical facilities as well as architectural design, construction and operation of NBC's physical plants, and for NBC's real estate activities.

SIDEBOTTOM NAMED DIVISION VICE PRESIDENT, DEFENSE MARKETING

A. L. Malcarney, Executive Vice President, DEP has announced the appointment of **J. H. Sidebottom** as Division Vice President, Defense Marketing. An engineering graduate of the University of Virginia, Mr. Sidebottom has had extensive experience in the management, marketing and technical phases of the aviation and allied industries.

In his new position, Mr. Sidebottom will have over-all responsibility for marketing of all RCA defense electronic products. He succeeds **Fred M. Farwell** who had been serving on a temporary assignment from his post on the corporate staff as Vice President, Marketing. Mr. Farwell continues in his corporate position, reporting to **C. R. Denny,** Vice President, Product Planning and Marketing. Mr. Sidebottom formerly was Administrator, DEP Marketing Staff.

A. N. CURTISS NAMED TO NEW POST IN RCA LABORATORIES

A. N. Curtiss will head the administrative and business activities of the RCA Laboratories in the newly-created position of Manager, Administration, RCA Laboratories, as announced by **Dr. James Hillier,** Vice President, RCA Laboratories.

Mr. Curtiss, who has been General Manager of the West Coast Missile and Surface Radar Division, DEP, will have his office at the Laboratories, Princeton, N.J.

Mr. Curtiss, an electrical engineering graduate of the University of Pittsburgh, joined RCA in 1930 and was engaged in engineering activities at Camden, N.J., and Indianapolis, Indiana, until his appointment in 1950 as Plant Manager of the newly-acquired RCA manufacturing facility at Los Angeles, California. In 1956, the Los Angeles facility was established as an autonomous operating unit of RCA, and Mr. Curtiss was named Manager of the newly created department. On September 1, 1959, he was appointed General Manager of the DEP West Coast Missile and Surface Radar Division.

SHORE TO HEAD SAINT FEASIBILITY PROGRAM

David Shore has been appointed to head a group responsible for the development, construction, and testing of the Air-Force SAINT space vehicle (for rendezvous and inspection of satellites). The group will be centered at the DEP Aerospace Communications and Controls Div. facility in Burlington, Mass. Mr. Shore, formerly Associate Director of DEP Advanced Military Systems, will be Program Manager for RCA's role in project SAINT.

The contract for the initial portion of SAINT is in excess of $30 million, and covers feasibility demonstration of the concept and hardware. The RCA SAINT group under Mr. Shore will report directly to **Walter G. Bain,** Vice President and General Manager, DEP Communications and Aerospace.

His group will manage the efforts of all participating DEP Divisions as well as the many subcontractors who will take part in the long-range program.

WALTER CITED FOR STUDY HONORS

J. C. Walter, Manager, High Power Radar Engineering, IEP, was recently cited by Lt. General G. W. Mundy, USAF, Commandant of the Industrial College of the Armed Forces, for having completed the college's course *The Economics of National Security* with honors. The course is designed for selected senior officers. Mr. Walter is a Captain in the U.S. Navy Reserve. His professional career has covered 35 years in high-power radio-communications design engineering, particularly in the vlf field, 25 of those years with RCA in engineering and management positions.

REGISTERED PROFESSIONAL ENGINEERS

L. P. Dymock, Tube Div.	Prof. Eng. 7417E, Pa.
G. A. Hamilton, Tube Div.	Prof. Eng. 7435E, Pa.
G. B. Bumiller, DEP	Prof. Eng. 37788, N.Y.
J. F. Petri, DEP-MDS	Prof. Eng. A-10431, N.J.
C. H. Wright, IEP	Prof. Eng. 11877, N.J.
R. Bergay, DEP	Prof. Eng. 11805, N.J.

PROFESSIONAL ACTIVITIES

DEP Applied Research, Camden: **M. S. Corrington** gave a series of lectures on the *Properties and Applications of Hilbert Transforms* at the Special Summer Session on Communication Theory and Information Handling at the University of Pennsylvania on June 20 and 21, 1961. **Dr. James Vollmer** spoke on *Plasma Physics* to members of the Mathematics Department at Villanova University on May 17, 1961 as an invited speaker in their program to keep abreast of work in industry. **A. Boornard** is acting Chairman of the Haddonfield High School Science Seminar for the 1961-62 session. **Merle G. Pietz,** attended the 7th Annual Meeting of the Technical Writing Institute held at Rensselaer Polytechnic Institute from June 12-16, 1961.—*W. Whittier*

IEP, Camden: **G. G. Zappasodi,** Manager of IEP Packing Design, was recently elected Vice President of the Philadelphia Chapter, Society of Packaging and Handling Engineers. He has also been appointed as a Judge in that Society's seventh Annual Packaging and Handling Show to be held on Nov. 13-14, 1961 at Baltimore, Md. **W. Lyons,** Manager of Station Facilities, Equipment and Systems, RCA Communications, Inc., was recently elected *Fellow* of the Radio Club of America.—*S. F. Dierk*

DEP-ACC, Camden: **D. B. Dobson** is Secretary of the AIEE "Checkout Systems Working Group, Support Systems Integration Subcommitte." Also, Mr. Dobson has been invited to serve as guest editor for a special issue of the IRE-PGMIL Transactions on *Automatic Test Techniques,* tentatively to appear in July 1962.

Tube Division, Harrison: **Eleanor McElwee** is serving on the Financing Committee for the National Symposium on Engineering Writing and Speech, IRE-PGEWS, to be held Oct. 16-17, 1961 in East Lansing, Mich. Miss McElwee is also Secretary Treasurer of the National PGEWS.

RCA Laboratories, Princeton: **Chet Sall** is serving on the Program Committee for the National Symposium on Engineering Writing and Speech, IRE-PGEWS, to be held Oct. 16-17 in East Lansing, Mich.

DEP-Moorestown: **R. J. D'Ortenzio** of the Moorestown Development and Design Engineering organization spoke to high school seniors at Central High School, Philadelphia. Mr. D'Ortenzio joined several engineers from other companies in the area in counseling the students and answering questions about engineering colleges.—*T. G. Greene*

DEP-AED, Princeton: **R. Callais** is Topic Chairman for *Space Photography and Image Sensing* at the 90th SMPTE Convention, to be held Oct. 2-6, 1961 at the Lake Placid Club, Essex County, N.Y.

Tube Division, Lancaster: **R. H. Zachariason** delivered an address on June 20 to 76 of the outstanding high school juniors from a six county area of Eastern Pennsylvania at a career planning camp at Camp Carlson, Pa. sponsored by the Rotary Club. Mr. Zachariason spoke on careers in engineering and science. He is manager of the Lancaster C&P Laboratory.—*J. D. Ashworth*

Record Division, Indianapolis: **R. C. Mayer,** Manager, Electrical Design Section and **Carl Martin,** Engineer in Compound Development Section of Record Engineering, Indpls. presented a program "Stereo and Hi-fi and Miracle Surface Records" before Public School teachers gathered for Business and Education Day. **Yin (David) H. Wang** completed a special summer program in Probabilistic Methods in the Control of Operations June 30 at MIT. **August Skele** attended the *Operations Research* Seminar at Purdue Univ. 16th June. **Robert C. Jones** attended the Industrial Engineering Seminar at the University of Michigan in June 1961.—*M. L. Whitehurst*

HARRISON ENGINEERING LECTURE FEATURES EUROPE REPORT

D. Y. Smith, Vice President and General Manager, RCA Electron Tube Division, and **J. T. Cimorelli,** Manager, Engineering, Receiving Tube Operations, presented the fourth in the 1961 series of lectures of general interest to 300 engineers on June 29, 1961. The lecture was entitled, *European Trip Report* and reviewed the status of research and development in Europe, with particular emphasis on the laboratories, plants and distributors visited by them in Italy, Switzerland, France, the Netherlands, and England. This lecture was sponsored by the Harrison Engineering Education Commitee.—*T. M. Cunningham*

COMPUTER LECTURE SERIES AT HARRISON

A near-record number of over 250 engineers recently attended a lecture on *What Does the Computer Mean to the Engineer* at Harrison. **John Gates** of ETD Data Systems and Services introduced the subject. He was followed by **Dr. O. H. Schade, Sr.,** and **Karl Angel** of Receiving Tube Engineering, and **Robert Conroy** of Harrison Receiving Tube Plant Quality Control.

This lecture was one of a general lecture series sponsored and arranged annually by the Harrison Engineering Education Committee. The Committee is planning guided tours and a course in programming for Harrison engineers to acquaint them with the potential of computers in the engineers' fields of interest.—*J. F. Hirlinger*

TUBE DIVISION 501 IN OPERATION

An RCA 501 has been put into operation by the RCA Electron Tube Division in Harrison and is making decisions on the quality assurance of approximately 300 different types of receiving tubes which, if handled by punch-card equipment, would have involved over two million cards. The system will also be used for production and inventory control, order handling, billing, receivables accounting, sales and cost analysis, and market forecasting. (*Ed. Note:* See article by Halstead, p. 20, Vol. 6, No. 4, RCA ENGINEER).

DEP PLASMA JET LAB IN OPERATION

DEP Applied Research has a plasma arc jet laboratory in operation. The jet which delivers 80 kw of plasma power continuously at temperatures as high as 27,000°F, is being used by **Dr. J. Wollmer, A. Boornard** and **R. Colby** to study electrical conductivity of plasma as a function of frequency. Conductivity enhancement techniques, solar simulation, and electromagnetic propagation in plasmas will also be investigated.—*W. Whittier*

... AN EDITORIAL ...

ENGINEERS SOUGHT FOR IMPORTANT HIGH-SCHOOL SCIENCE SEMINARS

A vitally important activity for engineers is that of broadening the interests of high-school students in science and engineering. Perhaps it should be termed a *professional responsibility*—for none are better qualified to inspire American youth to engineering and research careers than the men now in those careers.

Our engineering-college enrollment continues to drop off, while Russia's continues to gain. Grass-roots guidance to our high-school students is one solution—essential and effective to assure our future technological superiority and leadership.

One such program is the Haddonfield High School Science Seminar, of which **A. Boornard** of DEP Applied Research is Chairman for the 1961-62 season. RCA personnel have been instrumental in this program since its inception, serving as staff members, guest speakers, and project advisors. (See R. J. Hall, *A Breakthrough in Science Education*, RCA ENGINEER, p. 36, June-July, 1959.) *Those interested in presenting technical talks or otherwise participating are urged to contact Mr. Boornard in DEP, Camden, on PC-6609.*

In addition to the above program, a number of other RCA engineering groups have contacts with such groups (see *Professional Activities* column, opposite page, for examples). A couple of queries and a small amount of your spare time can help reverse a dangerous statistic. *You,* not the other fellow, are essential to such programs. So ask, *what can I do?* As a professional man, the engineer's answer must be . . . *volunteer a lecture to an existing group like the above, and check your local high-school*—you may find that a productive partnership of educator and engineer may be easily begun, if it doesn't yet exist. The benefits are obvious.

—*E. R. Jennings, Ass't Editor*

EDP SEMINARS FOR LEADERS

The EDP Division recently started a series of seminars for new EDP Engineering Leaders in which lectures will be presented on management techniques, budgets, cost estimating, engineering writing and patents, lines of communication, and EDP goals. A dinner on or about August 7, 1961, will conclude the series.—*S. F. Dierk*

RCA TV TUBE WINS "EMMY" AWARD

The National Academy of Television Arts and Sciences has honored RCA for its development of a new TV camera tube.

At ceremonies in New York's Ziegfield Theatre, *Emmy* awards were presented to RCA and the Marconi English Electric Valve Companies of Great Britain "for independent development of the 4½-inch image-orthicon and cameras." The awards were made for the Academy's *Outstanding Technical Achievement* category.

C. E. Burnett, Division Vice President, Industrial Tube Products, accepted the *Emmy* on behalf of the engineers who designed the tube at the Lancaster plant, a team headed by **F. S. Veith,** Manager, Camera Oscillograph and Storage Tube Engineering, which included: **R. G. Neuhauser, P. W. Kaseman, A. A. Rotow, H. M. Hambleton, R. E. Johnson, O. H. Schade, Sr., H. C. Werner** and **R. F. Kankus.**

NBC INSTALLS NEW TV CONVERSION EQUIPMENT

NBC is installing an RCA-built E.M.I. standards converter, the first of this type installed in the United States. The unit will enable the network to convert TV signals of all European standards to the American standards. This unit will be ready for operation by early fall.

Also, NBC is converting Studio 6A to a monochrome or color television studio which will feature the RCA transistor video switcher and all-transistor audio equipment. The studio will be ready for operation this fall.—*W. A. Howard*

WOLKSTEIN NAMED MANAGER

Herb Wolkstein, who has been (and still is) an especially creative and active RCA ENGINEER Editorial Representative, has been named Manager of Microwave Design and Development in Microwave Tube Operations, Electron Tube Division, Harrison, N.J. Herb will head a large group of design engineers and engineering leaders in developing new microwave products and improving existing ones.

Herb joined RCA in 1955, and in 1958 became Engineering Leader in charge of low-noise traveling-wave-tube development. He has made outstanding contributions to the design of slow-wave structures and periodic magnets for focusing electron beams. He holds a number of patents, and has written many papers on traveling wave tubes for the RCA ENGINEER, *RCA Review*, and a number of other journals.

In addition to his own writing, Herb has regularly done an outstanding job of soliciting and coordinating excellent technical papers from the Tube Division's Industrial Tube Products activity for the RCA ENGINEER.—*The Editors*

VOLKMANN TRANSFERS TO LABS

John E. Volkmann, an active RCA ENGINEER Editorial Representative for IEP's Audio Products Engineering group for almost six years, has transferred to the RCA Laboratories Staff, where he will continue acoustical consulting work for the Audio and Visual Products group, the Record Division, and other RCA divisions concerned with audio problems. He will carry on research and development work in the field of room, studio and auditorium acoustics in the Acoustical and Electromechanical Research Laboratory directed by **Dr. H. F. Olson.**

John's distinguished RCA career has spanned 33 years in the audio and acoustics field. Of no small importance has been his steady, active interests and advice in RCA ENGINEER matters, and his ability as an author (*Acoustical Consulting Service at RCA*, p. 38, Feb.-Mar., 1960).—*The Editors*

ERRATA . . .

Vol. 7, No. 1, Lane and Palmer, "Automated Design," on p. 39, third paragraph under "Conclusions," second sentence should read:

Optimization of design, over-all logic design of systems, placement of modules for more effective packaging, and optimum inter*connection networks appear to be achievable. Logic simulation to permit exhaustive testing of designs during the* early development stages also seems possible, [*etc.*]

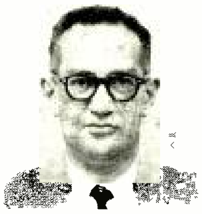
(Italicised matter appears erroneously transposed at bottom of center column on p. 39 and should be deleted there.) Also, the first two lines in column 1 of p. 38 should be interchanged.—*The Editors*

DEP ED REPS MEET TO PLAN THIS AND FUTURE ISSUES

It takes legwork to produce RCA ENGINEERS. The 13 pairs of legs above are shown in a typical DEP Editorial Board planning meeting, where ideas for DEP articles and deadlines, are hashed out. Frank Whitmore, DEP Editorial Board Chairman, holds such a meeting bimonthly. Ed Reps (and others) pictured above are: (rear, l. to r.) **Bob Jevon**, ACC, Burlington; **Irmel Brown**, MDS, Moorestown; **R. P. Dunphy**, Central Engineering, Camden; **Dick Crawford**, ACC, Camden; **Dave Dobson**, ACC, Camden; and **Lou Thomas**, AED, Princeton. Seated, l. to r.: **Wes Whittier**, Applied Research, Camden; **Ed Jennings**, Ass't Editor; **Wes Fields**, SurfCom, Camden; **Frank Whitmore**; **Russ Patterson**, SurfCom, Camden; **Bill Hadlock**, Editor; and **J. L. Connors**, ACC, Camden.

C. W. Fields

G. R. Kornfeld



M. P. Rosenthal

J. F. Gibbings

KORNFELD NAMED ED REP FOR NEEDHAM, FIELDS FOR SURFCOM; GIBBINGS, ROSENTHAL, RILEY ASS'T SURFCOM ED REPS

At the Needham Materials Operation, Semiconductor and Materials Division, Needham, Mass., **G. R. Kornfeld** has replaced **E. I. Small** as Editorial Representative.

In DEP, **C. W. Fields** has assumed a new Ed Rep post in SurfCom, to serve along with **R. E. Patterson.** They have named Assistant Ed Reps for outlying SurfCom activities: **M. P. Rosenthal** for the SurfCom Systems Lab. in New York, **J. F. Gibbings** for the SurfCom Systems Lab. in Tucson, Arizona, and **P. J. Riley** for the Cambridge, Ohio, plant.

G. R. Kornfeld graduated from Temple University in 1950 with a BA in English. After working for several months as librarian at the University, he was drafted and was trained by the Army as a radar technician. He joined the RCA Service Company in 1953, and until 1959 worked as writer, editor, and group leader of field technical writing groups. After an assignment preparing instruction books for the C-Stellarator, he was transferred to the Bedford Communications Projects Office (Massachusetts) to write evaluation reports on Time Division Data Link systems. In 1960 he joined SCM at Needham, where he is presently in charge of Engineering Systems and Procedures. In spring, 1961, he taught technical report writing at the Cambridge Center for Adult Education.

C. W. Fields graduated from Temple University with a BS in Journalism in 1955; he has since completed additional courses in electronics and technical writing. He joined DEP-SurfCom Engineering with responsibility for the technical publications generated by a large group of engineers, including proposals, reports, and handbooks. He has also written and edited articles for RCA magazines. His present position is Engineering Editor in the SurfCom Engineering Data Control section. He coordinates the review and submittal of all SurfCom papers, trade magazine articles, and press releases, and performs writing and editing tasks on a variety of technical publications.

J. F. Gibbings, Leader, System Projects, DEP-SurfCom, Tucson, Arizona, was educated in Electrical Engineering at Rugby and Oxford, England, 1939-44. He also received his B.S. in Industrial Management from the University of Arizona in 1949; and did graduate work at the University of Arizona in 1949-50. In 1950-51, he was with the Color Lighting Corp, and joined NBC in 1951 as an Engineer in the Technical Operations Dept. He then joined SurfCom Laboratory, Tucson, Arizona. His responsibilities include supervising test planning, test operations, and supervising all technical publications and presentations. He did original design for the Pictorial Instructional Device (PID) Development of PID programs, supervision of preparation of script, visual aids, sound tracks. He is a Member of the IRE, Armed Forces Communications and Electronics Association, and the SMPTE.

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