# Interlocking elements

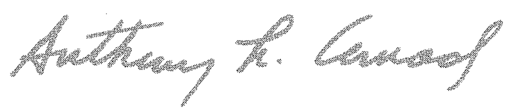
In today's business environment, success for a company like ours is the result of the interlocking of all the elements of the enterprise — from research through engineering and production to marketing.

It used to be that each part of a business would consider and attend to its own segment of the operation in relative isolation from the rest. Sometimes this worked, sometimes not. Today, the high risks and costs of failure are such that this approach becomes prohibitive. Every part of the business must mesh with the rest.

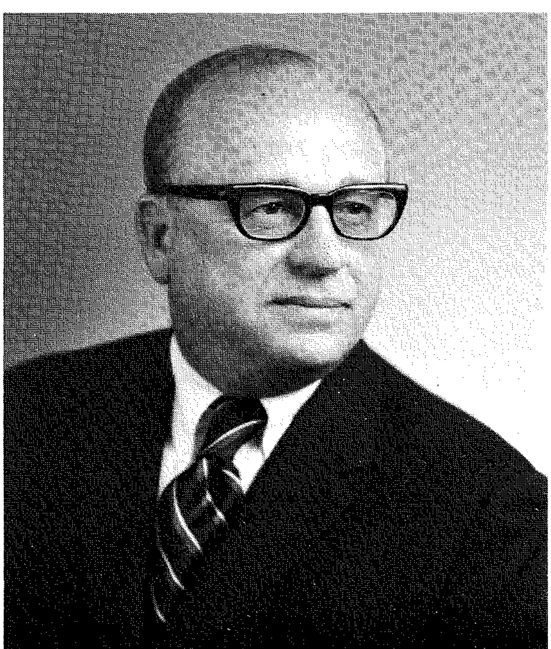
Research must be clearly aware of the markets at which the company aims. Engineering must proceed from realistic concepts of competitive costs, consumer needs, and quality demands. Marketing must be the radar — scanning the horizon of the future and relaying its findings back to the scientists and engineers. We must operate as an integrated system, with built-in feedback involving all elements of the company.

I believe in this principle very strongly. I look to it to be the basis on which we conduct all our operations, and I am encouraged to see the way it is taking hold. The recent Corporate Engineering Management Conference is one example. The attention that *RCA Engineer* is giving to the theme in this current issue is another. The response I have received from all levels of the company is a third.

But success in achieving this goal will not come through words alone. It must spring from a conscious will to make it work, demonstrated in the day-to-day activities and relationships through which the future of RCA is hammered out. I am confident this is happening, and I commend both the Conference and *RCA Engineer* for furthering that purpose.



**Anthony L. Conrad**
President and Chief Operating Officer
RCA Corporation
New York, N.Y.

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**Our cover**

... catches several scenes at the Corporate Engineering Management Conference in May of this year. The Conference — devoted to the theme of interdisciplinary planning — is covered in depth in this issue, with contributions from more than twenty key individuals in engineering and related staff activities throughout the Corporation (see pp. 58-89).

**Photo credit:** Bruce Hull, Electronic Components, Clark, N.J., **Cover concept and design:** Joan Dunn.

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Aug| Sept
1973

# RCA Engineer

A technical journal published by
RCA Research and Engineering
Cherry Hill, N.J.

• 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 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.

*RCA Engineer* articles are indexed annually in the April-May Issue and in the *Index to RCA Technical Papers*.

## Contents

### Theme — Corporate Engineering Conference

# Role of the Laboratories

**Anthony L. Conrad**

**Editor's note:** Because of its relevance to the theme of the management engineering conference papers in this issue...and because of its importance to all engineers and scientists at RCA, Mr. Conrad's recent address (given at an RCA Laboratories colloquium) is printed in its entirety.

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**Anthony L. Conrad**, President and Chief Operating Officer, RCA, New York, N.Y., is the eighth President in the history of RCA. As Chief Operating Officer he directs and supervises the daily operations of the Corporation. In this capacity he is responsible for all divisions and subsidiaries of the Corporation, except the National Broadcasting Company, Inc., which reports to the Chairman of the Board. In addition, Mr. Conrad has responsibility for the RCA Staff International activity and the Manufacturing Services and Materials activity. Previously, Mr. Conrad had been Executive Vice President, Services, since April, 1969. He was elected to the RCA Board of Directors at the company's 1970 annual meeting. He is a member of the Board of Directors of The Hertz Corporation, Random House, Inc., RCA Global Communications, Inc., Banquet Foods Corporation, and Coronet Industries, Inc., all subsidiaries of RCA. Mr. Conrad also is a member of the Board of Directors of Atlas Chemical Industries, Inc. and Chesebrough-Pond's Inc. Mr. Conrad served as President of the RCA Service Company for eight years prior to his appointment as Vice President, Education Systems, on Corporate Staff, in August 1968. He joined the RCA Service Company in 1946 following his discharge from the U.S. Army Signal Corps. He then held various managerial and engineering assignments with that RCA subsidiary. Mr. Conrad was named Manager, Missile Test Project, at Cape Kennedy, Florida, in 1953, and was responsible for establishment of the large RCA missile and space vehicle tracking operations there. He received the RCA Victor Award of Merit for his work in this field. He was elected a Vice President of the Service Company in 1956 and its President on January 1, 1960. Mr. Conrad was graduated from Lafayette College in 1943, with a BA in Physics, and was commissioned a Second Lieutenant in the U.S. Army Signal Corps shortly thereafter. During his military career, he was Commanding Officer, 220th Signal Radar Maintenance Unit and also served in various Signal Schools. Mr. Conrad is a Trustee of Lafayette College and is past President of its Alumni Association.

I want to talk to you about how the Laboratories plug into RCA. Few things are more important to the company, to you, and to me. Without your input, the bulk of our product and service activities would slow down and eventually cease to move.

Bob Sarnoff feels as strongly about this as I do. He stated it at our Annual Shareholders meeting last month when he pointed to our history of technological innovation and growth. He emphasized the company's determination to keep breaking new ground.

I made the same point two weeks later in a talk to our consumer product distributors. Technology is the theme of a new advertising campaign we are launching shortly. In brief, you and your technical colleagues in the divisions hold the keys to our future.

## Technology and business management

At this point, some of you may be wondering what a company so strong on technology is doing in frozen foods, home furnishings, rented cars; and why has RCA rid itself of some products — like general purpose computers and electron microscopes — that were successful technologically? Have we gone into the business of buying and selling businesses?

Although I assume you know the answers, a few explanatory points are in order. Every part of a company like ours is helped or hamstrung by the performance of the rest. Those that prosper add strength to all. If any fall behind, all the others feel the drain.

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It will interest you to know that in the years since we acquired them, Hertz, Coronet, and Banquet Foods have accounted for increasingly significant percentages of RCA's revenues. The profit percentages have run even higher.

You don't have to be an economist to appreciate what this means to over-all corporate strength. You've been among the beneficiaries.

Now take the reverse side. Sometimes we've had to abandon activities in spite of their technological success. For example, we made very good general purpose computers — as you probably know better than anyone.

Yet in the final year of our computer operation, we would have taken a loss of many millions. This would have slowed or stopped us in SelectaVision. It would have kept us from new explorations in solid state, information systems, business communications. In other words, it would have been a drag on every forward effort.

RCA is in approximately 40 businesses. We produce thousands of products. Unfortunately, not all of our businesses and products will be equally successful. Good business management is knowing when to stop as well as when to start.

But I can assure you that we are not in the business of buying and selling businesses. We are one of the world's largest electronics companies. This is more than 70% of our business. We intend to continue achieving growth through new products and services based on research and development in electronics.

## Understanding the market

We can do this only through a strong and highly motivated Laboratories operation. And as Bob Sarnoff and I understand it — and Jim Hillier, Bill Webster, and most of you — an effective Laboratories operation involves a lot more than the delivery of a demonstration model.

It calls for an understanding of the market our research is designed to serve; the needs it is supposed to fulfill; the factors that will make the results acceptable in cost and performance.

To meet these standards, the research operation has to relate its efforts to the goals of the Corporation. It has to recognize that creativity can be found in a market study as well as in a mathematical model.

I once heard Bill Webster talk about the importance of Laboratory contacts with RCA's marketing activities. He said that by spending as little as 10% of your efforts on using these nontechnical inputs effectively, the Laboratories could double their value to RCA.

You've already proven your worth as a top-flight corporate research organization geared to these realities. What I am asking now is that you accelerate and extend your efforts — that you expand the pattern of cooperation, joint studies and task forces with the divisions and with Corporate Marketing.

## Shortening the time cycle

One of the problems we face is shortening the time cycle from the laboratory to the marketplace. I know that pressuring research excessively can often produce the same results as rushing good wine. You get vinegar. Yet I remember well what the Laboratories accomplished when we had to come up with a compatible color system in a hurry.

Shortening the cycle is everybody's job. You know the combination. We would not have come out with COS/MOS for another two years if it hadn't been for the cooperation between the Laboratories and Somerville in solving production problems. We might still be having problems with circuit board production for the new television line if a Laboratories team hadn't shown Indianapolis a better way to copperplate.

You work with every divison. You see things more clearly sometimes than the people on the line. One of the ways you can speed things up is to find out what is slowing them down and then holler.

## Cost and reliability

I'm just as concerned about cost and reliability. We can develop the most ingenious circuitry in the world but it doesn't count if the wafers sell for $40 when they should sell for $5. Even though this looks like an engineering and production problem, it calls increasingly for more basic scientific understanding.

I'm also looking to the day when we will not need a serviceman to install a tv set. I see no reason why it can't work as it comes out of the box and no longer need a one-year warranty because of its inherent reliability.

## Corporate plans

Our corporate planners project a doubling of RCA's revenues over the next ten years or sooner — from $4 billion to $8 billion. This means as much growth in the next ten years as we achieved in our first fifty. The bulk of this will come from our electronics businesses, and most will be generated by products and services RCA does not have today. Obviously we look to the Laboratories to provide the means.

As you know, we've charted certain broad areas where we think the combination of RCA competence and market opportunity offers the brightest prospects.

### SelectaVision

Obviously a major growth opportunity is the entire Consumer Electronics market, sprearheaded at present by our SelectaVision effort. Ultimately, this business can rival color in its importance to RCA. I consider the work you have done on the video disc one of the outstanding achievements of the past ten years. There is still a way to go before it reaches the marketplace, and I ask you to bend every effort to see it through.

### Low-cost color camera

For home video recording, it is important that we move as quickly as possible with the low-cost color camera. We are in a good developmental position but we are not ahead of the pack. The market will be considerable — and for a lot more than just SelectaVision.

### Television

Television itself seems at the moment to be on a technological plateau. In the short run, its growth depends on what we can add to it. To strengthen our market position, we need innovative leadership in such areas as filter phosphors, automatic time control, all-electronic tuning.

These are improvements. Beyond that, we're looking for a completely new concept that will revolutionize the technology and create an entirely new market. We believe that one good answer can be the flat panel display screen, if it can be made practical.

I know you're moving forward and I also know the magnitude of the challenge. I'm sure you recognize its importance to the company Other laboratories are working on the same project, using other approaches. If we don't win, it would be a major defeat for the company that pioneered the medium. We don't intend to let this happen.

#### Consumer information centers

The whole consumer information field is wide open. There's need for a broad range of new products and devices centering on the television screen. For example, we look to an intensified effort by the Laboratories to develop a low cost microcomputer for home use; for techniques to multiplex single images over one television channel to many different subscribers; and for advanced communications, command and control devices to give the cable subscriber a wider choice of services. In the immediate future, it is important that we put a greater effort into CATV developmental work to help influence its growth and direction.

#### Solid-state products

Our record in solid state underscores the progress we can make when the Laboratories and operating divisions join forces. We were behind in the semiconductor business a few years back, COS/MOS came out of the Labs and turned the situation around to the point where we are the largest supplier of the market for this item. Now we are moving ahead with silicon on sapphire, offering higher speeds at lower power.

These are five keys to our growth in solid-state circuitry — cost, speed, size, complexity, and reliability. The contributions you can make here are almost limitless.

We're greatly interested in the work you're doing with West Palm Beach and Somerville on microprocessors — for example, the seat-belt computer. Once we get this item down to an acceptable cost, it has great market potential. We also hope to see you working even more intensively with the Broadcast division in developing digitalized television equipment.

#### Global communications

We're making a major corporate investment in Globcom and the entire range of business communications. This year, we're pouring 40% of our capital expenditures into Globcom. Our domestic satellite system alone — launch vehicles, satellites, and Earth stations — will cost about $100 million.

Obviously, major technological contributions will be needed here over the next few years. For example, Globcom will require solid-state microwave transmitters and low-cost sensitive receiver to use with unmanned satellite Earth stations.

We'll need Videovoice equipment with simpler circuitry and higher resolution to rent to telephone users for substantially less than it now costs.

Globcom needs simulations of real-time computer communications networks to avoid costly systems errors, to undertake better planning for the future, and to maximize cost effectiveness.

We're looking for a high speed facsimile device or other printout devices for the international record communications business or as the basis for an electronic mail service. The Globcom list is a lot longer, but this gives you an idea of the need.

## Responsibilities of autonomy

I imagine many of you are wondering whether all this leaves the Labs any freedom to pursue your own lines of inquiry, or even to stop and think things over.

The Laboratories has a long-standing tradition of autonomy. Time and again you have demonstrated the responsibilities that come with autonomy. I can assure you we have no intention of limiting it. Creativity doesn't go with a lock step. Yet I think you will agree that a realistic appraisal of your role as a corporate research organizaion requires something between absolute liberty to follow any research trail and arbitrary restriction to a company shopping list. I think you've achieved a workable balance.

I rank you among the two or three greatest corporate research centers in the world. You may not have as many quantum physicists as IBM, say, or Bell. But I believe that person for person, the people at Princeton are more creative than those at any other laboratory in the country.

We're moving more deeply into applied science and technology. But I can assure you we have not abandoned our commitment to basic research and exploration. We consider it a practical necessity to replenish our sources of knowledge. We feel it almost a moral obligation, especially in the face of diminishing government support for scientific activity.

I see no imcompatibility between basic research and its application to practical use and to profits. Is there anything wrong with developing a product or service that will bring pleasure and utility to others? Or anything shameful about earning a return for the company that makes it?

The accountants tell me we have assets of more than $3 billion, I consider the skills and talents here perhaps the greatest assets we have — because this is where it all starts.

We look to you as we do to no other part of the company for a constant replenishment of concepts, systems, products. The problems you solve, the ideas you produce are not only important for their own sake — they have given RCA the reputation it enjoys all over the world. A company that looks to the future rather than to the past. A company that not only looks to the future, but helps shape it.

We count on you to help guide RCA to its own venturesome and prosperous future. In turn you may be sure that you can count on our full and unstinting support.

# How RCA Distributor Products serves the electronics distribution market: a profile

J. A. Haimes

**The Distributor Sales and Merchandising function for electronic components has existed under various departmental descriptions since early in the history of RCA. In October 1957, however, as part of the Electron Tube Division, this function was designated RCA Distributor Products. It has continued under that name to the present and is now a key activity of RCA Electronic Components. Its headquarters is in Harrison, New Jersey and it has seven field sales offices located in: Hollywood, California; Dallas, Texas; Overland Park, Kansas; Des Plaines, Illinois; Cleveland, Ohio; Atlanta, Georgia; and Edison, New Jersey. It is served by warehouses situated strategically across the country in Los Angeles, Dallas, Des Plaines, Atlanta, Marion, Ohio, and Lancaster and Scranton, Pennsylvania.**

DISTRIBUTOR PRODUCTS is RCA's direct outlet to the two billion dollar electronics distribution market for the products manufactured or sold by RCA Electronic Components. In contrast to other operations of RCA Electronic Components, where primary effort is devoted to moving product directly to original equipment manufacturers (OEM), Distributor Products sells through a nation-wide network of electronic "parts" distributors. These appointed distributors handle replacement receiving tubes, solid-state devices, picture tubes, and test equipment used in the radio and television servicing industry, and also supply moderate-sized requirements for the original equipment market. In addition, they serve the needs of the growing industrial replacement, maintenance, and repair industry and in many cases sell consumer products such as solid-state experimenter kits, blank audio magnetic tape, and batteries.

Distributor Products has the largest assortment of diversified product lines, more customers in more physical locations than any other single part of the

**Joseph A. Haimes** Division Vice President, Distributor Products, RCA Electronic Components, received his B.A. degree in Business Administration and a B.S. degree in Industrial Engineering from Columbia University; he also attended the Middle Management Program of the Harvard Business School. Mr. Haimes joined RCA in Camden, New Jersey, in 1948, and the following year was appointed a renewal salesman with the Electron Tube Division in Harrison, New Jersey. During 1951, he was recalled to active duty in the U.S. Air Force and rejoined RCA in 1953 in an administrative capacity in the renewal sales activity. For the next five years, he served successively as an Administrator for Distributor Promotion, Renewal Promotion, and Equipment Promotion. In 1957, Mr. Haimes was transferred to the RCA Semiconductor Division as Manager, Promotion, and in 1958 he was promoted to Manager, Merchandising-Entertainment Tubes for the Electron Tube Division. He was advanced to Manager, Administration and Controls, in 1959, and became Manager, Market Planning, Receiving Tubes, in 1961. A year later, he became Manager, Distributor Entertainment and Industrial Tube Merchandising. In 1963, Mr. Haimes was appointed Manager, Distributor Sales, and held this position until January 1967 when he was appointed to his present post of Division Vice President, Distributor Products.

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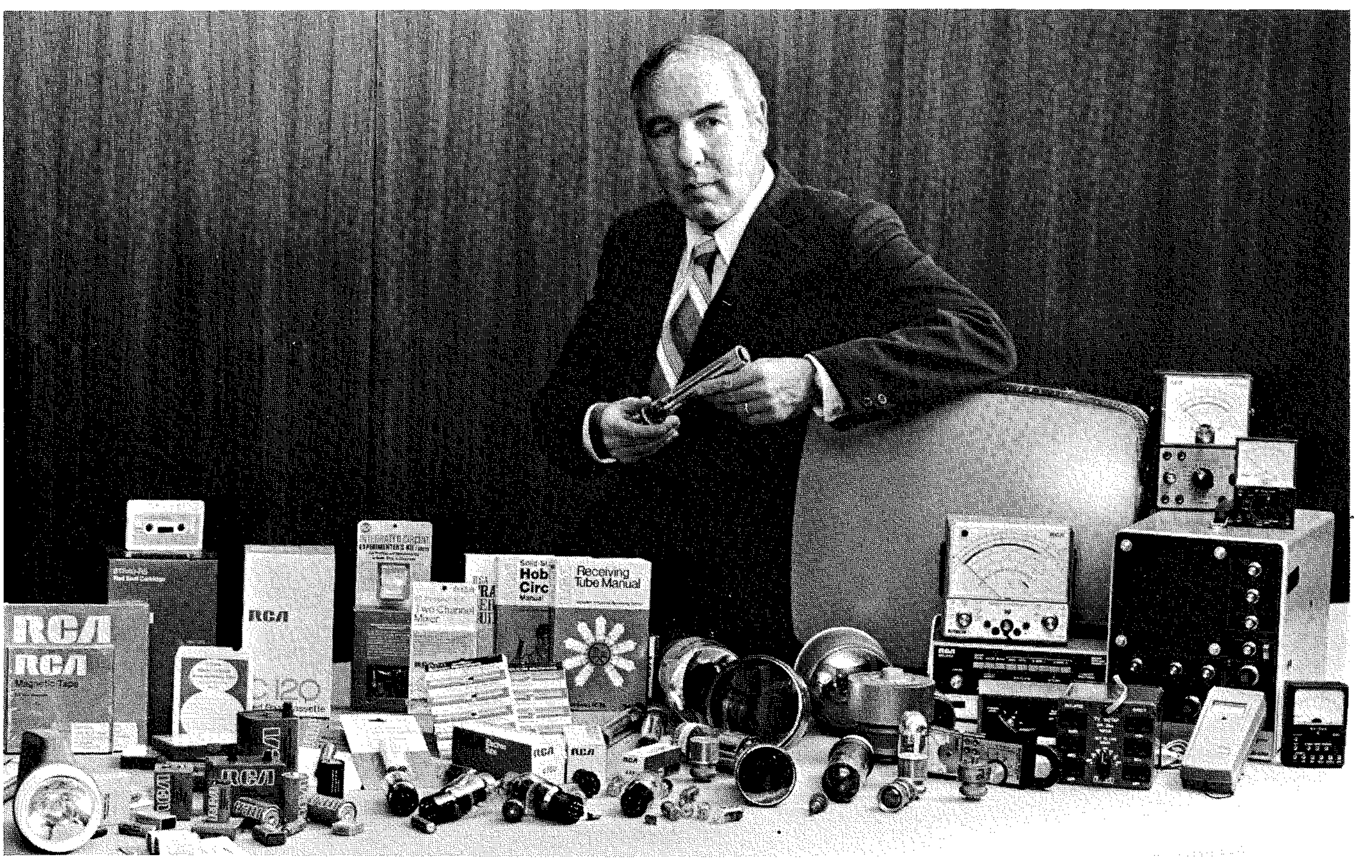
Manuscript received January 17, 1973



Corporation, and it is most probable that it currently ranks as the number one supplier, in terms of dollar sales, to the dynamic electronic parts distribution business.

The electronic distribution market consists of approximately 2400 outlets located in every major trading area of every state in the Union. And today, almost every component manufacturer is looking to this channel for low-cost effective, across-the-board market coverage for its products.

RCA Distributor Products has coverage in about half of the total distributor outlets located in all of the important market areas in the country. Because of RCA's early preeminence in the radio-electronics field, Distributor Products had first entree to the largest, most important, and best established distributors in the business in every state including Hawaii and Alaska.

### Kinds of distributors

There are many different types of distributors. The main classifications are the dealer-service distributors, who sell primarily to the retail trade for replacement purposes, and the industrial distributors, who sell to the broadcast stations and all other users of electronic components whether for maintenance purposes or for incorporation into the manufacture of equipment.

Some distributors also operate outlets selling directly to the consuming public and some sell primarily through mail-order catalogs. A typical distributor may be engaged in one or a combination of two, three, or even all four of these facets of the business.

Another distinction commonly used is "one-step" vs. "two-step" distribution. A one-step distributor sells to a customer who then uses the item himself, while the two-step distributor sells to someone who then resells the product to the end user.

As contrasted with the RCA Consumer Electronics approach, where TV, radio, and stereo equipment basically are marketed through distributors in exclusive territories, Distributor Products goes to market on a multiple distribution basis whereby, in most markets, it has two or more distributors. By the same token, many of these distributors carry a competitive line of tubes or other components in addition to the RCA line. Appointments are made on a product line basis, so that not all distributors necessarily carry all of the RCA product lines.

- Radio & tv service - dealers
- Broadcast stations
- Industrial/commercial firms
- Educational institutions
- Government agencies
- Research laboratories
- Transportation industries
- Hobbyists, amateurs, experimenters
- Mass merchandisers
- Consumers

**Fig. 1 — Electronics distributor — customer categories.**

The dealer-service distributors are engaged primarily in the market which sells to radio-TV service dealers, hobbyists, amateurs, experimenters and consumers and to some extent the mass-merchandisers. The balance of the customers shown in Fig. 1, other than service dealers, are basically sold on a one-step basis by either the industrial or consumer distributor. Products which have a strong consumer appeal, such as RCA blank audio magnetic tape and batteries, are sold not only through radio and television service shops but also by drug stores, department stores, hardware stores, and discount chains.

The industrial distributors perform an important selling function for RCA Distributor Products in another vital area. This group of distributors sells a wide variety of electron tubes and other components to broadcast stations and to other users of electronic components, whether for maintenance purposes or for incorporation in the manufacture of equipment. This segment of business presently accounts for about fifty percent of the electronics distribution market and represents one of the areas of greatest potential growth.

Essentially, the industrial distributor is viewed as an extension of the OEM selling organization pursuing the smaller quantity orders for OEM use in addition to normal replacement requirements. Indeed, the industrial distributors are a vital selling force when you consider that their sales volume is about twenty percent of total component sales to the OEM market. Because of the technical nature of the market they serve, many industrial distributors have a technical sales force which can provide in-depth coverage of their customers' engineers and purchasing agents, particularly those in out-of-the-way areas which Electronic Components' OEM sales force could not reach adequately or efficiently.

### Industrial tube products

The industrial distributors most closely serve the needs of RCA's industrial tube product line. This diversified product line (see Fig. 2) includes a wide variety of industrial electron tube and solid-state electro-optics products. The spread of products goes from tiny solid-state silicon diode lasers to huge, man-sized, power tubes.

The broad line of power tubes, microwave devices, electro-optic devices, and industrial receiving tubes is channeled through the industrial distributor to the original equipment market and to the other markets he serves such as broadcast stations, research laboratories, government agencies, and others.

Even in the face of heavy competition in certain product areas, RCA is the leader in the industrial tube market today. RCA has been in the business over four decades, has a very broad product line, and carries with it an extremely im-

*Electro-Optics*

Silicon Diodes
Injection lasers
Infrared emitting diodes
Laser arrays
Display tubes
Image tubes
Phototubes
Camera tubes
Cathode ray tubes

*Microwave devices*

Traveling-wave tubes
Pencil tubes
Microwave solid-state devices

*Power devices*

Vacuum power tubes
Klystrons
Magnetrons
Ignitrons
Rectifiers
Thyratrons

*Industrial receiving tubes for:*

Mobile communications
Fixed station
Other industrial applications

**Fig. 2 — Industrial Tube products classifications.**

pressive research and development support. With these assets, RCA Distributor Products backs up its industrial distributors with the type of technical expertise which, for both breadth and depth, is not available from any other tube supplier. As a current example of the utilization of these resources, NUMITRON digital display devices and certain solid-state electro-optic diode devices are being used by many equipment designers and manufacturers in small production quantities. Because of this usage, RCA's Distributor Products industrial distributors are performing a valuable selling job by in-depth coverage of this market and by providing samples, technical literature, and even applications assistance supported by RCA-provided working demonstration models.

## Electronic instruments

RCA is the oldest continuous manufacturer of radio and television service test equipment in the United States. Some of its instruments such as the VoltOhmyst [R] and Chanalyst are among the best known trade names in the electronics industry. Today, the line includes over forty test instruments and sixty accessories. See Fig. 3. There are instruments to test components such as diodes, transistors, and color picture tubes, and instruments to check an entire TV system. The electronic instrument activity does its own product planning, engineering, and design. Manufacturing is performed on a select sub-contract basis supported and supervised by an expert RCA quality control staff. In effect, this organization is a highly autonomous one specifically geared to the needs of its own highly specialized, fast-moving market.

To support the warranty on these products, the electronic instrument activity has authorized over 35 independent repair depots located all over the U. S. In addition, Distributor Products field engineers support the distributors' selling efforts by holding several hundred servicing seminars each year at which service technicians are shown the latest servicing techniques and shortcuts utilizing RCA test equipment.

Two new instruments have recently been introduced which are interesting departures from the conventional RCA line. These units are the lightweight sound level meter (Fig. 4) which opens new areas concerned with measuring noise pollution, and a new, insulated, clamp test meter (Fig. 5) for electrical maintenance and appliance servicing.


**Fig. 4 — SOUND LEVEL METER — Portable, uncomplicated, low in price, the WE-130A simplifies measurement of environmental sound levels and monitoring noise pollution. Also handy to check the effectiveness of acoustical material such as sound-insulating tiles, pads, baffles and walls. Meter frequency response "A" weighted to closely respond to human hearing.**

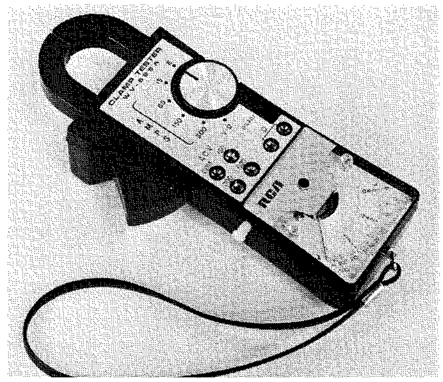



**Fig. 5 — CLAMP TESTER — This unit permits current measurements without direct connection to electrical circuit and is designed for servicing electrical equipment such as motor-operated machinery and appliances. The WV-526A measures AC current to 300 A, AC volts to 500 V, and has two resistance ranges which are fuse-protected. Special "stop-lock" switch "freezes" meter pointer for convenient reading.**

As electronics penetrates deeper into both the entertainment and industrial market areas, more and better test instruments will be needed both for manufacturers and servicing. Opportunities for growth in these areas with new test instruments appear very promising.

## Batteries

For over 25 years, RCA has been an important factor in the radio-electronics replacement market for batteries. The line is marketed through distributors to a wide range of outlets across the country and includes over 160 types—alkaline, carbon-zinc, mercury, and silver-oxide. The batteries are used as power sources for radios, portable TV receivers, tape recorders, toys, lighting, photographic

| | |
|---|---|
| *Meter-Type Instruments* | |
| Volt-ohm-milliammeter | WV-516A |
| Volt-ohm-milliammeter | WV-517A |
| Volt-ohm-milliammeter | WV-518A |
| Volt-ohm-milliammeter | WV-519A |
| Volt-ohm-milliammeter | WV-520A |
| Volt-ohm-milliammeter | WV-38A |
| Volt-ohm-milliammeter 'Service Special' | WV-529A |
| VoltOhmyst | WV-77E |
| Senior VoltOhmyst | WV-98C |
| Solid-State Master VoltOhmyst | WV-510A |
| AC Vacuum-Tube Voltmeter | WV-76A |
| 120-Volt Power-Line Monitor | WV-120A |
| 240-Volt Power-Line Monitor | WV-503A |
| Picoammeter | WV-511A |
| Clamp Tester | WV-526A |
| Sound Level Meter | WE-130A |
| *Oscilloscopes* | |
| Super-Portable 3-Inch Oscilloscope | WO-33A |
| 5-Inch Solid-State Oscilloscope | WO-505A |
| 5-Inch Triggered/Recurrent Sweep Oscilloscope | WO-535A |
| *Signal Generators* | |
| RF Signal Generator | WR-50B |
| Audio Signal Generator | WA-44C |
| Solid-State Audio Signal Generator | WA-504A |
| Stereo FM Signal Simulator | WR-52A |
| Mini Chro-Bar Color Bar Generator | WR-508B |
| Master Chro-Bar Color Bar | |

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|---|---|
| *Signal Generators (cont'd)* | |
| Generator/Signalyst | WR-515A |
| TV Sweep Chanalyst | WR-514A |
| Crystal-Calibrated Marker Generator | WR-99A |
| RF/IF/VF Marker Adder | WR-70A |
| Marker/Signalyst | WR-525A |
| *Tester* | |
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| Color and B&W Picture Tube Tester/Reactivator | WT-509A |
| 3-Meter Picture Tube Tester | WT-334 |
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| Transistor/Diode Checker | WC-506A |
| Resistance-Capacitance Circuit Box | WG-412A |
| *Probes and Accessories* | |

**Fig. 3 — Categories of RCA electronic instruments.**

equipment, hearing aids, and many industrial and special applications.

### Audio recording tape

Audio tape is one of the product areas of largest potential growth in the electronics industry, and RCA Distributor Products covers this market with a comprehensive line of blank audio-magnetic recording tape and accessories. Through its nationwide network of distributors, RCA tape is sold to a wide spectrum of users in the home, in business, and in various municipal applications such as teaching and public safety. The product line includes cassettes, 8-track and reel-to-reel tape, and associated accessories. Latest to join RCA's expanding line are two new tape products: Red Seal cobalt-energized extended-frequency cassettes, and Red Seal low-noise, 8-track cartridge tape, premium lines for the growing hi-fi tape recording market.

### Television picture tubes

The fact that RCA pioneered black-and-white TV, was responsible for all-electronic color TV, and has produced over 20 million color tubes has obviously helped RCA's position as leader in replacement color picture tubes.

Because it is advantageous for RCA picture tubes to be able to replace the tubes in the sets of just about all manufacturers, RCA Distributor Products has the broadest picture tube line in the replacement market. It has nevertheless, one of the shortest lines by-type because of its very broad interchangeability

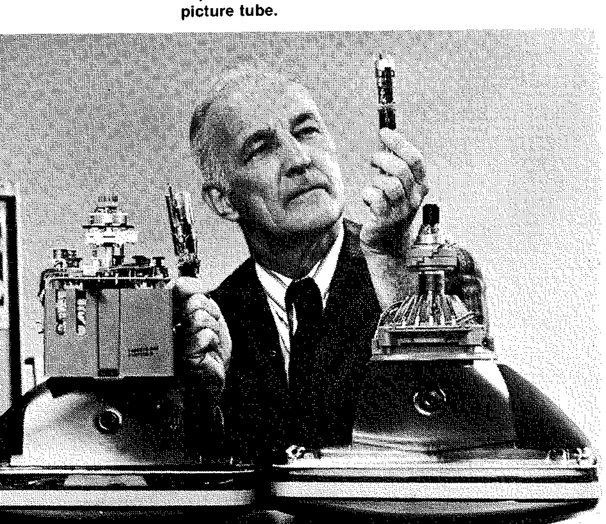


**Fig. 6 — NEW RCA PRECISION IN-LINE COLOR TUBE SYSTEM — Hollis Carter, RCA Engineer at Lancaster, compares the new compact precision in-line gun and simplified picture tube assembly, at right, with a standard delta-gun and color tube with its bulky yoke assembly. The new tube is 1.8" shorter and 2.5 pounds lighter than present 90° tubes and will make installation and setup adjustments comparable to that of a black-and-white picture tube.**

capabilities. With only 168 RCA types of universal replacement picture tubes, the service technician can replace 936 different industry picture tube types.

RCA has been the leader in about every major development in color tubes and today is the only domestic company in color tube production all the way from glass manufacturing, phosphors, masks, and guns to finished tubes. RCA has a strong commitment to continue as the major replacement supplier in the color TV replacement tube business.

Recently, RCA introduced a radically new color picture tube with a precision unitized, in-line triple beam gun structure which is expected to become the industry standard for the next generation of portable-size color TV sets. See Fig. 6. The industry has responded to the new development with a great deal of enthusiasm, and Distributor Products looks forward to considerable sales for these new color picture tube types.

### Receiving tubes

Almost from the inception of the electronics distribution industry, receiving tubes have been the "bread and butter" of the replacement business. And, almost from the start, RCA took the lead and staked its reputation on the quality and ready availability of its tubes. RCA was the leader then and is still the front runner. Over 1,000 entertainment receiving tube types are marketed by RCA in the replacement market, and this number of tubes covers about 98 percent of the industry replacement requirements. It should be stressed that RCA tubes have to be able to operate not only in RCA sets but in all makes and types of equipment including TV receivers, radios, stereos, tape recorders, intercoms, and in a variety of communication receivers and industrial control equipment. Meeting these varied requirements is where RCA design and application engineers play a significant role. There is no question that the reputation for quality and reliability is a significant factor in the size of RCA's replacement business.

It is interesting to note that when transistors were first introduced on the scene twenty-five years ago, it appeared that the days of the receiving tube business were numbered. But the transition to solid state has not taken place as early or as

**Fig. 7 — GUIDE TO INDUSTRY-WIDE SOLID-STATE REPLACEMENT —The SK Series Replacement Guide, SPG-202N, cross references 156 RCA SK solid state devices — rectifiers, diodes, thyristors, transistors and IC's — with more than 51,000 discrete devices and IC's they replace. SK data is provided on EIA Types, foreign types, and types identified only by device manufacturers' or equipment manufacturers' parts numbers.**

completely as predicted. According to Electronic Industry Association figures, the replacement industry sold almost 100 million receiving tubes in 1972 and expects to sell at high volume levels for the next several years. More than 1,200,000,000 receiving tube sockets are in use in various types of TV equipment today, and this potential need for eventual replacement provides RCA with a tremendous challenge and opportunity. To benefit from this opportunity, RCA plans to pay even closer attention to quality, to merchandise imaginatively, to promote vigorously, and to sell hard for a long time to come.

### Solid-state replacement devices

Although the major market for solid-state devices is OEM, it is the electronics distributors who are best equipped to handle the wide-based replacement needs for servicing. As the number of semiconductor applications rapidly expands in home entertainment and industrial equipment, service technicians more and more face the need for replacement solid-state devices. To meet this need, RCA Distributor Products acts as RCA's Solid State Division's arm in marketing a line of solid-state devices, the SK Series, specifically engineered for replacement use. This line is supported with ample technical information, accurate replacement data, and hard-to-get mounting hardware.

The SK Series, which includes a line of rectifiers, diodes, thyristors, transistors, and integrated circuits, replaces USA in-

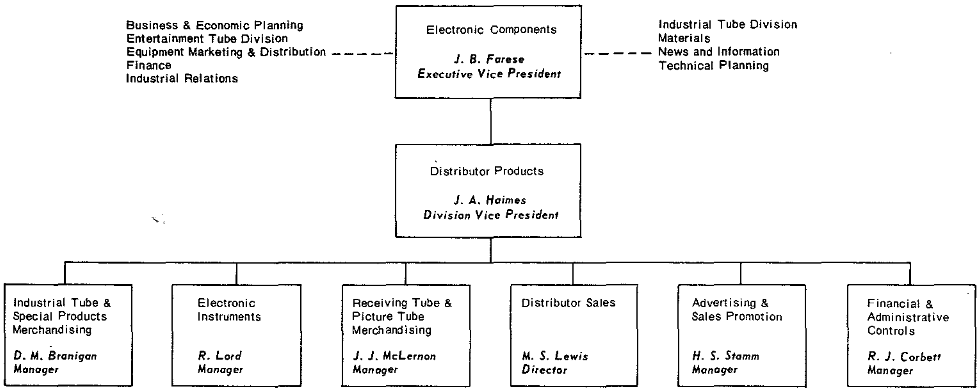



**Fig. 8 — RCA distributor products organization.**

dustry standard EIA types, foreign types, and types identified only by device manufacturers' or equipment manufacturers' parts numbers. The widely distributed RCA SK Replacement Guide in its current edition (Fig. 7) cross references 156 RCA SK series solid-state devices with the more than 51,000 discrete and integrated circuit devices they replace.

Included with this product line are a series of experimenter's kits and integrated circuit project kits. The IC kits are designed to provide an introduction to practical applications of IC's for both experimenters and professionals interested in learning more about these devices.

## Distributor Products sales organization

To maintain a position of leadership in the distributor market, Distributor Products has consistently created complete sales promotion and selling packages for the distributor featuring arrays of merchandising and selling aids and sales literature such as fliers, broadsides, mailing pieces, window streamers, and wall charts of just about every type and description. It has used dealer mailings, radio and TV commercials, national and local magazine advertising, as well as cooperative advertising.

In addition, a great variety of servicing aids has been prepared to help the service dealer and his technicians with information on the products he services or installs. As further aids to the service technicians, RCA Distributor Products has made available a library of technical manuals and audio/visual training aids and has supplemented these with "live" training seminars. The industrial distributor has benefited by a very broad line of catalogs, data booklets, and application information which has enabled him and his customers to gain maximum familiarity with RCA's broad line of products.

Through the years, RCA Distributor Products salesmen have built up a special relationship with the electronic wholesalers they serve. In fact, these RCA sales people look upon the distributor as a business partner and act often as a business consultant selling through the distributor rather than to him. As business consultants, the RCA sales people must have a complete grasp of the markets they serve. They are expected to know the market potential by product line, the trading area potential, and sales objectives. They have to advise on what to stock and in what quantity. They are even called upon to help the distributor on financial matters, organization, marketing, advertising, and especially his sales organization and sales efforts.

RCA Distributor Products salesmen also conduct training programs with the distributor's sales staff. At these programs, they provide product information, coach salesmen, and even delineate the most promising markets. Frequenty, RCA salesmen make sales calls with the distributor's sales force to develop potential customers and help close important sales.

If there are any technical problems, Distributor Products field engineers are called in. These RCA technical representatives make calls on broadcast stations, schools laboratories, and the distributor's OEM and maintenance and repair customers to provide support in the form of information or application assistance and to otherwise assist in the sales of RCA Distributor Products merchandise.

Today more than ever before, distributors welcome ample information and technical help in selling their products. And there is no other single manufacturer or supplier organization in the industry so well equipped, so immersed in the total affairs of the distributors, and so dedicated to help them as the RCA Distributor Products sales organization.

## The future

The future holds great promise for growth in many areas. The servicing business is expanding rapidly, and the replacement parts market on which it depends is keeping pace with it. As electronics applications proliferate in home appliances, in consumer goods, and in the automobile industry, the market for replacement parts will continue to expand and become more challenging in both volume and technical diversity.

And in the industrial distributor market area, too, the expanding product lines presage expanding sales, particularly as distributors continue to provide greater coverage of the OEM market.

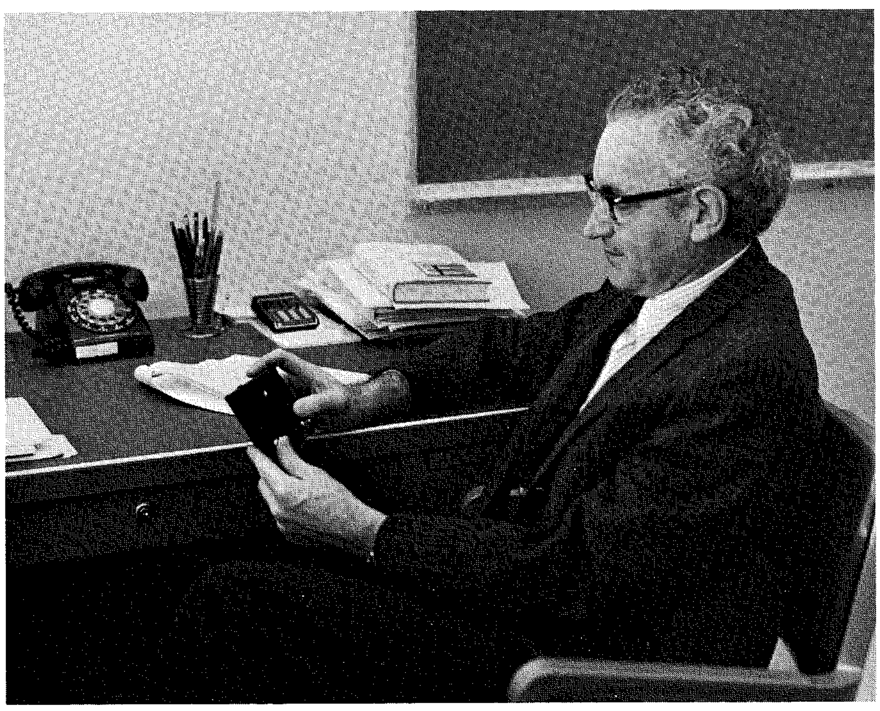
# East meets West in Hungary

**Dr. J. I. Pankove**

**This paper is based on the author's three-week visit to Hungary in August, 1972 under the sponsorship of the scientific exchange program between our National Academy of Sciences and the Hungarian Academy of Sciences. Some general impressions of life in Hungary are followed by a summary of work done at several institutes.**

LET us sit at this table, away from the gypsy orchestra that will start again in a few minutes. We can order a coffee (espresso, of course) or, if you fear its punch, perhaps a cola. It is nearly 11 P.M., but the night is still young; this place won't close for several hours. The people at the next table are just placing their order for a dinner that will take at least a half hour to prepare. Have you tried yet the cold-fruit soup? This is not a compote; it is slightly starchy, with a refreshing fruit flavor, particularly gooseberry or sour cherry. Or, the delicate "fogash," a fish found only in Lake Balaton. Alas, it is threatened with extinction not by pollution (they say it is the purest water in the world; if you can't see beyond a foot, it is due to fine sand stirred up from the bottom), but the recently introduced eel competes successfully with the native fogash in eating up the smaller fish.

**Dr. Jacques I. Pankove,** Semiconductor Device Research Laboratory, RCA Laboratories, Princeton, N.J., received the BSEE in 1944 and the MSEE in 1948, both from the University of California. In 1948 he joined the RCA Laboratories; in 1956, he received a David Sarnoff Fellowship to study at the University of Paris, France, where he obtained a Doctorate in 1960. He has done research on various semiconductor devices, including transistors, photocells, and lasers. He has worked on superconductivity and investigated the optical properties of heavily doped semiconductors. Currently, he is concerned with luminescene in gallium nitride. Dr. Pankove has published over 80 papers and one textbook and has over 50 issued patents. He is a fellow of the IEEE and of the APS, an associate editor of the *Journal of Quantum Electronics* and of *Solid State Electronics*.



I see your eyes following the micro skirt; you probably noticed the other girl with the dark undergarments showing through the white outer clothes. Is Budapest a swinging city? At least, it is a lively one, where everyone expresses his individuality. The cars are from all over Europe; from Renault to Volvo, from the luxurious Mercedes to the plastic Trabant. There appears to be an abundance of everything, and the queues, if any, are very short.

Hungarians express a high degree of national cohesion consolidated by an isolationist language: it has no common roots with the languages of adjacent countries. The people are extremely proud of the famous names they have contributed to the arts and sciences: Bartok, Dennis Gabor (and Zsa-Zsa, too), Kodaly, Von Neuman, Eugene Ormandy, Teller and Wigner, to name a few. In contrast, have you ever met an Englishman deriving pride from Sir Issac Newton?

The present meets the past in Hungary on the 20th of August. This national holiday celebrates the founding of the new Constitution on a day conveniently chosen to coincide with an older national holiday, the birthday of Steven the First, a much revered, good King who made Hungary a nation. This day is also the "Feast of the New Bread," baked with newly harvested wheat. You will find most of the population crowded along the

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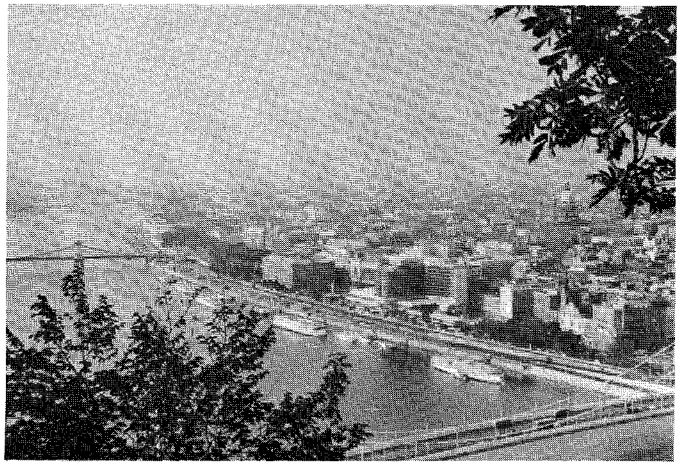
banks of the Danube, watching the air show, a parade of boats and floats and, at night, enjoying the fireworks.

This is the Westernmost part of the Socialist Bloc. It is in Hungary that East meets West. The sophistication and dynamism are characteristically Western. The Eastern characteristics hardly meet the tourist eye: just the lack of non-Communist newspapers. However, the libraries of institutes subscribe to *Time* magazine, and I saw the latest issue of *National Geographic* in one of the homes I visited. Another Eastern characteristic (this one not evident without asking) is the restriction on travel abroad, and even this is not as stringent as in other Socialist countries. One can have a holiday in a Western country every three years (although with an allowance of only $120). Of course, there is no restriction on business trips. In fact, travel by scientists is encouraged to improve knowledge and skills and to establish personal ties.

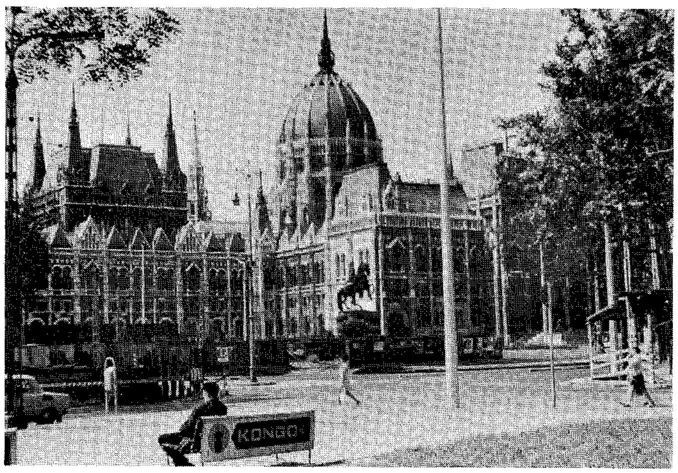
The exodus from Hungary after the 1956 events has seriously hurt the technological development of the country. The depletion of intellectuals at that time manifests itself today by the shortage of executives in the 45-60 year bracket. On the other hand, it is felt that the violent change was needed to save the government from neo-Fascists.

### Standard of living

The standard of living of the majority has greatly improved since the establishment of Socialism. Everyone will admit it, even those who belonged to the privileged class and personally suffered a drop in comfort. There seems to be a housing boom. Large apartment buildings are going up in all of the towns, and the freshly mortared brick of new privately owned homes is evident along all the country roads. Lower-income people can get a low-rent apartment, but higher income people have the option of getting on a waiting list for the renting of an apartment, or they can participate in a cooperative construction, or they can build a private home. A low-interst mortgage can be obtained for 25 to 30 years. The cost of construction is about $11 per square foot. For the average professional, a private home represents ten years of salary. Any family is allowed to own two homes — a house or apartment in the city, and one in the country.

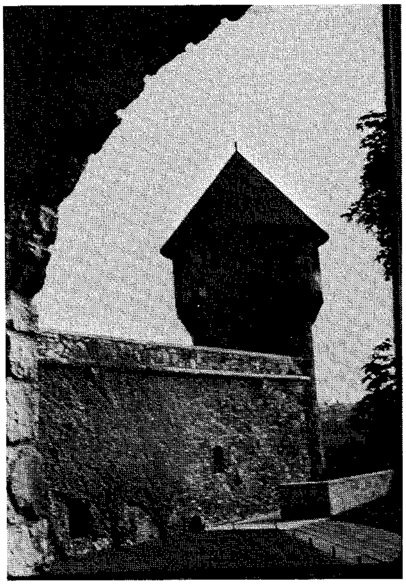


Panorama of smog-covered Budapest and the Danube from Gellert hall.

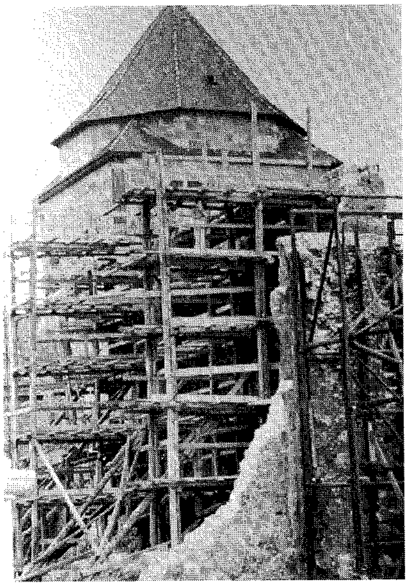


Parliament house on a quiet Sunday afternoon.

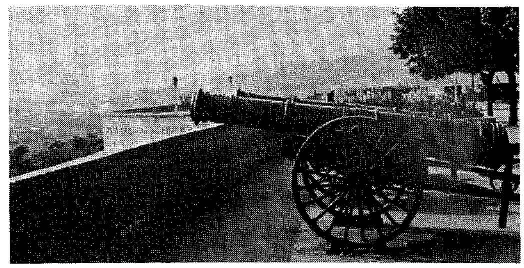
Hojok square at the end of a vast boulevard.



Lookout tower of the castle in Budapest.



Reconstruction on Castle Hall.



Above: Secret view of Hungarian artillery.
Below: New Suburb of Szeged.

Perhaps the saddest segment of the population is the old farmer who had to give up his farm house with all the irreplaceable sentimental attachment in exchange for a modern flat in a communal cluster. This change was seen as necessary in order to convert small scattered plots into large farms that can be worked with modern agricultural machines. In a folk art exhibit, a primitive polychrome sculpture represents a farmer clutching against his chest a model of his farm house. When flying over the Austria-Hungary border one can readily identify the two countries: on one side, small farm plots; on the other, large cultivated fields.

Not all farm houses are yielding to fields. In the provincial city of Szeged, the suburb has expanded into the surrounding farmland. There, single farm houses are torn down to be replaced by tall multi-apartment structures. In that same suburb of Szeged, there are five-story buildings of recent vintage which are already slated to be torn down to make space for taller and more spacious apartments. Isn't this a sign of rapid economic advance?

## Advertising

You have noticed the profusion of neon signs and advertising posters. You will find these even inside subway cars above the windows, just like in New York City Well, there may be an order of magnitude fewer neon signs than in an American city, but it is certainly an order of magnitude more than in the USSR, Czechoslovakia, or Romania. I saw a small airplane dragging a lettered sign along the shore of Lake Balaton — the sign advertised a refrigerator, even though there is only one manufacturer of refrigerators in Hungary. On tv, however, all the ads are placed at the end of the program.

If you looked at the prices in store windows, you must have noticed the "bargain" psychology: the old price crossed off and the new price about 30% lower.

## Trade

In contrast to Czechoslovakia, where the much lower living standard is blamed on the 19% skimming by the Soviet Union, in Hungary they exploit the economic contact with the USSR: the Russian raw products are brought in for processing; the good merchandise is exported for hard currency, while the poorer stuff goes to Russia.

Apparently, just as in the U.S., the Soviet economic difficulties stem from the high cost of military expenses. Furthermore, they say that production in Russia is not efficient and services are poorly organized.

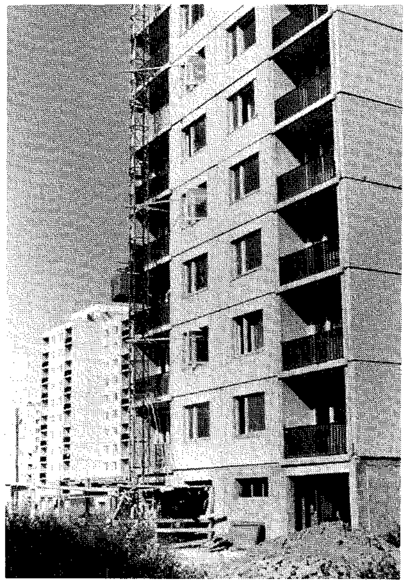
I suspect that the economic progress of Hungary is due in part to profit incentive and in part to full utilization of all manpower resources. Women can retire at 60, men at 65, but if they elect to continue work they can collect both pension and salary. However, Laboratory Directors must retire from executive responsibilities at 70, though they may continue working in other capacities.

The incentive appears in the fact that a bonus based on merit is added to the salary; it averages about 10% of the salary; profits are shared by employees in proportion to their salaries (the Director gets the largest share). The salary of a beginning scientist is 2kf/month, and the highest level reached is 12 kf. (A tv set costs about 6 kf, and a good meal 50f; $1 = 26-f (forint).

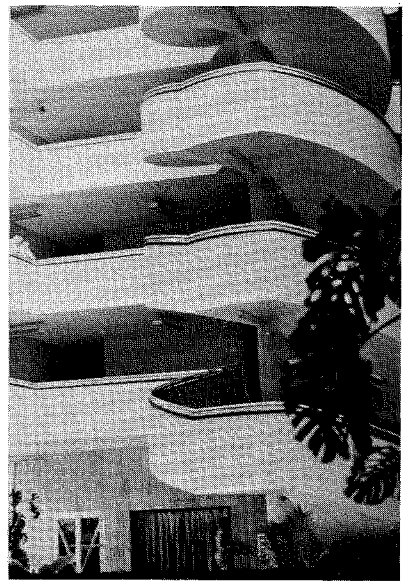
Both authors and reviewers are paid (authors receive 100f/page). Inventors either sell their patents or receive a royalty. In the case of royalties, the government gets ½ of the proceeds, the inventor ½ to ⅔ of the remainder. There is no income tax on regular salaries, but extra revenues, such as royalties on books, are taxed (10-15%). 10% of the salary is deducted for social security and pension.

During sickness, the pay is reduced and it is reduced even further in case of hos-

Above: Thatched roof cafe near Szeged.
Below: Minitaxi in Budapest



Ten-story apartment building of modular construction.



Foyer of the modern City Hall with indoor helical staircase.

pitalization (but then, room and board in the hospital are free).

There are not enough people to do all the work that needs to be done. The Government encourages a higher birth rate by various incentives: allowance for each child and for the working mother who stopped her work (600 forints/month for 2 years); childrens' clothes are inexpensive because of Government subsidy.

Although the salaries appear low, there are many free services available to the citizens: medical services and medication are free of charge; however, it is customary to tip the doctor. Public education and college are free. In the afternoon (public school ends at 2:00 P.M.) parents may then send their children to religious school, or to study music or other specialized subjects not offered in public school. Of course, these special classes, mostly run by individual enterprises, are not free.

### Budapest

Look at the illuminated fortress dominating the city. From its ornate ramparts you have a magnificent view of the city on the other side of the Danube. The bridges with their strings of bright lights reflect into the black water. Paris has no comparable view of the Seine. Inside the fortress there are many reconstructed XVIII Century buildings. The Academy owns several of these buildings; one houses a chemistry lab, another the computer and offices and meeting rooms. A former mansion is now used as the guest house of the Academy. This is where I am quartered. There are spacious rooms furnished elegantly, but simply. One enters the private bath through a door frame made of cut stone. The hallway is tortuous and its ceiling is gracefully arched. Every morning, someone picks me up to go to the Institute or, on the weekend, for an excursion, and brings me back in the afternoon. This may sound leisurely, but one of the days was quite full with exposure to computers, holography, magnetics, ion implantation and the evening finished with a discussion of anomalous water with two Russian biophysicists who were staying at the same guest house.

In my free time, I take a bus to the center of town (a 7-cents ride) and visit one of the many museums. Sometimes I stroll through the old streets of the fortress catching the distorted perspective of their varying widths, looking at the freshly painted pastel facades and contrasting them with the still unreconstructed ruins. What a fantastic task to transform this chaotic rubble into period masonry! Some old walls are still peppered with bullet wounds. Toward the end of the War, the Nazis who were barricaded in the fortress had blown up all the bridges to stop the Russian army at the Danube. But later, when the siege was ended and the Germans could leave, they systematically blew up all the buildings — a senseless act of vandalism. As the area is reconstructed, the intricate network of underground tunnels is transformed into wine cellars connecting to the many fine restaurants in the fortress. You must peek into one of these caves, where little tables are set in the cranies of the rock with a dim light casting an eerie glow. As you can imagine, the fortress is a touristic high spot. Concerts are given almost every night either outdoors or in the church, or in one of the other buildings on the square. Large tour busses disgorge waves of camera-toting tourists from many countries.

In the rest of the city you must have noticed the many parts interspersed among the massive turn-of-the-century buildings with their caryatids supporting balconies, or just holding up a decorative ledge.

### Science

But, let me tell you about their activity in science. They have made a great investment in scientific research, a calculated risk intended for a drastic jump in the near future. Hungary is capitalizing on the availability of intellectual and skilled manpower rather than on relatively cheap labor. Thus, one can find capital investment for equipment alone of $10,000 per year per scientist whose average yearly earnings may be of the order of $1500.

### Research Institute for Technical Physics — Budapest

This Institute, built in 1965 consists of two tall buildings joined by a two-story structure, the first floor of which is a giant hallway, plus cafeteria, and the second floor is a common administrative area. The seven-story structure housing the basic research employs about 300 people (60 scientists and 60 technicians). This represents about 20% of the total personnel at this Institute; the rest doing applied research in a separate lab where I was not taken.

The whole laboratory was extremely neat, the benches uncluttered, without the usual tangle of loose wiring about electrical equipment, and the specimens were lined in orderly fashion in glass cabinets. It looked as though the lab had been closed for vacation, though there were still many people at work. When I asked about the neatness, I was told "Our lady technicians are good housekeepers." In general, the laboratory is well-equipped with modern machines from many countries: Mettler differential microbalance from Switzerland, two JEOL electron microscopes from Japan, spectrometers from the United States and E. Germany, oscilloscopes from Hungary, Poland, and the United States.

There are three libraries. The one I visited had the latest *Journal of Applied Physics* on the shelf. All the books were numbered in order of reception, although they are also cross-indexed in the Dewey system.

The history of the research institute dates back to the beginning of the incandescent lightbulb which is still one of Budapest's most important industries (Tungram). The laboratory first solved the problem of filament sagging by adding *Al* to the tungsten, which allowed raising the filament temperature by 300°. Then a further improvement followed by the substitution of *Ar* for the *Ne* inert ambient. They were leading in the manufacture of cathodes for vacuum tubes until RCA came out with the *BaO* coating. In 1945, Dr. Szigeti obtained a basic U.S. Patent on EL diodes with a broad claim — a single crystal insulator between two metallic electrodes becomes a source of light when a sufficiently high electric field is applied across these electrodes to produce conduction. The interest in luminescence has become a traditional pursuit of this group which has considerable experience in photometry. They claim to have no interest in devices.

### Central Research Institute for Physics — Budapest

This is the largest research institute in Hungary. It is located atop one of the hills of Buda, in the wild forest park which drapes several hills at the edge of the city. The Institute has a campus-like atmosphere with many buildings scattered in the woods. However, the whole complex is surrounded with barbed wire fence and look-out towers — these are now empty relics of a sterner past. The guards at the gate are unarmed civilians. The present 1800 workforce cannot be expanded because of saturated facilities: water, gas and electricity (the isolation of this Institute, would make bringing in more services too expensive).

The range of work extends from fundamental and applied research to pilot production. One half of the support comes from the Academy of Sciences, the rest from industrial contracts and from the manufacture of computers. The contract work along brought in about $40 million in 1971. The research, in turn, has promoted the growth of Hungary's industry, technology and scientific culture. The transition from fundamental to applied work is helped by improved instrumentation made readily available and by incentive remuneration such as a large share in patent royalties. Some projects, such as the ion implantation are helped by close cooperation with Soviet institutes.

### Institute for Automation and Measurement

This Institute headed by Dr. Vamos employs 500 people (of which 200 are of scientist level). One half of the million-dollar budget goes to research. The major areas of work are computer-aided design, mini computers (under French license), man-machine interface, and process control for chemical plants.

The Laboratory is housed in an old building and the facilities are extremely crowded. But, the equipment is modern. Except for the British spectrophotometer, the French UV monochromator and the East German spin resonance spectrometer, most of the equipment is Hungarian. All the Hungarian machines (multichannel counters, scopes, recorders, amplifiers) have English inscriptions on the knobs "because all Hungarian scientists are familiar with English terminology."

### Szeged Biological Research Center

Szeged is a city of 125,000 near the Romanian border. Its major industries are textiles, salami, and cables. There are three universities. The Biological Research Center is a tall, eight-story slab-shaped building with attached one-or-two story miscellaneous wings. The main building is partly occupied, the rest is still under construction. Temporary buildings house the library, green houses, and some administrative offices. The eighth floor will have guest rooms and animal cages (a curious combination).

There are four distinct "institutes" or departments: Plant Physiology, Genetics, Biophysics, and Biochemistry.

The laboratories are already stuffed with modern equipment, mostly American, but the refrigerators are Russian. The budget for equipment averages about $10,000 /scientists/year, and the same amount is anticipated for the next two years.

Teaching physics to medical students takes six hours per week (three for lectures and three for laboratory work). This is taught in the first year of the six-year medical program — right after high school. This course emphasizes electronics and measurement principles.

### Conclusion

The scientific and cultural exchange programs between our two countries is a powerful generator of mutual understanding. These programs should be maintained with Hungary, and with many other countries. The next step should be a program of interdependence where nations could collaborate with their respective unique resources, tools, materials, and skills.

# NBC Election returns 1972

**William A. Howard**

**During the 1972 national elections, NBC was able to update vote information on the Presidential, Senatorial, Gubernatorial, and Congressional races by State within seconds after the information became available. In addition, NBC was able to predict the winners at a very early time on all races.**

THE DIRECTOR of NBC News/Elections called the November 7, 1972 election returns "the most important scheduled news event in the free world." The NBC Research Department estimated that 120 million viewers watched some part of the election night coverage originated by the three television networks. It was estimated that the three networks spent about $10 million for the one-shot coverage of the election returns. NBC began its coverage at 6:30 p.m. with the Nightly News on November 7th, and provided continuous coverage until 1:30 a.m. the next morning.

The NBC live coverage was transmitted to its more than 200 affiliated stations in the United States by its regular network facilities. The program was also transmitted via satellite to the largest foreign audience ever to watch American Presidential election returns, a coverage that included 18 nations on four continents.

This special election return program originated in studio 8H, New York, with three other studios used for transmission to foreign countries. Studio 6B was used to report to the European networks, studio 3K to Japan, and studio 5E to Mexico.

In addition to the New York studio facilities, studios in Washington were used for interviews with key political figures. Twenty two television and radio mobile units with correspondents were deployed to headquarters of many of the principals in high interest races.

The procuring and tabulation of vote count on all races throughout the United States was provided by News Election Service (NES). NES was formed in 1964 by NBC, CBS, ABC, The Associated Press and United Press International. However, NES makes no projections or analysis of election returns.

Of the 175,000 voting precincts in the United States, NES had representatives at 100,000 of these precincts reporting vote count by telephone and wire service to six regional centers located in New York, Philadelphia, Cincinnati, Chicago, Dallas and Los Angeles. These regional centers tabulated the vote count as reported to them, and by the use of wire service, fed this information into two computers at NES national control center in New York as illustrated in Fig. 1. The vote count information, after being tabulated, sorted, and processed at the national control center was distributed by wire service to three television networks and the two wire services in a special NES format.

In addition to the vote count information supplied by NES for updating of display boards in studio 8H, NBC News had 4050 field reporters deployed throughout the country. The field reporters were posted in key precincts and special tag precincts in 48 states of the continental United States.

The key precincts were barometric, selected on the basis of past performance to be typical of the United States as a whole. Projections were based on the key

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precinct samples. The special tag precincts provided demographic analysis of the political races, and they were selected to reveal how the vote was going from such viewpoints as income, race, ethnic composition, religion and blue-collar voters.

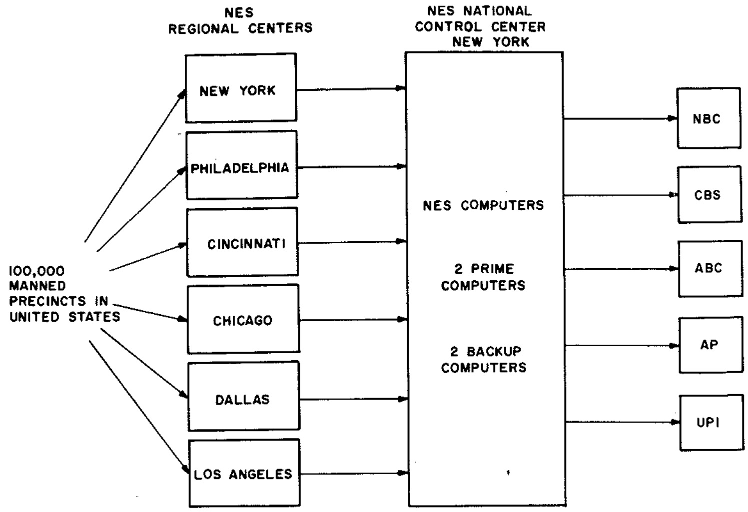



Fig. 1 — Facilities and location of News Election Service (NES) for the 1972 election returns.

## Major system components

NBC reporters assigned to these key and tag precincts reported the vote totals by telephone and wire servic to the RCA computer center at Cherry Hill, New Jersey. Two RCA Spectra 70/46 and one Spectra 70/61 computers were used to process the vote count from the special precincts manned by the reporters and to make comparisons with the vote count from NES. This information was available on call-up by a Video Data Terminal (VDT) from the NBC projection and analysis desk in studio 8H, New York. It was also made available on hard copy by a 740 teletype printer for use by show talent. Figure 2 illustrated the routing of information for the NBC analysis and projection coverage. This system made projection and analysis possible at a very early time.

Fig. 3 shows a block diagram of the overall air and monitor display system at NBC. The equipment used in studio 8H, for air displays, were five computer controlled display boards. These were the

- Presidential National Popular Vote,
- President by State,
- Senate by State,
- Governor by State, and
- House of Representatives by State, with special selected congressional districts.

The five display boards replaced the old "Chinese Wall" with its more than 100 tote boards, a graphic feature of NBC's News Election Central for television coverage for the past years.

The presidential National Popular Vote display was controlled by a computer interface unit that was specified and procured by the NBC Engineering Department in 1968, and was used on the 1968 election returns with outstanding success. The interface unit accepted a low speed teletype feed directly from NES.

The four State display boards were controlled by two RCA Spectra 70/45 computers located adjacent to studio 8H. These two computers were under NBC's control and received teletype signal information from the NES national control center. All pertinent information on all races was stored in long term memory in the Spectra 70/45 computers and upon demand, supplied an output of up to four selected races at a time via a Video Data Terminal (VDT). This information from the computer was in the form of a teletype signal and was processed by four NBC display interface devices that were specified and procured. The RCA computers also justified the incoming information from NES, introduced a percentage of vote and stored projected winner candidate information for display call-up.

The input to the NBC interface equipment accepted a serial teletype feed from the computer on call-up by the VDT. The call-up from the computer and the recognition load into the display units were one and the same action. The interface devices were required to recognize, sort, and store one complete message which contained state, title, and up to four candidate vote lines. The display interface required no operating panel, as all call-ups were via the computer VDT terminals.

An editorial closed circuit monitor display system was used which consisted of six CO-75 Computer Optics character generators. These character generators received a feed from the Spectra 70/45 computer and fed 150 video monitors distributed throughout the operating area.

## Computer controls

The input to the two RCA Spectra 70/45 computers under NBC's control consisted

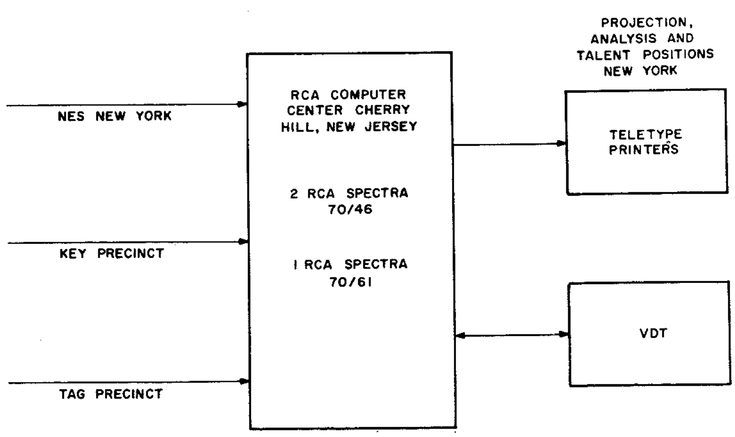



Fig. 2 — Location and equipment used by NBC for analysis and projection coverage for the 1972 election returns.

of eight low speed and three high speed teletype lines from NES national control center. Fig. 4 illustrates the input-output circuits of the Spectra 70/45.

The eight low speed teletype lines were 10-characters/second, 75-baud Baudot code, and carried vote count information for President, Senate, and Governor by state. The three high speed lines were 150 baud, eight-level ASCII code and carried vote-count information for the House by state with special Congressional Districts. These lines terminated at NBC in TDOSD3/4S data terminals which fed the inputs to the computers.

The outputs of the Spectra 70/45 computers consisted of three 2400 baud and six 1200 baud teletype circuits. The 1200-baud circuits were ASCII code, terminating in 202D data terminals. These lines were used to feed six CO-75 Computer Optics Character Generators which provided monitor displays for President, Senate, and Governor by state. The 2400-baud circuits were ASCII code, terminating in 330D data sets and fed the four interface units by state.

## Presidential national popular vote interface equipment

The Presidential National Popular Vote interface equipment as shown in Fig. 5 accepted a low-speed 10-character/second Baudot code teletype signal from NES national control center. There were two identical lines from NES, each terminating in a R760 repeater where the line feeds were changed from a polar loop to a 60-mil neutral loop. The input to the interface equipment was bridging and the lines terminated in a M28 teletype receiver which produced hard copy.

The interface equipment converted the incoming from serial to parallel feed. It also sorted and sorted one complete message according to percentage of precincts reporting, candidate's name with party affiliation, vote count for each candidate and percentage of votes for each candidate. At the end of message this information was automatically posted on the air display board. A complete message was transmitted by NES every minute.

The first line of the air display board consisted of three numerical flap units for

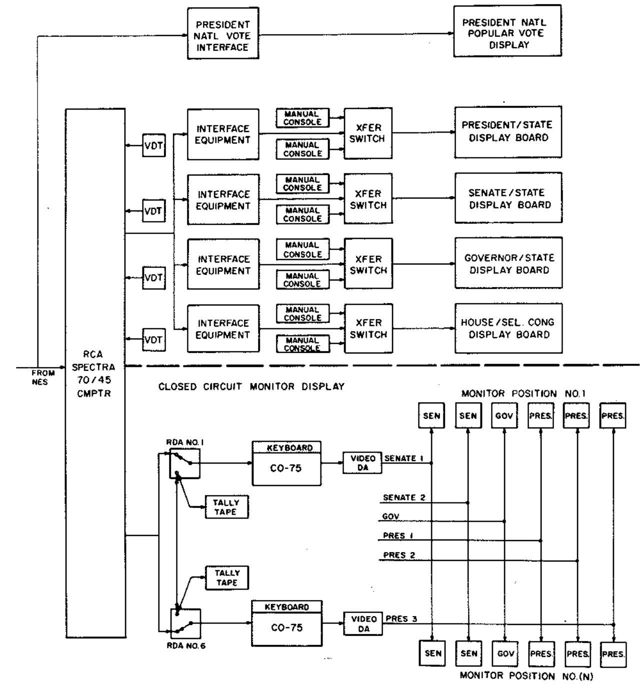



**Fig. 3 — NBC setup in New York for air displays and closed-circuit monitoring for the 1972 election returns.**

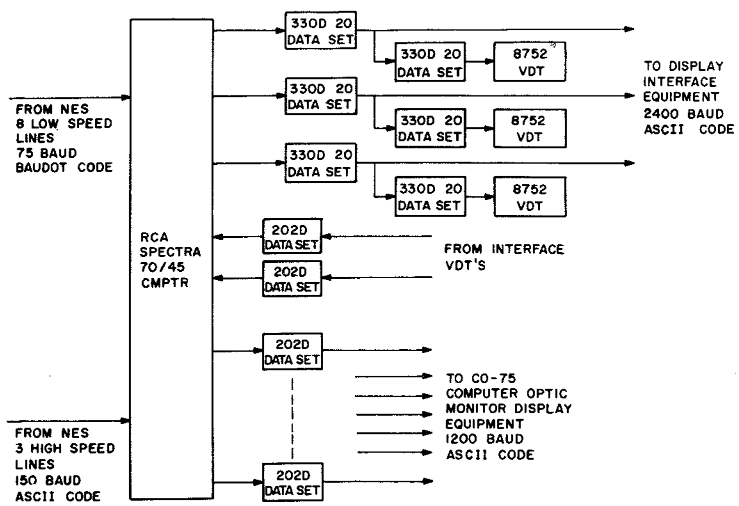



**Fig. 4 — Input-output circuits to the RCA Spectra 70/45 computers in New York which controlled the air display boards for the 1972 election returns.**

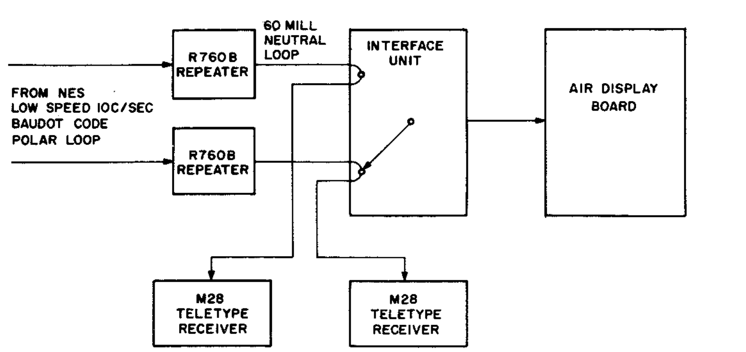



**Fig. 5 — Interface and air display equipment for national presidential popular vote showing input circuits for the 1972 election returns.**

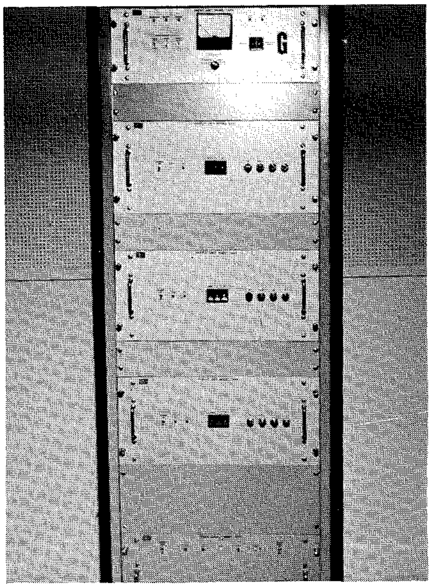


Fig. 6 — One system contained in one rack of the Governor-by-State interface equipment controlling the Governor air display board. A similar rack of equipment was required for President, Senate, and House by State.

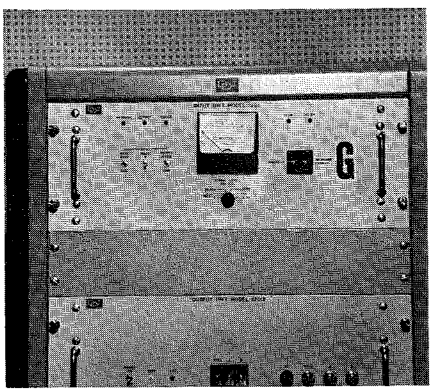


Fig. 7 — Input chassis of the Governor interface equipment showing selection of input controls and also the address and message length selection controls.

displaying the percentage of precincts reporting. This was followed by four candidate vote lines. Each candidate vote line consisted of one alphabetic character flap unit which indicated candidate name and party affiliation, eight numerical flap units indicating candidate votes, and three numerical flap units indicating percent of vote for each candidate.

## Special symbols

The message format from NES contained certain symbols and alphanumericals which were recognized by the interface equipment. An open parenthesis "(" indicated start-of-message (SOM) and the information that followed was to be recognized by the interface equipment. Space-hyphen-space " - " indicated the start of the percentage field, and the percent sign "%" closed this field. A colon-space ": " indicated the start of the vote field which would recognize up to eight digits. The number sign "#" indicated end-of-text (EXT) and instructed the interface equipment to post the message received. Certain symbols in the message format were ignored by the interface equipment including those used for source identification and a time-code stamp following EXT.

The following is an example of a complete message received every minute from NES by the Presidential National Popular Vote Interface.

(PNAT
NATL 44,887 - 26%
NIXON R: 11,185,570 - 50% IEV 263
MCGOVERN D: 10,700,410 - 47% IEV 264
SCHMITS A: 656,524 - 3% IEV O
SPOCK P: 36,747 - 0% IEV O
#1639W

## State-by-state interface equipment

The display interface equipment for the four display boards by state is made up of four identical units. Each unit is housed within one 77-inch rack which consists of one input chassis, two output line-drive chassis, and the required power supplies. One unit contains a spare output-line drive chassis as shown in Fig. 6.

The normal requirement, as used in the 1972 presidential election returns, was for the input chassis to feed only two output line drive units. However, it is capable of feeding up to four output line drive units. This specification allows two interface units to be placed side-by-side to provide an eight candidate display interface when appropriately interconnected. This would meet special requirements in many of the primary races when there could be up to eight candidates. A switch on the front panel of the input chassis marked "Message Length" determines the upper limit of the candidate vote lines which would be accepted in any given race. The functions of the input chassis is illustrated in Fig. 7.

The input chassis includes the logic circuits necessary to perform the following functions: timing, assembling the sequential teletype input signal into characters, recognizing certain characters that are to be excluded, recognizing errors, and controlling the storage and output section of the interface system. Fig. 8 illustrates these functions. A clock generator provides timing for the system for 1200- or 2400-baud input signals. A switch on the front panel provides for these selections. The eight-level ASCII-code input is converted to a two-digit octal code, six-bit character, one-bit parity, and one-bit control. The input accepts data of plus or minus six volts, 100 ohms source termination. A switch is provided on the front panel for the plus or minus input. A switch is also provided for the selection of odd or even parity.

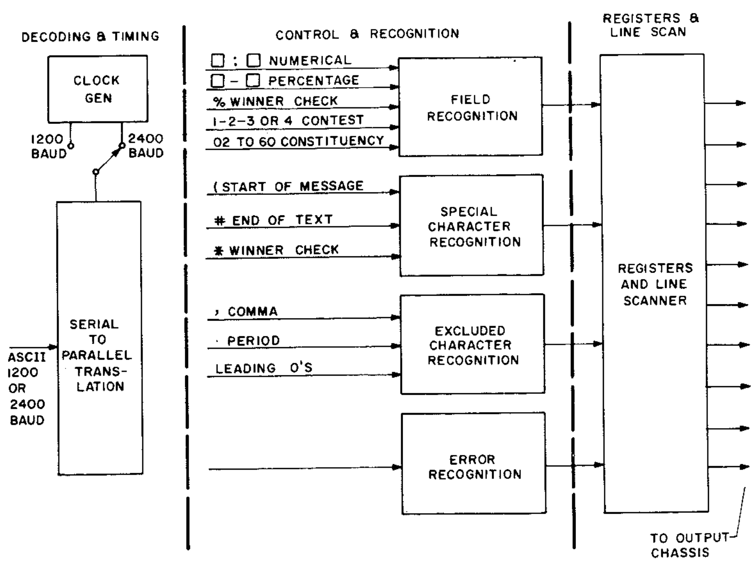



Fig. 8 — Input chassis of the interface equipment.

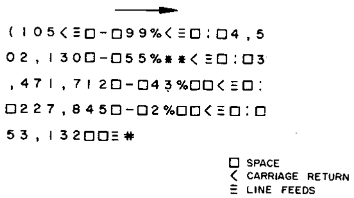



**Fig. 9 — Data flow symbols for one complete message into the interface equipment of the Presidential race for the State of California.**

With the required message-at-a-time update, the equipment had to store and control 52 characters simultaneously. Four seconds is required between the end of message character and the start of the next message character, to allow for adequate re-cycling time. The data flow for one complete message to the input of the interface equipment is shown in Fig. 9.

### Vote format

The input message format that was recognized by the input chassis of the interface equipment consisted of three basic parts: the transmission code line, the title line, and the candidate vote line.

The transmission code line began with an open parenthesis "(" which indicated SOM. A tally on the front panel marked "message" indicated a valid message being received. The transmission code following the SOM character consisted of two fields: a contest field and a constituency field. The contest-field character consisted of one numerical digit, indicating the nature of the contest involved: 1 for President, 2 for Senate, 3 for Governor, and 4 for House. A thumbwheel control on the front panel marked "address" was provided for the selection of the proper contest field. The constituency field character consisted of two numerical digits 01 to 60 were assigned to the 50 states or to congressional districts: such as 02 Alaska, 05 California, 32 New Mexico or 51 Wyoming, etc. These digit characters controlled a 60 vane name flap unit on the display board. The transmission code line ended with a carriage return-line feed.

In the title line, the interface equipment recognized only the percent-reporting field. This was the percent of precincts reporting. The opening of the percent field was a space-dash-space "-" character which was followed by one to three numerical digits. Percentages which rounded to less than one in all percentage fields were represented by zero. The title line was terminated by a percent sign "%", carriage return, and line feed.

In the 1972 election returns, the candidate vote line on all races were set for a maximum of four lines each which accommodated four candidates. Each candidate vote line consisted of a vote field, a percentage field, and a winner check field. A space-colon-space ":" character was used to open the candidate vote field which consisted of up to seven numerical digits with commas where necessary. The interface equipment did not recognize the commas or any leading zeros in the vote field. The vote field was closed with a space-dash-space "-" character which also served to open the percentage field.

The percentage vote field consisted of from zero to three numerical digits and was closed with a percent sign "%" which also served to open the winner check field. The sum of all candidate percentages equaled 100%.

The character used for the winner check was a double asterisk "**" which appeared only at the end of the candidate line of the candidate projected as a winner by the NBC Analysis Desk. This information was entered into the format in the computer via a teletype machine near the Analysis Desk so that after a winner had been projected, the red winner check would be displayed at the end of the appropriate candidate line each time the race was called up. On the candidate vote lines where a winner had not been projected, a double space replaced the asterisks. A carriage return and line feed terminated the candidate vote line.

Normally, all candidate vote lines had identical format characteristics with the exception of the last line which contained only a line feed at the end. A number sign "#" followed the line feed and indicated end of text (EXT) for the interface equipment. This was the character that was used to direct the outputs of the storage section to the appropriate line of flap units within one display board simultaneously.

The following is a complete message format for a four candidate Presidential race reporting on the returns from the state of California:

(105
- 99%
: 4,502,130 - 55%**
: 3,471,712 - 43%
: 227,845 - 2%
: 53,132
#

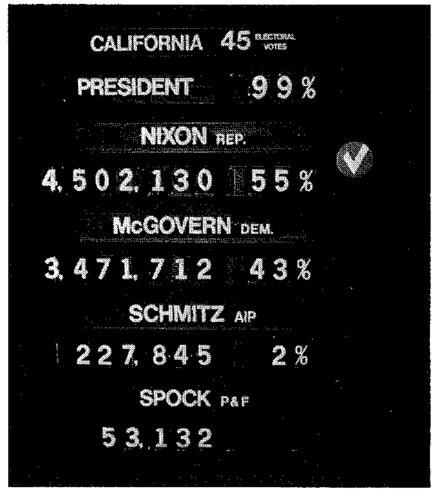



**Fig. 10 — Presidential display board after the data from the message in Fig. 9 had updated the board.**

Fig. 10 illustrates a picture of the air-display board after this information had been posted.

### Output-line drive chassis and flap units

The output-line drive chassis contains memory for the storage of one complete message and the output circuitry for driving the flap units on one display board as illustrated in Fig. 11. The updating is one message at a time in which the equipment must control and store at least 52 characters simultaneously. The flap units on one display board do not start to assume their new position until end-of-message signal, at which time all characters move at once.

The signal into the output-line drive chassis is in the form of a two-digit octal code and contains information for code name characters, seven vote digits, three percent digits, and a winner-check digit. The output section serves to direct the output of the storage sections to the different lines of flap units within one display board.

Each output-line drive chassis is capable of controlling one set of transmission code lines, one set of title lines and two sets of candidate vote line flap units. On the NBC 1972 election air displays, the transmission code line consisted of two Mischiatti 60-vane flap units indicating the nature and the geographical constituency of the contest. The title line

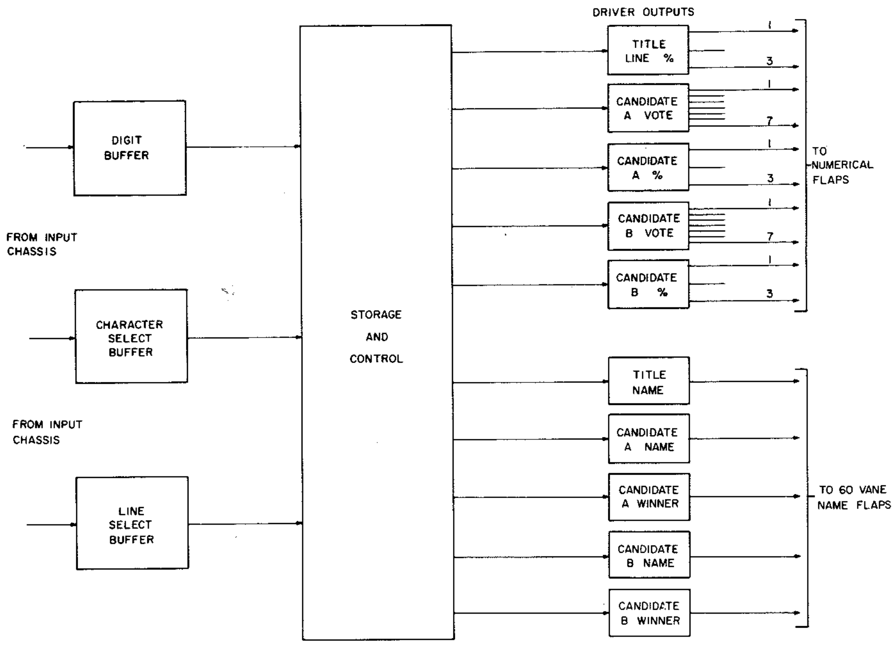



**Fig. 11 — Output line drive chassis of the interface equipment for the 1972 election returns.**

consisted of four Signaltron 12-vane flap units indicating percentage of precincts reporting. All percentage displays were capable of reporting up to 100% and displaying a percent sign. Each candidate vote line provided for a 60-vane flap unit indicating candidate name with party affiliation. It also provided for seven 12-vane flap units indicating candidate vote plus four additional units indicating percentage of vote. The last flap unit in the candidate vote line was a 60-vane unit indicating the red winner check sign. Thumbwheel controls on the front panel provide for the selection of the proper title and candidate vote lines as shown in Fig. 12.

The 12-vane flap units used for numericals and percentage signs were the Signaltron flap units requiring 115-V ac drive and incorporated a normally closed wafer switch which required three seconds for one revolution. This unit is shown in Fig. 13. These units were modified to include a 24-V dc relay so that the solid-state switches in the output chassis switched 24 V dc. The 115 V ac was supplied to the flap units at the display board.

The 60-vane flap units used for names and winner check signs were the Mischiatti integrated solid state displays which avoided the complex problems inherent in relay controls. The control for these flap units required 0 V dc for code 1 and open circuit, to +24 V dc for code 0 and closed circuit using a special Mischiatti 6-bit code. The 6-bit code is embossed on the metal surface of a code wheel within the unit. The drive for the flaps is a 115-V ac motor with this voltage being supplied at each display board.

## Closed-circuit monitor display

An editorial closed-circuit monitor display system was used which consisted of 150 video monitors that were distributed throughout the operating area. These displays were used for editorial, analysis, and projection purposes. The video monitors received their feeds from six CO-75 Computer Optics character generators which were automatically loaded from the RCA Spectra 70/45 computer through a Remote Data Adapter (RDA) as illustrated in the Fig. 3 block diagram.

Each CO-75 character generator consists of a separate control unit and separate display units capable of 3000 characters. Each unit operated from a low-speed 110-baud non-buffered RDA, with the code being a 10-bit character, Computer Optics ASCII. The character format consisted of one start bit, seven data bits, one even parity bit, and one stop bit.

The video output from the CO-75 is 1 V p/p into a 75-ohm termination from a 75-ohm source impedance with 0.71 V video, 0.29 V sync, conforming to EIA standards. Video distribution amplifiers were used between the CO-75 character generators and monitors.

The six low-speed RDA's interfaced to the RCA Spectra 70/45 computer, each having a dedicated circuit out of the computer through 202D data sets. The feed from the RCA computer into the RDA's was 1200 baud ASCII code.

Two tally tape units were used in conjunction with the CO-75 character generators to provide an emergency service in case of failure of the computer. Six formats were stored in each of the tally tape units and a series arrangement with an off-line/on-line switch on each display, so that any one unit or all 6 units could be fed by the computer or the tally tape units.

The formats stored by the tally tape units were two Senate, one Governor, and three President formats with no dynamic data being stored. In an emergency

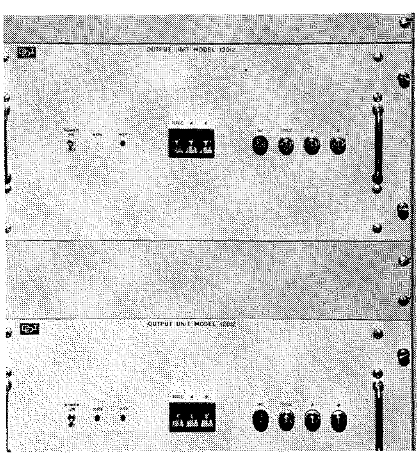


**Fig. 12 — Output line drive chassis showing controls for selection of title and candidate lines.**

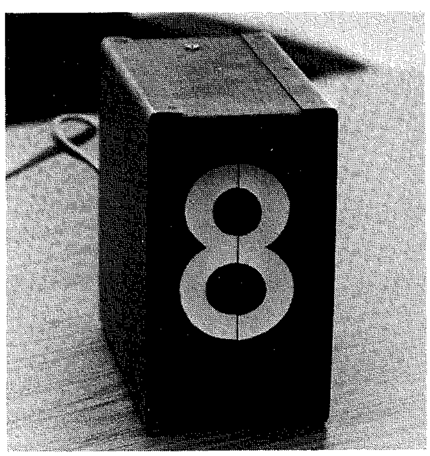


**Fig. 13 — 12-vane Signaltron flap unit used for display of numericals and percentage signs.**

operation, the dynamic data would be entered into the CO-75's by the manual keyboard as taken directly from the NES lines.

The CO-75 character generators and control equipment consists of two parts. The necessary power supplies and logic equipment are housed in a rack with space provided for the RDA's. The second part consists of a display monitor and keyboard. The keyboard can be separated up to 1000 feet from the terminal equipment.

### Video data terminal director's operating position

Fig. 14 illustrates the VDT operator's position for the Governor air display board. There were similar positions for the President board by state, the Senate, and Congressional districts. Each operating position was adjacent to the air display board. The VDT display and keyboard are located on the right, and a video monitor with a feed from the Computer Optics character generator with the Governor's format is on the left. The air display is directly above.

The address to the computer by the VDT was a special format for each race. The format used for calling up the race illustrated on the air display board in Fig. 14, was as follows:

TG (for Governor)
TEX (for the state of Texas)
transmit key

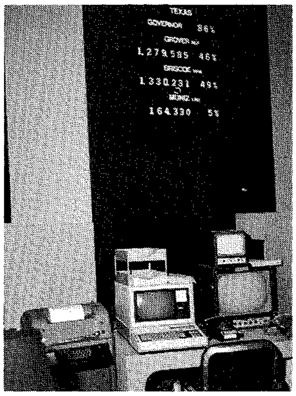
As this time, the vote format for the race that was called for would be displayed on the VDT display monitor by depressing the "call-up" key. In order to load this format into the interface equipment and onto the display board, the call-up key would be depressed the second time.

The call-up format for the President for the State of Alabama would be as follows:

TP (for President)
ALA (for Alabama)
Transmit key

The call-up for the 1st Congressional District for the State of New York was as follows:

TH (for House)
N/Y (for the State of New York)
01 (for the 1st Congressional District)
Transmit key



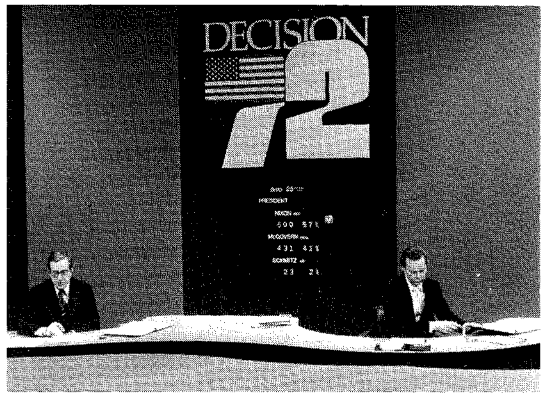


**Fig. 14 — (left) Video Data Terminal (VDT) Director's operating position for the Governor display board. The Governor's race for the state of Texas is displayed on the air display board. Fig. 15 — (right) Presidential air display board by state with talent positioned in the foreground. Presidential races from all 50 states can be called up for air display and can be viewed from one camera angle.**

### Transfer switch

Each of the four air display units were connected through a relay transfer switch to either the interface equipment for automatic operation, or to two manual control consoles. The transfer relays and receptacles for one candidate vote line was included on one chassis which consisted of twelve relays with multiple-C contacts for transferring individual circuits and four rows of twelve receptacles each on the rear of the chassis.

A manual override switch was provided for the transfer relays. The output drivers of the interface equipment was paralleled with one of the manual consoles. This was necessary to provide A-B switching in the manual operating mode.

### Test procedures

A test set was provided for check-out of the interface equipment and the air display boards independent of the computer. The test set consisted of an ASCII Test Message generator for 1200 or 2400 baud code, using a Tally model 625 tape reader. A test tape could be punched from a standard teletype machine using the same vote format that was provided on the output of the computer that fed the interface equipment. A tape cartridge was also prepared using the NES vote format so that the entire NBC system, including the computer, could be tested independent of NES.

### Conclusions

The performance of the NBC system, using the automatic updating of the four races by State was highly satisfactory. This enabled NBC to air the update vote information of these four races within seconds after it was made available from NES and also to project winners at a very early time on all races. This system also simplified the operation and excluded the use of many manually operated display boards and the large amount of paper work necessary to update these displays as used in years past.

From a production viewpoint, this system offers a tremendous advantage in that up to 60 races can be covered from one camera angle. Fig. 15 illustrates how talent can be positioned in front of the display board so that both can be viewed simultaneous from the same camera.

The limitations of the system used by NBC in the 1972 election returns were the mechanical alphanumerical display units. We will continue to look for the development of an all-electronic unit using modern display techniques that will meet our requirements for air displays. NBC will continue its efforts to improve its performance in bringing to its viewers fast and accurate information in reporting election returns.


### Acknowledgments

The author gratefully acknowledges the contributions made by his colleagues in the NBC Engineering Department and also the helpful suggestions from NBC News Election.

# The impact of the space shuttle on unmanned spacecraft design

**B.P. Miller**

**Various shuttle payload designs and their associated cost factors are examined and evaluated in this paper. Standard spacecraft employing common subsystem modules and cluster spacecraft incorporating similar standard subsystem modules are considered. Such standardization will provide greater overall economy and flexibility for system designers and planners.**

A MAJOR OBJECTIVE of the Space Shuttle program is to improve the productivity of space operations by:

1) Reduction of launch costs through consolidation of launch vehicles and facilities, and reuse of launch vehicles, and
2) Reduction of payload costs through the relaxation of traditional constraints that have become the cost drivers in space payload design.

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The purpose of this paper is to examine the aspects of the Shuttle program that will open the way to the reduction of payload costs, and to explore some of the payload concepts that may be exploited to achieve lower payload cost.

## Shuttle payload types and characteristics[1]

Space Shuttle payloads consist of spacecraft and/or experiments and passengers that are launched into orbit by the Shuttle. Three types of payloads have been considered for the Shuttle: unmanned spacecraft, sortie modules, and research and application modules (RAM). Unmanned spacecraft are deployed from the Orbiter and inserted into mission peculiar orbits. After deployment the unmanned spacecraft will

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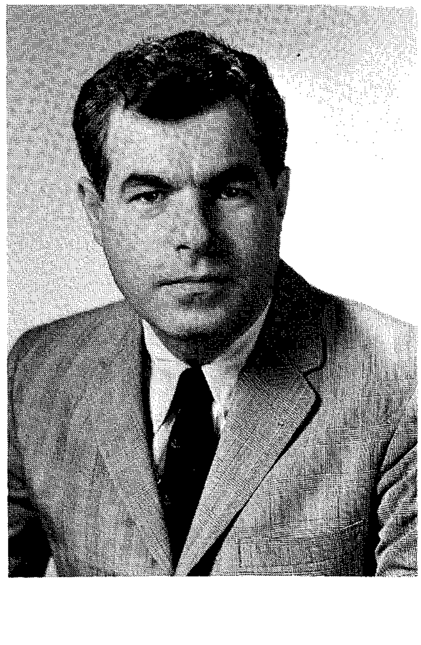


operate independently of the Shuttle. In the case of earth orbiting missions, these unmanned spacecraft can be revisited for refurbishment and maintenance. The Orbiter may also be used to recover these unmanned spacecraft and return them to earth for refurbishment.

Typical unmanned spacecraft that may be carried as shuttle payloads are:

1) TIROS O
2) Applications Technology Satellites
3) Earth Resources Satellites
4) Commercial Communications Satellites
5) Earth Observatory Satellite.

Experiments that remain an integral part of or attached to the orbiter are called Sortie payloads. The Sortie payloads may be manned or unmanned, and rely upon the Orbiter for support functions. Sortie modules have been proposed for the disciplines of:

- Communication and navigation
- Astronomy
- Life sciences
- Earth observation

Research and applications modules are large, free-flying satellites, generally servicing the astronomy discipline. The research and applications modules operate unattended for 2 to 6 months, and are then serviced by the Orbiter. The research and applications modules are differentiated from unmanned spacecraft by the existence of a manned pressurized area for use during refurbishment of these large telescope-carrying satellites.

Research and applications modules have been proposed for advanced stellar and solar astronomy, x-ray stellar astronomy, and high-energy stellar astronomy.

Although the concepts of subsystem modularization and standardization discussed later in this paper are described in the framework of unmanned spacecraft, these concepts are equally applicable to the sortie and research and application modules.

## Shuttle Orbiter Payload Capacity[2]

The Shuttle Orbiter will have a cargo compartment that will measure approximately 15 feet in diameter and 60 feet long, and be capable of delivering about 65,000 pounds of payload to a low inclination near eart orbit. The additional increment of velocity needed for higher energy orbits or escape trajectories will be imparted by a Tug operating in conjunction with the Orbiter.

| HARDWARE | NO. PROG. | TOTAL $ |
|---|---|---|
| STD. S/S | 30 | 8.647B |
| STD. S/C | 4 | 0.732 |
| CLUSTER S/C | 11 | 3.530 |
| BEST MIX TOTAL | 45 | 12.909B |
| BASELINE | 45 | 19.777 |
| SAVINGS | — | 6.868B |

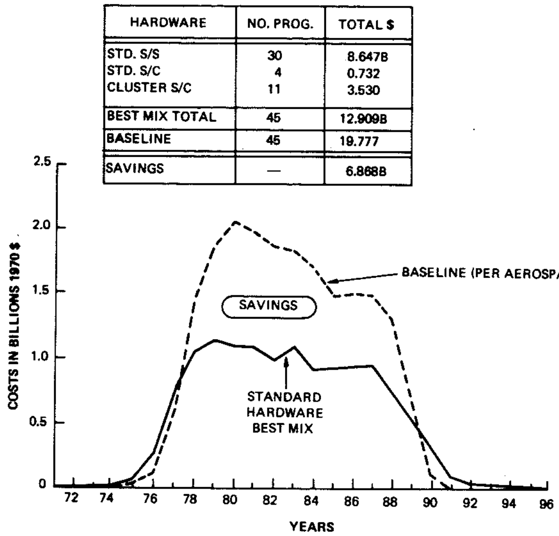



Fig. 1 — Savings in billions of dollars by use of standard hardware.

Table I — Summary of cost savings.

| Type Hardware | Case | Payload Cost | Payload Saving | $ Billion<br>$7.3M Shuttle<br>Total Program Cost | $7.3M Shuttle<br>Total Savings | $10.5M Shuttle<br>Total Program Cost | $10.5M Shuttle<br>Total Savings |
|---|---|---|---|---|---|---|---|
| Expendable Payload | A | $16.17 | — | $19.78 | — | $19.78 | — |
| Low-Cost Refurbishable | D | 10.18 | $ 5.99 | 14.59 | $ 5.19 | 16.40 | $ 3.38 |
| Standard Subsystems | E | 9.46 | 6.71 | 13.86 | 5.92 | 15.68 | 4.10 |
| Standard Spacecraft | F | 9.06 | 7.11 | 13.29 | 6.49 | 15.06 | 4.72 |
| Best-Mix (Cluster-Mix) | G | 8.96 | 7.21 | 12.91 | 6.87 | 14.55 | 5.23 |

## Payload cost factors[3]

Two factors that operate in an interrelated fashion to control payload cost are:

1) Uniqueness of design, and
2) Need to maximize performance for minimum size, weight, and power.

NASA studies have shown that there are at present 87 operating or planned civilian spacecraft representing 43 different spacecraft types. Thus, on the average, each type of spacecraft is flown only twice. With the existing constraints, on size, weight, and power, almost each spacecraft type has its own uniquely developed and qualified subsystems. Moreover, the size, weight, and power constraints prohibit the designer from incorporating excess capacity or margin in his design. These requirements lead to costly designs, extensive testing, and tight production control. Although technology is often carried over from one design to the next, the need to fit performance to each unique spacecraft/mission requirement often results in redesign and requalification. These same factors further compound the payload cost problem by leading to small quantity builds with limited test and flight experience.

With the advent of the Shuttle, it will be possible to alleviate the requirements to minimize size, weight, and power. The reduction of these physical constrainst will open the possibility of development of standard subsystems and standard spacecraft, with major potential for improved reliability and cost. The Standard Subsystems could be applied to all three classes of Shuttle payloads, while many of the unmanned spacecraft payloads could make use of standard spacecraft configurations.

## Payload design[4]

### Standard subsystem modules

The detailed requirements of 45 different automated payload programs were examined in a NASA study, and it was concluded that a specific inventory of standard modules can be identified. These may be applied not only to mission peculiar spacecraft, but also to standard spacecraft, cluster spacecraft, sortie modules, and research and applications modules. The inventory of standard modules does not appear to be dependent upon the specific mission model (i.e., the mix of missions as a function of time), and can be applied using simple module variants to other mission models. A universal inventory of standard modules appears to be readily obtainable. Fig. 1 illustrates the potential savings from the use of standard hardware. When compared to a baseline of mission peculiar spacecraft, a total savings of more than $6 billion is forecast during the period of 1975-90. As shown in Table 1, the savings increase with increasing modularization and standardization, and decrease as the shuttle operator cost increases from $7.3 to $10.5 million per mission.

The general configuration of a typical standard module is shown in Fig. 2. The modules are designed to provide for easy access, removal, and installation without need for special tools. Module size and weight are determined by the requirement for easy installation by a shuttle crewman. A simple mechanical and functional interface is provided between modules, and operating tolerances on individual modules are selected so that module replacement will not require payload recalibration.

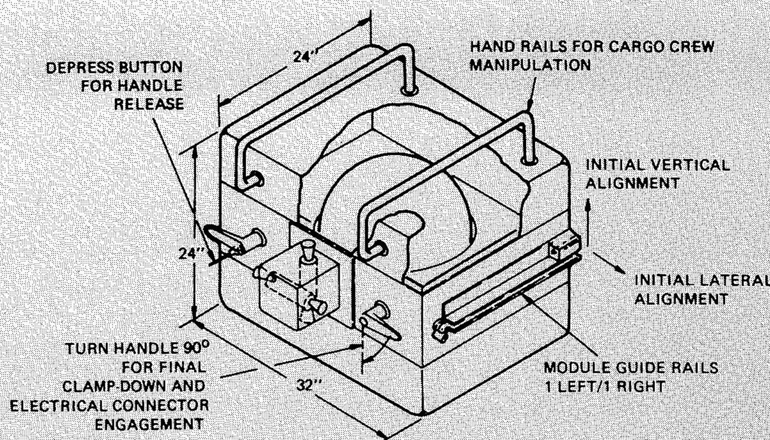
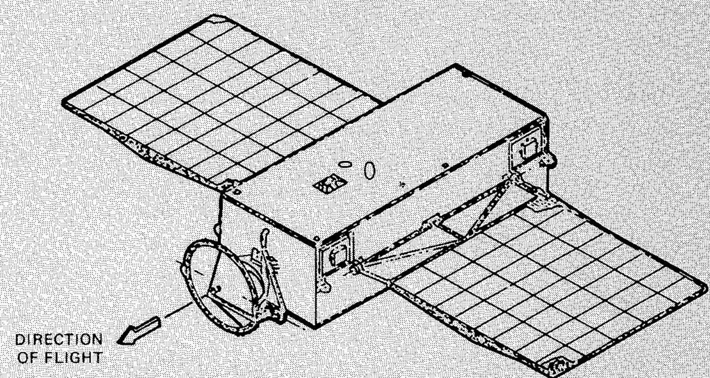
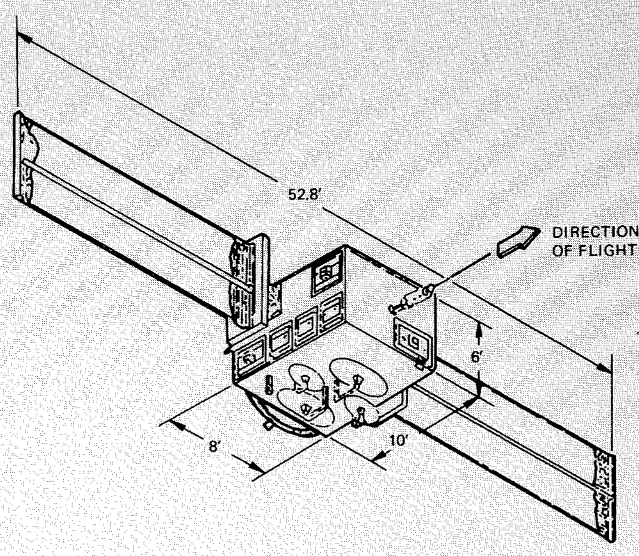



Fig. 2 — Typical standard module.




Figs. 3 and 4 — Different spacecraft configurations employing common or standard structural elements.

## Standard and cluster spacecraft

Standard and Cluster Spacecraft are defined as:

*Standard spacecraft*: A small quantity of different types of spacecraft, incorporating standard subsystem modules, each type capable of replacing a significant number of mission peculiar spacecraft defined in the NASA mission model. The spaceframe, integral wiring harnesses, and thermal control elements of each standard spacecraft type are standardized.

*Cluster spacecraft*: A spacecraft incorporating standard subsystem modules and capable of supporting concurrently the experiment/sensor packages of several missions defined by the NASA mission model.

The designs of the standard spacecraft and cluster spacecraft for all missions except the large observatories such as HEAO-C, Large Stellar Telescope (LST), Large Radio Observatory, and Large Solar Observatory can have similar appearance and utilize common structural elements; the sizes vary depending on the mission. Fig. 3 and 4 are typical configurations. The designs of the single-mission standard spacecraft and the multi-mission cluster spacecraft for the low earth-orbiting observatory missions are quite similar; the principal differences in the cluster spacecraft are:

1) The length of the spacecraft is increased about 2 feet to accept additional spacecraft and experiment peculiar modules,

2) The average power requirements are higher and require additional battery modules and solar arrays, and

3) An additional mounting adapter and articulation yoke are required to allow simultaneous pointing to two different targets.

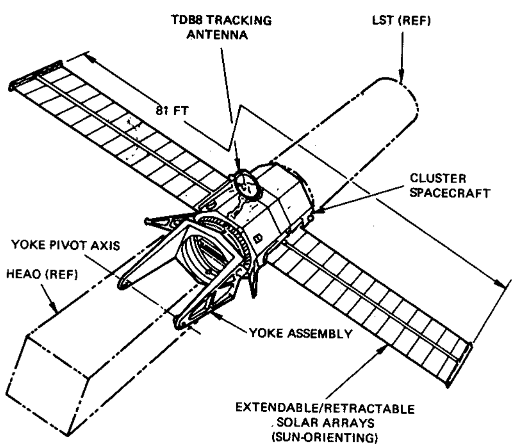



**Fig. 5 — A cluster spacecraft which is an extension of standard subsystem modules.**

**Table II — Standard and cluster spacecraft savings for 15 LEO missions**

| | | | | $ Billion | | | |
|---|---|---|---|---|---|---|---|
| | | | | $7.3M Shuttle | | $10.5M Shuttle | |
| Type Hardware | Case | Payload Cost | Payload Saving | Total Program Cost | Total Savings | Total Program Cost | Total Savings |
| Expendable Payload | A | $ 8.21 | — | $ 9.10 | — | $ 9.10 | — |
| Low-Cost Refurbishable | D | 4.35 | $ 3.86 | 5.51 | $ 3.59 | 6.00 | $ 3.10 |
| Standard Subsystems | E | 4.05 | 4.16 | 5.21 | 3.89 | 5.70 | 3.40 |
| Standard Spacecraft | F | 3.65 | 4.56 | 4.68 | 4.42 | 5.11 | 3.99 |
| Cluster Spacecraft Mix | G | 3.55 | 4.66 | 4.26 | 4.84 | 4.57 | 4.53 |

Fig. 5 shows a typical cluster supporting the HEAO and LST experiment packages.

Both the standard spacecraft and the cluster spacecraft appear to be straightforward extrapolations of the application of standard subsystem modules to mission peculiar spacecraft. The significant difference between the standard and cluster spacecraft missions is that the Cluster offers a decrease in transportation costs, because the shuttle visits only a single orbit point to provide support to several missions. A limitation of the study was the use of standard and cluster spacecraft for only the low earth-orbiting (LEO) mission. Table II compares the payload and program total cost and savings for the 15 LEO missions studied for the two shuttle users costs of $7.3M and $10.5M per flight.

Although the use of standard and cluster spacecraft for synchronous equatorial and Planetary missions was not considered in the study, their application to these missions appears to be both feasible and desirable, and should afford further savings.

## Conclusions

The availability of the payload capacity of the Shuttle Orbiter will alleviate or remove the need to minimize the size, weight, and power demands of payload subsystems. The removal of these constraints will make it possible for system planners to specify and develop families of standard subsystems for use in the Shuttle payloads. The standardization of subsystems will provide economies in design, development, production, and testing. Standard spacecraft, and multi-mission standard spacecraft, called cluster spacecraft, appear to be logical extensions of the standard subsystem concept and should result in further economies in payload design.

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# White noise test evaluation of power tubes

**H. J. Werntz**

**This paper discusses a test which measures the linearity characteristics of rf electron power tubes under conditions similar to actual operation, such as in data transmission applications. This white noise loading test for power output and signal-to-intermodulation distortion of linear amplifier tubes fills the need for an improved testing technique for the more sophisticated radio communication systems and is specified by Method 2206 of MIL-STD-1311. The test method is explained and compared to the classical two-tone test. Results are given of tests performed on RCA linear amplifier power tetrodes. These test results are compared with the results of the two-tone test.**

THE CURRENT TREND in radio communications, especially in the military, is toward the use of single-sideband service to optimize the use of the rf spectrum. This mode of operation, particularly when used for multichannel applications, requires highly linear systems.

### Single-tone and two-tone tests

It is impractical to establish a tube or system test based on a voice signal because of the irregular wave forms and the varying ratios of peak-to-average signal power found in various voices. A convenient testing method is to use a single-tone driving signal (such as from a sinewave audio signal generator) to modulate the SSB transmitter. Such a test signal at full modulation will operate the amplifier at a steady peak envelope power level and the amplifier performance can be determined by meter readings. However, this single-tone test does not give information on the linearity of the amplifier. To test linearity, a means must be provided to vary the output level from zero to maximum signal in a regular pattern. One such method is the two-tone technique, which is defined in Method 2204A of MIL-STD-1311. This technique uses two sinewave signal sources which are combined and represent two sideband frequencies. Intermodulation distortion products appear only when the rf signal has a varying envelope amplitude. When an rf signal having a varying amplitude is passed through a non-linear device, many new distortion products can be produced. In some non-linear devices, the frequency and amplitude of each component can be determined mathematically and can be represented by a power series. Even-order products resulting from even-order terms in a power series do not fall near the two fundamental tones. All odd-order products fall near the desired frequencies and possibly within the passband of the tuned circuits. The distortion products which are usually measured are the third- and fifth-order intermodulation distortion products which can fall within the passband of a tuned circuit intended to pass voice or other intelligence. Because third order harmonics are generated by the differences between the second harmonic of one test tone and the fundamental of the other test tone, third-order harmonics appear at frequencies above and below the two tones and are displaced by an amount equal to the difference in frequency of the test tones (see Fig. 1). The amplitudes of the third- and fifth-order intermodulation distortion products are measured in dB-down from the amplitude of either of the two equal fundamental test tones. The third- and fifth-order intermodulation products produced by the two-tone test method provide a figure of merit and serve only to permit a comparison between tubes, amplifiers, and systems.

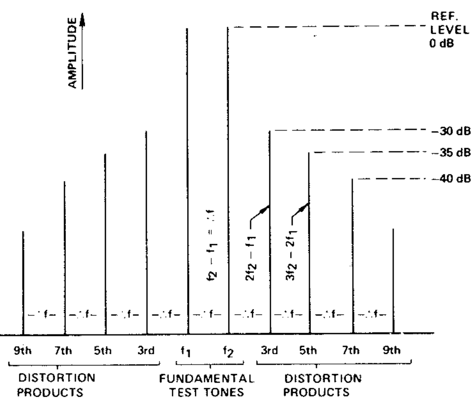
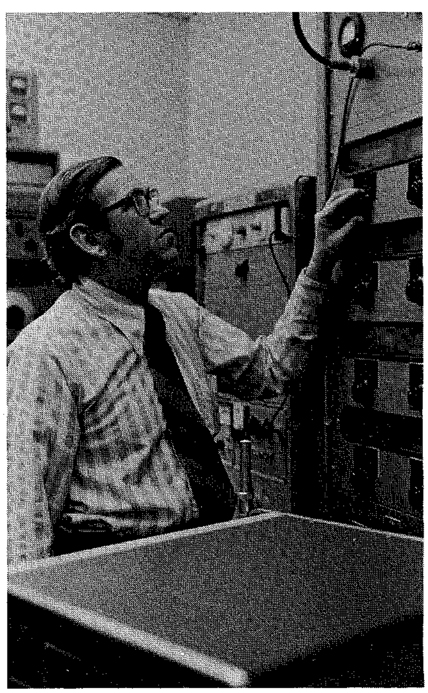



**Fig. 1 — Two-tone frequency test presentation.**



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Because this technique measures the distortion products produced between two specific frequencies and ignores harmonics above the fifth order, it can be misleading in many applications. For instance, seventh- and ninth-order harmonics can be quite powerful and present strong interference in multichannel communication systems. Moreover, the two-tone test is performed at peak power and hence ignores the possibility that difference in intermodulation distortion products occur in many tubes at reduced power levels. Also, in actual practice, a multiplicity of frequencies are present and no measure is taken of their effect. The two-tone test thus does not simulate even a basic voice communication. With multiplexing, frequency shift keying, and data transmission, the differences are considerably greater.

Single-sideband service first originated with a single voice or teletype channel. As various forms of multiplexing entered the single-sideband-usage picture, the modulating signal, by virtue of its complexity, lost a great deal of its single-signal peaking characteristics and took on more of an averaging characteristic. Two-tone testing at peak envelope power ratings does not adequately define the linearity requirements of the more sophisticated single sideband systems.

## White noise test

Because of the limitations of the single-tone and two-tone tests, a new system-evaluation method was developed by industry and the military. This method employs all frequencies in the useful audio spectrum and, consequently, gives a more accurate measure of performance. In this method of measuring the noise-power ratio the transmission channel(s) is loaded with a white-noise signal of Gaussian amplitude distribution having an

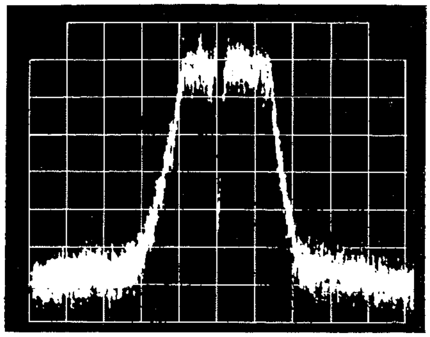


**Fig. 3 — Waveform of white-noise test signal.**

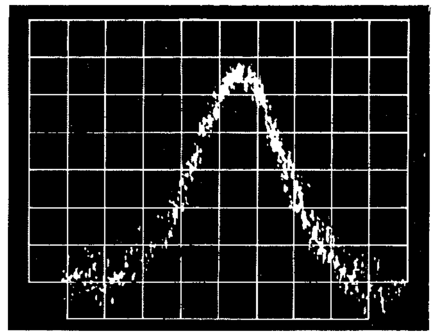


**Fig. 4 — Waveform of notch.**

insertable, narrow notch located near the center of the channel passband. This method, which is defined in MIL-STD-188C (Military Communication System Technical Standards), is basically a system test in which the noise signal in the audio-frequency range is passed through the transmitter, and Noise Power Ratio is measured at the output of the receiver. In this case, both input and output are in the audio-frequency range.

The linear-amplifier power tube is used in the output stage(s) of the single sideband (SSB) transmitter and is operated at an rf frequency (1 to 32 MHz). Because of the frequency of operation, the white-noise test method, as defined in MIL-STD-188C, had to be modified to be adapted for a tube test. This modified tube test was prepared by the JEDEC Single Sideband Subcommittee, submitted to the military, and issued as Method 2206 of MIL-STD-1311. It is similar to the systems test except the input noise signal (as shown in Fig. 2) has a 12-kHz bandwidth (representing four audio channels). A photograph of the white-noise test signal is shown in Fig. 3. A photograph of the notch is shown in Fig. 4. The center frequency of the notch is in the frequency range of 1 to 32 MHz, instead of 1600 Hz for the systems test. The noise test signal may be initiated at an audio or rf level. The RCA test uses a noise-test signal, which is translated to an rf frequency with the notch center at 4 MHz.

The output of a perfectly linear device which introduces no interference due to blower noise, inter-element resistance, arcing, *etc.* would be a perfect replica of the input. However, because of the non-linearities inherent in every amplifier, the depth of the notch is reduced by the generation of noise, harmonics, and interference. The relative depth of the notch with respect to the average signal amplitude is a measure of the effective performance of the tube in linear applications. The system test measured all noise in the system regardless of the source, because any noise affects the intelligibility of the transmission. The same is true of the tube test. However, the primary concern in the tube test is the noise contributed by the intermodulation distortion products generated within the tube with noise from other sources reduced to a minimum. It was necessary, therefore, to develop associated equipment of high linearity to eliminate its effect on the measurement. A block diagram of the test setup is shown in Fig. 5.

Fig. 6 is a photograph of the RCA white noise test set. It consists of three basic units: the driver, the tube-under-test chassis with its associated metering, and power supplies. The white-noise driver

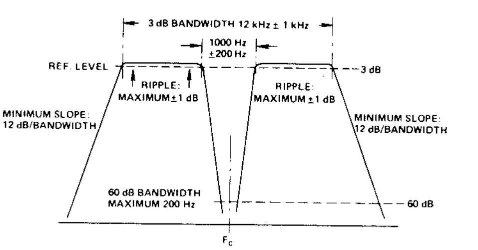



**Fig. 2 — Characteristics of power-tube white-noise test signal (notch-in-case).**

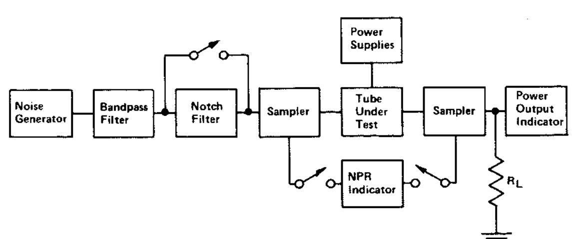



**Fig. 5 — Block diagram of test setup.**

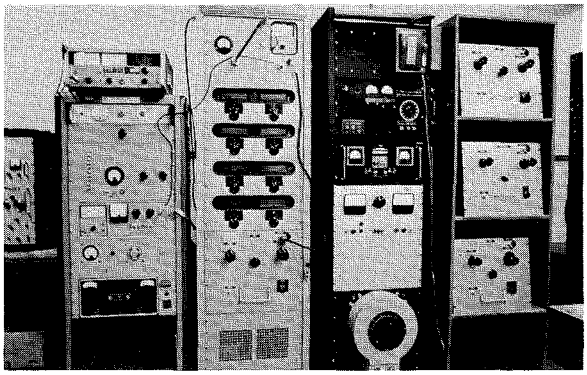


Fig. 6 — RCA white-noise test equipment.

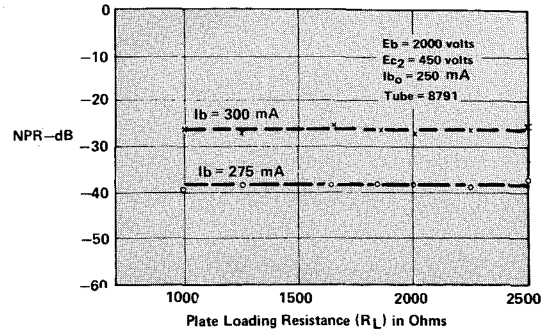



Fig. 7 — Noise power ratio versus loading.

was designed and developed under contract to RCA by the Research and Advanced Development Laboratory of Electronic Communications Inc., St. Petersburg, Florida. This driver meets the requirements of Method 2206 of MIL-STD-1311. Its output power is continuously variable between 10 mW and 100 W at a minimum notch depth of −50 dB.

### Test set operation

For the white-noise test, the tube under test is set up to its static operating conditions. The tube is then driven with the test signal shown in Fig. 2, but with the notch out. It is driven to a specified value of an average dc plate current or mean noise-power output measured at the resistive load of the tube under test. Other conditions for drive may also be desirable. The voltage across the load is measured with a Hewlett Packard 3400A rms voltmeter. The mean noise power output is calculated by squaring the measured rms voltage and dividing by the load resistance. The output of the tube under test is sampled and fed back to the noise power ratio (NPR) or signal-to-intermodulation distortion (S/IMD) indicator. The amplitude of this sample can be adjusted so that it will indicate a 0-dB reference level on the indicator. The notch, as shown in Fig. 2, is then inserted in the noise drive signal. The amplitude of the noise drive signal is then adjusted to the same specified value of average dc plate current or mean noise-power output of the tube under test as for the notch-out case. A sample is then taken from the bottom of the notch appearing in the output signal of the tube under test. This sample is fed back to the indicator and measured with respect to the 0 dB reference level. *NPR* or *S/IMD* is the ratio of the mean noise powers measured in the notch-filter bandwidth for the notch-in and notch-out conditions with total system mean noise-power output equal for both conditions. This ratio is indicated by a direct meter reading. The *NPR* can be measured for the output and the input for the tube under test. The accuracy of the *NPR* or *S/IMD* indicator used with the driver is ±3/4 dB.

The tube-under-test chassis contains a grid-driven amplifier circuit. The grid circuit is untuned, not neutralized, and "swamped" with 50 ohms at the grid of the tube. The output circuit is a variable-Pi network to match the tube to a 50-ohm load. Meters having an accuracy of 0.5 % are used to measure the voltages and current of the tube under test. All power supplies except the one for plate voltage are electronically regulated to 1.0% or better for line/load variations.

### Performance evaluation

An evaluation of the test set was made on RCA tube types 8791 and 8792. Both tubes are RCA Cermolox tetrodes designed specifically to meet the high linearity and low noise requirements of modern single sideband equipment. The evaluation for type 8791 was performed at a plate voltage of 2000 V and a screen-grid voltage of 450 V. These voltages were the same values used for a two-tone intermodulation distortion test at a peak envelope power of 500 W.

The variables during the evaluation were plate idling-current, drive, plate loading, and "cathode feedback." The grid-No. 1 bias was adjusted for plate idling currents of 150mA, 200mA, and 250mA with drive powers varied to produce average dc plate current increases of 25-mA increments above the plate idling currents until high grid-No. 1 currents were drawn which produced poor noise-power ratios. The plate loading was adjusted for 1000, 1250, 1650, 1850, 2000, 2250, and 2500 ohms. The plate-loading measurements were made with a Hewlett Packard 4815A rf vector impedance meter with the tube cold. All of the above combinations were evaluated with no "cathode feedback," 5 ohms "cathode feed", and 10 ohms "cathode feedback." The "cathode feedback" is provided by a non-inductive, unbypassed resistor between the tube cathode and ground.

The data obtained showed the similarities and differences between white noise tests and two-tone tests even though there is no interdependent mathematical correlation between the results for the types of ssb tests.

The similarities are as follows:

1) The noise-power ratios improve similarly to third-order intermodulation products with increasing plate idling currents. There are both minimum and maximum boundary conditions for the plate idling current that depend upon the transfer characteristics of the tube and its operating conditions, but these conditions generally apply to both types of SSB tests.

2) The distortion improves with increasing small amounts of "cathode feedback." The distortion-cancelling effect of the cathode resistance improves with increasing resistance, but a maximum value is reached that actually causes a degradation in distortion. Here again, these observations apply to both types of SSB tests performed on the RCA tetrodes.

3) The distortion degrades as the tube starts to draw grid-No. 1 current and is progressively worse as the grid current increases. The cause of this degeneration may be peak clipping resulting from saturation of the transfer characteristic or from a load change reflected back to the drive source.

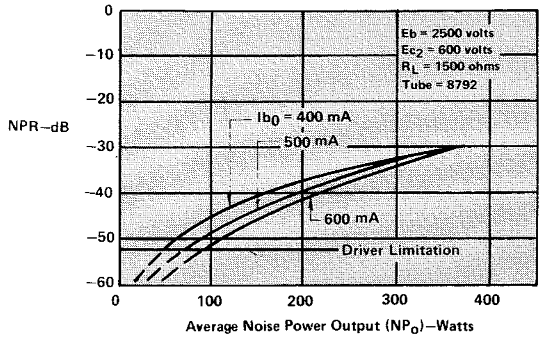



Fig. 8 — Noise power ratio versus noise power output.

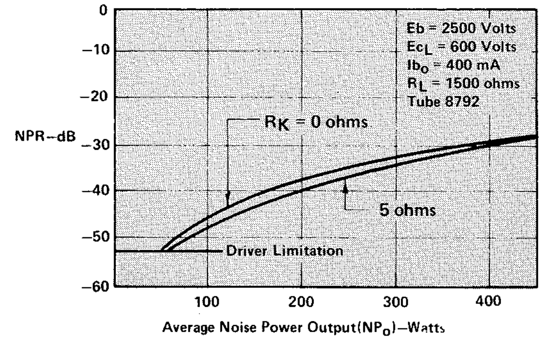



Fig. 9 — Noise power ratio versus noise power output for cathode resistance.

The differences are as follows:

1) The noise-power ratio is not as sensitive to a change in plate loading and cannot be optimized for the individual tube as is the case for two-tone testing. Fig. 7 indicates practically no change in *NPR* for type 8791 when the load was varied between 1000 and 2500 ohms and driven to the same average dc plate current. Theory would predict this observation to be true forsboth ssb tests because the tube is driven to the same level on the transfer characteristic. Practice does not always agree with theory in the two-tone test, and it is often possible to find a distortion cancelling region which is not exhibited in the white-noise test.

2) The tube-to-tube variation for *NPR* is small and more closely defines the basic tube design, whereas the two-tone test gives a much wider range of third-order intermodulation products because of the many parameters that can be varied to optimize the linearity of the individual tube. When these parameters are held constant, a wide variation of third-order intermodulation is witnessed when a group of tubes is tested. In the two-tone test, any odd-order harmonics above the fifth order are ignored in the test results. If one can visualize the white noise test as an infinite number of two-tone tests occurring simultaneously with an infinite number of frequency and amplitude combinations over a four-channel audio bandwidth, one can see why this test more closely approximates actual ssb operation and gives more meaningful results.

3) The tube draws grid-No. 1 current at a much lower average plate current level during the *NPR* test. Typically, in two-tone ssb testing, the 8791 can be driven from a plate idling current of 250 mA to an average two-tone plate current of approximately 425 mA before the tube draws positive grid-No. 1 current. The same tube will start to draw positive grid-No. 1 current when the tube is driven with a gaussian white noise signal from a plate idling current of 250 mA to an average dc plate current of approximately 300mA. This difference is due to the high peaking characteristic of the white noise signal and emphasizes the need for a "stiff" dc bias supply and "stiff" driver.

The evaluation of type 8792 was performed at a plate voltage of 2500 V and a screen-grid voltage of 600 V. These values were the same values used for a two-tone intermodulation distortion test at a peak envelope power of 1200 W. Again, the variables during the evaluation were plate idling current, drive, plate loading, and "cathode feedback." The grid-No. 1 bias was adjusted for plate idling currents of 400, 500, and 600 mA with drive powers varied to produce mean noise power outputs between 50 and 350 W. Plate loading was adjusted for 1000, 1200, 1500, and 1800 ohms. "Cathode feedback" tests were made at 5 and 10 ohms, in addition to tests without any "cathode feedback." The similarities and differences noted between the two types of SSB tests during the evaluation of type 8791 were again observed during the tests on type 8792.

A plot of *NPR* as a function of noise power output for type 8792 for various plate idling currents ($I_{bo}$) and a plate load of 1500 ohms is shown in Fig. 8. A similar plot for type 8792 at a plate idling current of 400 mA and a plate load of 1500 ohms showing the improvement in *NPR* with the addition of a 5-ohm cathode resistor to the test circuit is shown in Fig. 9.

| | | | |
|---|---|---|---|
| DC Plate Voltage | 2500 | 2500 | V |
| DC Grid No.2 Voltage | 600 | 600 | V |
| DC Grid No.1 Voltage | –74 | –70 | V |
| Zero Signal DC Plate Current | 500 | 600 | mA |
| RF Load Resistance | 1500 | 1000 | Ω |
| Average DC Plate Current | 560 | 695 | mA |
| Average DC Grid No.2 Current | –10 | –11 | mA |
| Driver Power Output | 4.5 | 8.5 | W |
| Output Circuit Efficiency | 90 | 90 | % |
| Noise Power Ratio (NPR) | –40 | –40 | dB |
| Unbypassed Cathode Resistor | 0 | 5 | Ω |
| Useful Noise Power Output ($NP_o$) | 200 | 265 | W |

Fig. 10 — Class AB, CCS operation with white-noise loading as specified in method 2206 of MIL-STD-1311 at 4.0 MHz.

In addition to the above, variables, the screen-grid voltage was varied between 525 and 650 V with no change in noise power ratios for the same noise-power output. For this comparison, the grid-No. 1 bias was adjusted to maintain the same plate idling current for each screen-grid voltage. The screen-grid voltage affected the noise power ratio only when it was reduced to a level which resulted in insufficient plate current for $AB_1$ operation.

Typical class-$AB_1$ operating conditions for RCA type 8792 using a gaussian white noise drive signal is shown in Fig. 10. These conditions are typical for tubes designed specifically to meet the high linearity and low noise requirements of modern single sideband equipment.

These observations have been limited to RCA Cermolox ssb tetrode tubes and it is not implied that these conclusions can be applied to all other types of power tubes.

## Conclusion

The *NPR* or *S/IMD* test is similar to the two-tone test. The two tests use the same type test chassis, power supplies, and metering. The drive signal is different, however, and the test result is a direct meter reading. The most significant characteristic of the *NPR* test is that it is less sensitive to variations in plate loading and screen-grid voltage. The tube draws grid-No. 1 current at a much lower average plate current. The *NPR* test signal more nearly approaches the actual conditions of the more sophisticated ssb applications. The tube-to-tube variation for *NPR* is small and more closely defines the basic tube design which is the real value to the tube user.

# Automatic diagnostic testing of a large-scale communications subsystem

**M. E. Fohl**

**This paper describes the diagnostic features included in the R100, the developmental model of a communications switch controller. All facets of the system are described, including a processor structure designed for ease of test and diagnosis, the techniques for test generation and fault isolation, and the external hardware required for test application. Current results are discussed, as is an outline of modifications of and extensions of the current diagnostic system.**

THE TEST EQUIPMENT AND DIAGNOSTIC PROCEDURES discussed in this paper were designed for use only after a hardware failure has been detected in the subsystem under test. Although the equipment and procedures may be valuable in prototype development and production testing, their primary purpose is corrective maintenance.

There are five criteria which characterize a diagnostic system:

*Automation*: Minimum dependence on operator intervention.
*Speed*: Minimum time between initiation of test procedure and replacement of faulty components.
*Diagnostic resolution*: Isolation of actual failure to minimum number of replaceable modules.
*Cost*: Minimum testing hardware/tested hardware; minimum software costs.
*Test coverage*: Capability to exercise maximum amount of hardware in the unit under test.

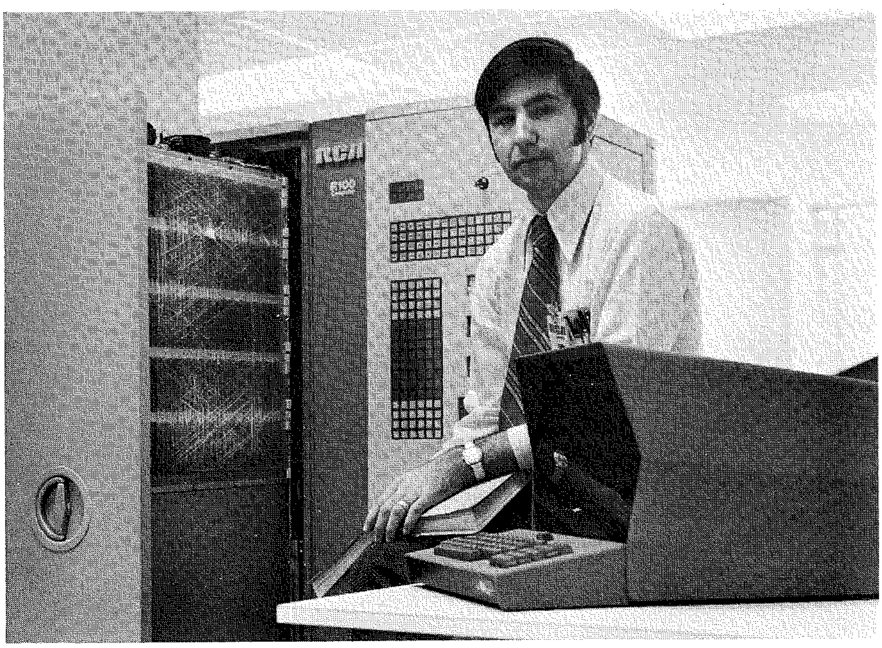
All of these criteria except the last are functions of the external hardware and software dedicated to test and diagnosis.Test coverage is partly a function of access points where stimuli can be applied and responses can be observed. This capability must be provided in the design of the machine to be tested. If this capability is introduced early enough in the design cycle, minimum penalties are imposed upon the logic designer, and the diagnostic results and ease of debugging of the original machine are significantly enhanced.[1]

This paper deals with the test and diagnostic effort for a central processing unit. There are two reasons for this. First, the processor is usually the largest and most complex element in a communications system, therefore requiring special diagnostic considerations. Second, in the absence of any other diagnostic equipment, the processor can function as a test vehicle for other system elements, and the integrity of the processor is a prerequisite for such testing.

## Computer architecture, test generation, and failure isolation

The easiest method of testing large-scale digital machines is to partition the machine into an arbitrary number of manageable segments and then to test each segment. If the segments are small enough, generating tests for each segment is very simple, and a crude level of fault isolation is already established.

**Mark E. Fohl**, Digital Equipment Technology, Government Communications Systems Division, Camden, New Jersey, received the BS in Engineering from Case Institute of Technology in 1969 and is currently completing work toward an MS in Systems Engineering at the University of Pennsylvania. Mr. Fohl joined RCA in 1969 as a member of the engineering rotational program. Upon entering the Communications Systems Division, he was responsible for test generation software for the Diagnostic Control Unit of the R100 Processing System. He was also responsible for conception, design, and implementation of the fault isolation programs used in conjunction with the diagnostic tests. Mr. Fohl was also involved in several design aids and design automation programs associated with the development of the R100.

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**Final manuscript received February 14, 1973.**

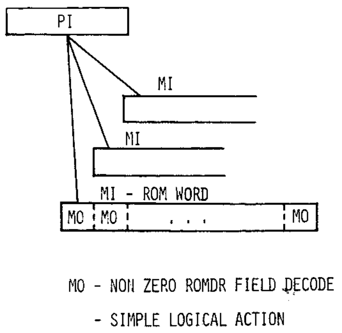


**Fig. 1 — Microprogram control structure.**

The foundation of the R100 diagnostic system is the microprogram control structure of the central processing unit. Each of the program instructions, *e.g.*, Load Register, Branch on Condition is implemented by a series of sequentially accessed words from read-only-memory (ROM) called microinstructions (MI's). Each MI, in turn, is composed of 21 control fields (see Fig. 1). A decoded nonzero value of a control field is called a micro-operation, or MO. The MO, when logically combined with processor timing signals and possibly other machine conditions, controls the execution of elemental processor functions such as resetting registers and triggering counters. (The zero value of each control field, which is very important for diagnostic purposes, simply means that no action is initiated by the field.) All processor operations can be defined in terms of MO execution. A complete test of the processor, therefore, consists of tests for all MO's, and of verification of the means by which parameters are supplied to the MO's and the means by which execution of the MO's can be observed.

In the R100, the outputs of all machine registers are observable at the maintenance panel. Most machine registers, including the ROM Data Register (ROMDR), from which MO's are decoded, are also loadable from the maintenance panel. In addition, the timing level generator is both observable and controllable from the maintenance panel. The registers and timing level generator are the means of supplying parameters to the MO's. Certain functional elements of the R100, *e.g.*, the adder and counters, are the means by which MO execution can be observed.

A crude level of partitioning the machine into manageable segments is achieved by specifying registers, timing, functional elements, and MO control as separate entities. Tests for machine registers consist of verifying the ability of each bit of each register to change from a 0 value to 1 and then from 1 to 0. A test for the timing level generator consists of verifying its ability to properly sequence through all its states. In the actual test procedure, these tests are executed first. They serve not only as a check for the particular elements, but also as a rough check on the interface between the machine and the testing hardware. Tests for functional elements can be generated by some suitable automatic or semi-automatic procedure.

A very fine level of partitioning is available by virtue of the ROM control structure. Logic associated with each MO becomes a segment for diagnostic purposes. Each MO is isolated for individual testing by forcing to 0 all fields of ROMDR except the one which contains the MO under test. Fig. 2 shows a typical MO and its implementation. The contents of the program counter are transferred to the memory address register by MO 6 at Timing Level α. The implementation of this MO can be viewed as a three-input function for each bit:

$$MAR_n = MO\ 6 \cdot (TL\ \alpha) \cdot (PC_n)$$

Assuming the normal fault modes of gates ( . *i.e.*, gate inputs or outputs stuck-at-1 or stuck-at-0, no multiple faults, and no intermittent faults), tests can easily be prescribed for this MO. Four tests are necessry to test this MO for every fault mode. All MO's are tested in this fashion.

Since there are more similarities among MO's than differences, the test generating procedure for all MO's can easily be automated. A set of tests is prescribed for each type of MO (MO's which transfer register contents, MO's which add register contents, etc.). A computerized file of all MO descriptions is then scanned to determine which MO's are of the type under consideration, and MO numbers, register names, and timing level values are used as parameters to the test generation procedure. The computerized file of MO's is of particular value during the original design cycle of the machine, since many MO's are changed, added, or deleted. The task of bookkeeping under these circumstances is too laborious and too error prone to be done manually.

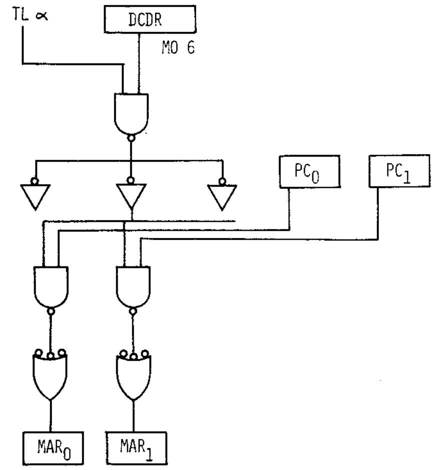


**Fig. 2 — Implementation of a typical micro-operation.**

One further set of tests is required, and that set consists of verification of the contents of ROM. This is easily done by accessing each ROM word, *i.e.*, depositing each word into ROMDR, and comparing the actual contents to the correct contents.

The next problem is associating replaceable hardware with test failures. This is a simple matter when considering the tests for machine registers and functional elements, since each register or function occupies three or four printed circuit boards at most. The difficulty arises in the tests of the MO's. A tracing procedure has been developed [2] which can determine all the hardware associated with each MO. Fig. 3 shows MO 6 as it may be partitioned in the actual machine. Four printed circuit boards (PCB1-4) are shown, as are some of the necessary interconnections. The tracing routine proceeds basically as follows:

1. Determine wire information of source pin.
2. Record wire name and MO number.
3. If wire name is identical to destination register name, stop.
4. Determine destination pin(s) of wire.
5. Determine printed circuit board (PCB) location of each destination.
6. Determine PCB type(s).
7. Determine affected PCB output pin(s).
8. Replace original source by new output pins; go to step 1.

In the first pass of this routine, the source pin in step 1 is the output pin at the ROMDR decoder of the MO under consideration. The destination register name of step 3 is the register affected by the MO (in the example of Fig. 3, the destination register name is MAR).

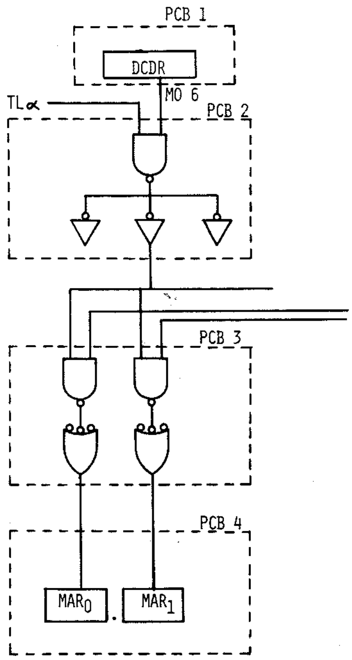


Fig. 3 — Partitioned MO 6.

Three data files are necessary for execution of this procedure: A list of all wire names and associated destination pins ordered by wire source pin; a list of the PCB types for each location; and a list of all affected PCB output pins for each input pin of each type. This information is available as part of the other R100 design automation systems (wire-wrap, PCB layout, etc.)

Note that in Step 2 of the procedure, the wire name is recorded along with the MO number. When the traces for all MO's are obtained, it is possible to determine those MO's common to each wire name. This is the basis for creation of a diagnostic dictionary. If the test procedure indicates that a certain group of MO's fail, then the faulty hardware must be common to all of them. The diagnostic dictionary is organized by groups of MO failures and the corresponding common logic. In the event that a non-ideal failure yields an MO failure pattern for which there is no diagnostic dictionary entry, then the faulty element must be one of those elements which implement any of the MO's whose tests failed. In this case, the results from the traces of each MO can be used for fault isolation.

### Diagnostic control unit

The Diagnostic Control Unit (DCU) shown in Fig. 4 is the external hardware which applies test stimuli to, and accepts responses from, the R100 processor. Its primary components are an input medium, a comparator, and an interface with the processor under test. It depends on the processor under test only for dc power, so it can execute any tests on the processor regardless of the nature of the failure. The simplicity of the DCU has two important ramifications. First, it is small enough to be portable, and one DCU can be shared among several processors. Second, its simplicity makes it less prone to failure than any subsystem it tests, and it is almost simple enough to perform self-diagnosis.

The DCU interfaces with the processor at the maintenance panel. All signals to and from the processor can originate from or terminate at either the maintenance panel or the DCU. Hence, the timing level generator and the machine registers are available to the DCU, and the DCU becomes an automated maintenance panel. Fig. 5 is a simplified block diagram of the paper tape reader-DCU-processor interconnections.

All input to the DCU is in the form of instructions. The three instructions are Load, Step Timing, and Read. A Load Instruction passes data from the DCU to a specified machine register. A Step Timing Instruction contains a specific timing state to which the processor is to be advanced. The Read Instruction, also called a test, contains data to be compared with the actual contents of a specified machine register. Along with each Read Instruction is a decimal test number to be used for the identification of MO failures. In practice, the Load and Step Timing instructions are used to supply parameters to the MO's and the actual tests are executed by the Read Instructions. As an example, consider one of the tests for MO 6 (see Fig. 2, above). Consider a test which verifies that MO 6 executes properly when all control signals are present. The sequence of DCU instructions would be:

| | |
|---|---|
| LOAD all 0's → ROMDR | initialize ROMDR |
| LOAD all 0's → MAR | initialize destination register |
| LOAD 11 1's → PC | initialize source register |
| LOAD MO 6 → ROMDR | i.e., load the decode value into ROMDR |
| STEP TIMING → TL α | advance timing level generator |
| READ MAR; COMPARE with all 1's (test number 6) | compare actual contents of MAR with all 1's |

All MO tests are similarly written.

Once a failure is detected in the processor, the DCU test procedure begins. Normal operation of the processor is disabled, and the DCU, processor, and paper tape reader are interconnected. The processor is initialized via a General Reset, and the paper tape reader is properly loaded. Tes-

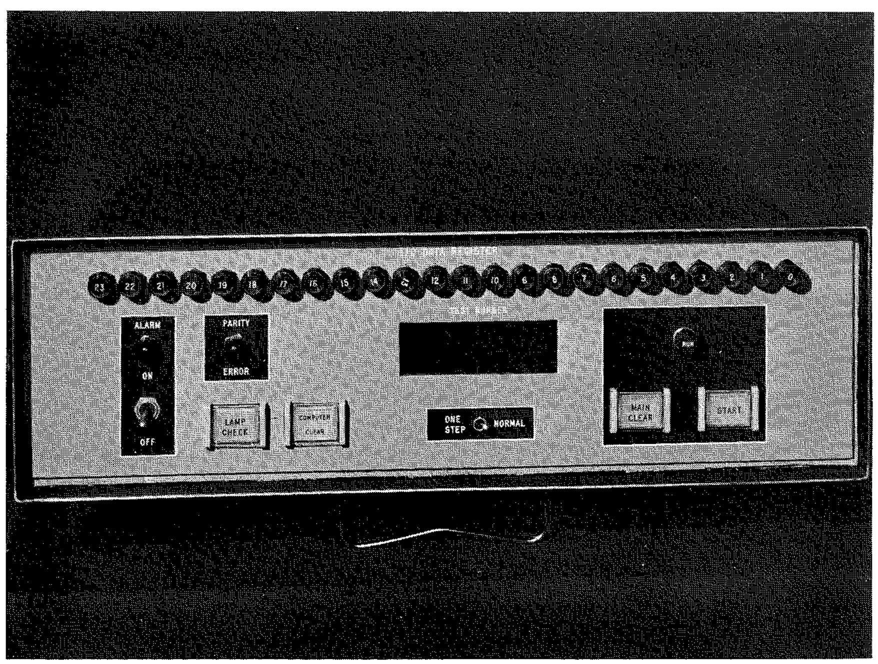


Fig. 4 — Diagnostic Control Unit (DCU).

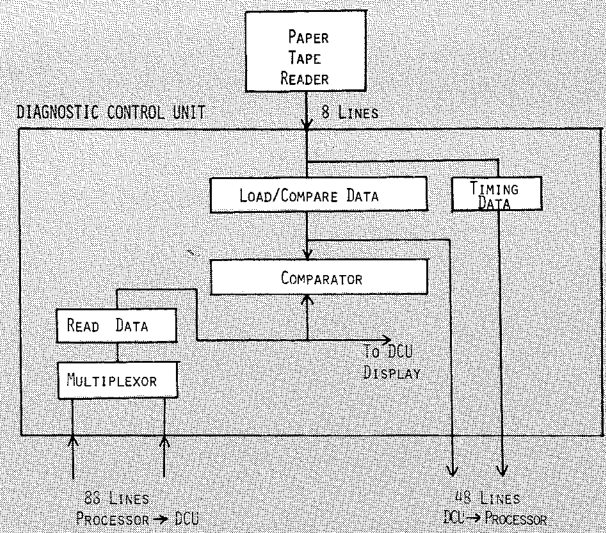


**Fig. 5 — Paper tape reader — DCU — Processor interconnections.**

ting begins by depressing a start button on the DCU console. Instructions are continuously fed to the DCU until a test failure occurs, at which time it stops and displays the identification number of the failed test. An operator records the identification number of the failed test and restarts the DCU. When all tests have been exhausted, the diagnostic dictionary is searched for an entry which matches the series of recorded test numbers. The suspected faulty printed circuit boards are then replaced.

## Results

The developmental model of the DCU is now fully operational; *i.e.*, the interface has been verified, and diagnostic tests have been successfully executed. The current input medium is a 300-character-per-second paper tape reader. About 95% of the necessary software has been written. The total test package will involve about 28,000 instructions (about 190,000 paper tape characters), of which 8,000 are actual tests. Total test time, assuming a continuous reel of paper tape, would be about 11 minutes. A first-cut version of the diagnostic dictionary has been developed. Use of the dictionary with the MO test programs yields an average four printed circuit boards per failure.

The DCU was a very useful debugging tool during R100 checkout. Several types of processor errors and failures were discovered, including wiring errors, discrepancies between documentation and implementation of the machine, printed circuit board failures in instances where the boards were not subjected to a vigorous test procedure, and failures in the ROM. In addition, during the development of the diagnostic dictionary, selected failures were inserted in the R100, and the results of the diagnostic dictionary were verified.

At the beginning of this paper, five criteria of a machine diagnostic scheme were introduced. The DCU will now be examined in light of those criteria.

*Automation* — The functions of an operator in this scheme are to connect cables from the DCU to the processor under test and the paper tape reader; to mount and rewind the reels of paper tape containing the tests; to record test failures as they occur; and to search the diagnostic dictionary for an entry corresponding to actual results. This procedure is susceptible to human error, of course, but a lot less so than a procedure in which tests are applied manually and comparisons of actual to correct responses are made manually.

*Speed* — Mean-time-to-repair is now about 35 minutes (5 minutes cabling and initialization, 25 minutes test, and 5 minutes parts replacement). The factor contributing most to the long test time is use of the paper tape reader. Not only is the input speed slow, but large volumes of data cannot be rapidly handled. The current scheme however, provides an enormous time savings over manual methods. The DCU can verify the contents of the R100's 512-word, 80-bit ROM in less than 3 minutes. It has been estimated that this task would require about 3 man-days if done manually.

*Diagnostic resolution* — A resolution to four printed circuit boards is satisfactory considering that of 360 printed circuit boards in the R100, approximately 30% of them are universal logic modules.

*Cost* — A strong feature of the DCU is its low cost. Also, it is small enough to be portable, and can be shared among several processors.

*Test coverage* — Maintenance panel access to the timing level generator and machine registers allows test coverage of about 90% of the processor logic. Most of the logic for which there is no access involves the real-time interrupt structure and ports to peripheral devices. A rationalization for this is the fact that the uncovered logic can be exercised by software test and maintenance routines.

An alternate method of test application might involve replacement of the DCU by a Diagnostic Transfer Channel (DTC) for multiprocessor operations. In this scheme, the DTC would be a buffer between the testing processor under test. All data transmission between the testing processor and the DTC would be executed by program instructions. Data to be loaded into the processor under test would first be transferred from the testing processor to the DTC, then to the processor under test. In Read Instructions, the testing processor would send an address to the DTC, and the DTC would fetch the contents of the appropriate register in the unit under test and send it back to the testing processor. The testing processor would then compare the data with a predetermined value and record the failure if it occurred. When the tests were exhausted, a list of test failures would be printed, and an operator would search the diagnostic dictionary for a matching entry.

The primary advantages of this scheme are a significantly increased speed of test execution and a removal of some dependence on operator intervention. The primary disadvantage is that each DTC would be housed with its own processor under test, hence a small increase in system cost.

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# Automated test facility for engineers

**W. A. Harris | E. J. Sass | R. C. Ubben | J. R. Hannum**

**With the increasing demand on engineers for shorter design cycles, higher technical performance from equipment, and lower design costs, it is apparent that the procedures used in the past will not suffice. Because of this, GCS took steps several years ago to find a solution. The result was an Automated Test Facility to aid engineers in their design and development of equipment.**

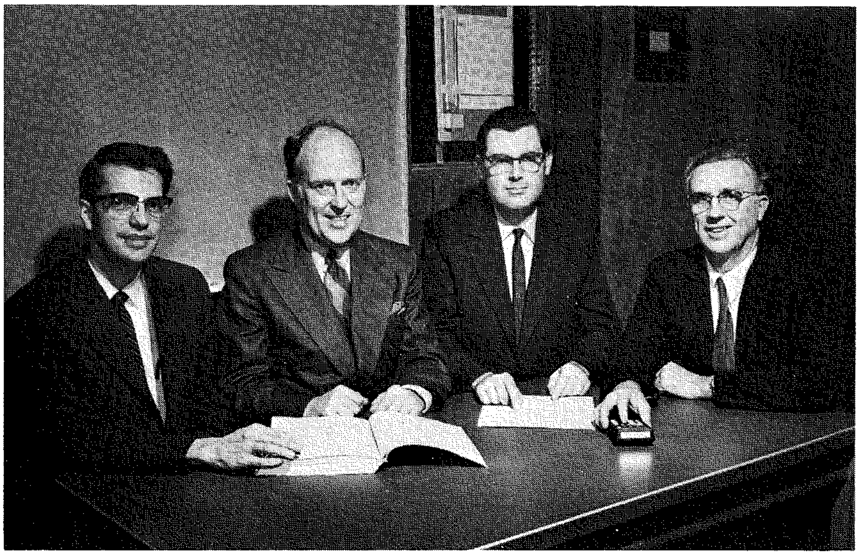
**Walter A. Harris,** Mgr., Advanced Development, Communications Equipment Engineering, Government Communications Systems, Camden, New Jersey, received the BSEE in 1940 from the University of Arizona and did graduate work at the University of Pennsylvania and Drexel Institute of Technology. After joining RCA in 1940. Mr. Harris assisted in design of several commercial broadcast transmitters and designed the AVT-112 Aircraft Transmitter, and portions of the Navy ATB HF Transmitter. He was later responsible for the design applications of vacuum tubes and the solution of tube problems affecting equipment design. As Leader, Mobile Communications, Mr. Harris managed a group which designed a number of commercial HF and VHF Transmitters and Receivers, both mobile and fixed station. Mr. Harris was responsible for the transmitter design and production follow-up of the AN/ARC-34. He then became Manager of the UHF Airborne Communications Engineering Group, where his responsibilities included the AN/ARC-34, AN/ARC-48, and AN/ARC-62. As Staff Engineer, CSD, Mr. Harris provided engineering assistance on a number of design problems including AN/GRC-50 Radio Relay, GKA-5 UHF Transmitter/AN/ARC-104, AN/ARC-142 HF Transceivers, and Airborne TACSAT Transceiver; he managed a group which designed the AN/PRC-35 Army Pack Set (the first pack set which was fully transistorized); and he managed a group which designed and produced classified electronic warfare equipment. From 1969 to the present, Mr. Harris has managed the Communications Engineerin-Advanced Development Activity with responsibilities for the activity's IR&D projects and advanced techniques contracts. Mr. Harris is a Senior Member of IEEE, Past Chairman of Philadelphia Aeronautical and Navigational Electronics IRE Professional Group, and a member of Franklin Institute, Audio Engineering Society, NPA and AOPA.

**Earl J. Sass,** Ldr., Advanced Development, Communications Equipment Engineering, Government Communications Systems, Camden, New Jersey, received the BSEE in 1945 from the University of Nebraska and the MSEE in 1954 from the University of Pennsylvania. He joined RCA after receiving his undergraduate degree and worked on rf and i.f. coils and transformers and the first RCA printed-circuit television tuner. He was then assigned responsibility for product design of picture and sound i.f. amplifiers for RCA's first commercial color television receivers. Next, he supervised half of the electrical design of commercial color television receivers and remote control receivers. He then transferred to RCA's Government Communications Systems Division where he was responsible for the design of 1) the ground receiving equipment for the DYNA-SOAR Project and 2) a part of the GRC and 744 PROJECT. Later he was responsible for the design and development of the AN/TRC-97 exciter, receiver, and shelter. At present, he is Group Leader in charge of the advanced development for military radio equipments. Included in this group is the Automatic Test Facility. He holds three U.S. patents and is the co-author of five published articles. He is a Senior Member of the IEEE, is a registered Professional Engineer in the State of New Jersey, is a member of the Armed Forces Communications and Electronics Association, is a member of Sigma Tau and Pi Mu Epsilon, and has received an RCA Professional Excellence Award in 1967.

**Roger C. Ubben,** Advanced Development, Communications Equipment Engineering, Government Communications Systems, Camden, New Jersey, received the BSEE from Iowa State College in 1958 and the MSEE from Drexel Institute of Technology in 1963. He joined the Communications Division of RCA in 1958 where he worked on a feasibility model of a 2-GHz parametric amplifier. Later, he was responsible for the airborne receiver mixers and varactor multipliers for the local oscillator and transmitter on the DYNA-SOAR Program. From 1963 to 1967, he was employed by the Westinghouse Electric Corporation where he developed an fm modulator and a wideband, phaselocked, pm modulator. He also worked on the development of a universal demodulator for a.m., pm, fm, and pulse signals. In 1967, he rejoined RCA where he has worked on several uhf power amplifiers, designing the protection and control circuits and the feedback a.m. modulators. He has developed several programs for the automatic network analyzer. Mr. Ubben is a member of the IEE and Eta Kappa Nu and a registered professional engineer in the State of Maryland.

**John R. Hannum,** Advanced Development, Communications Equipment Engineering, Government Communications Systems, Camden, New Jersey, received the BSEE in 1969 from Syracuse University and the MSEE in January, 1972, also from Syracuse University. While attending S.U., he worked as a technician and engineer in the Medical Electronics Laboratory where he assisted in the development of electrocardiographic and magnetocardiographic instrumentation. He joined RCA in 1970 and worked on i.f. filters for the RCA MIC up-down converter and also assisted in the development of the RCA digital synthesizer for a high-performance hf receiver. He was next given responsibility for the development of an MSK modem as part of the Tactical Radio Communications Study (TRCS). Because of his background in computer theory and application, he was also made responsible for engineering support of the Automatic Test Facility (ATF). In this capacity, he has developed a number of programs to enhance the ATF measurement capability. At present, he is part of the team working on the development of a compressive receiver and is also assisting on various proposal efforts.

The authors, left to right, Roger Ubben, Earl Sass, John Hannum, and Walter Harris.



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THE AUTOMATED TEST FACILITY (ATF), located in Building 10-7 in Camden, N. J., has now been in successful operation in the Communications Equipment Engineering section of Government Communications Systems, CSD, for over two years. A basic element of the ATF, shown in Fig. 1, is two automatic network analyzers capable of total characterization, via *S*—parameters, of any one- or two-port, active or passive device, over the frequency range from 100 kHz to 12.4 GHz. Additional elements of the system place under computer control many of the test instruments which were formerly manually controlled as well as a whole new breed of instruments designed especially for computer control. As a result, the ATF is able to perform tests and analyze data that would be unobtainable by network analyzers alone. Because of its automatic mode of operation, the ATF speeds analysis by as much as a factor of ten, minimizes human error, provides repetitively uniform and highly accurate measurements, formats and displays the results, and, with its operational speedup feature, affords the engineer more time for design work and problem solving.

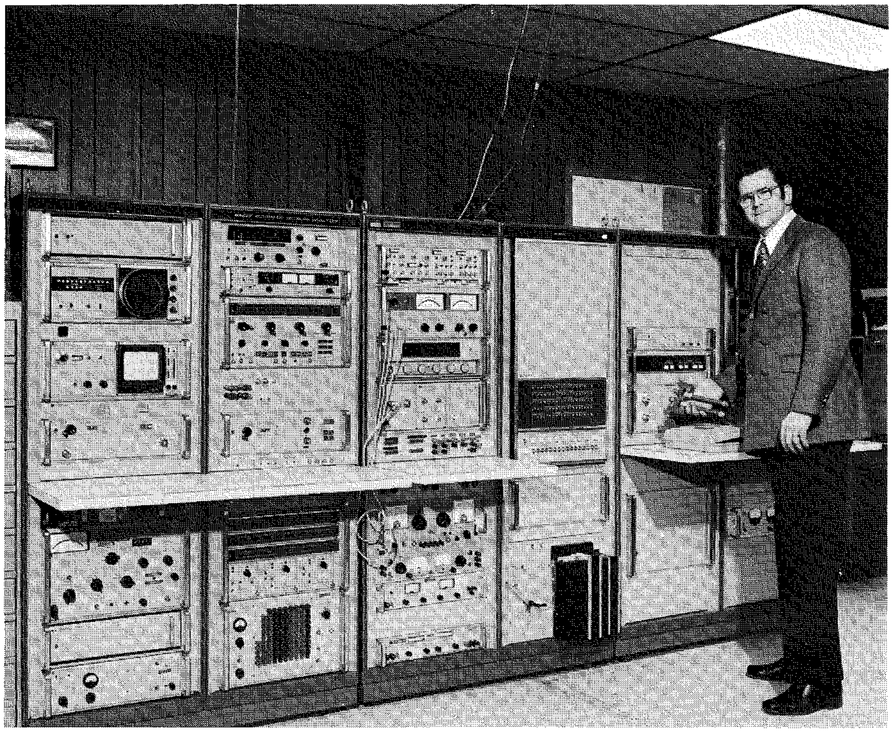

Fig. 1 — The Automated Test Facility (ATF) with Edward Stevens, system analyst for the ATF.

The ATF can be divided into three major subdivisions. The Hewlett-Packard (HP) 8542 automatic network analyzer system is used for circuit characterization over the frequency range of 110 MHz to 12.4 GHz. The HP8543 automatic network analyzer system performs circuit characterization over the frequency range of 100 kHz to 110 MHz. Additional subsystems, not part of either of the above systems, are used in the special purpose measurements, such as bit-error-rate or short-term stability.

## Automatic network analyzer

For measurements in the frequency range of 110 MHz to 12.4 GHz, the HP8542 automatic network analyzer system is used. This system is made up of an rf stimulus subsystem, a measurement subsystem, and a control and digital processor subsystem, as shown in Fig. 2.

The rf stimulus subsystem utilizes a plug-in oscillator covering the 110-MHz to 12.4-GHz range with three rf units and a frequency synthesizer incorporated as a precision frequency reference. In operation, the rf unit of the plug-in oscillator appropriate to the desired rf frequency is selected by the computer. The synthesizer is automaticaly set to a subharmonic of the required rf frequency. The rf oscillator output is then phase-locked to the appropriate harmonic of the synthesizer frequency. This results in a worst-case tuning accuracy of 1 part in $10^6$.

The measurement subsystem consists of two selectable test sets and a network analyzer unit. The test set is a passive device that selectively feeds the proper signals to the network analyzer and the device under test to determine the scattering parameters of the test device. Each test set contains broadband directional couplers, a calibrated line stretcher for line length equalization, and an array of microwave switches. Two test sets are required, one for the 110-MHz to 2-GHz band and the other for the 2-GHz to 12.4-GHz band. They are switch selectable. In operation, the output of the rf subsystem is channeled to the test set appropriate to the frequency concerned. Then, under computer direction, the test set switches the rf to the device under test and switches the reflected or transmitted signal from port 1 or port 2 to the network analyzer unit.

The network analyzer subassembly is a two-channel instrument that makes amplitude and phase measurements from 100 MHz to 12.4 GHz to determine reflection and/or transmission coefficients of a test device. It includes a dual-slope, integrating, analog-to-digital converter to digitize measured information for data manipulation and polar and rectangular displays for both corrected and uncorrected data. In operation, the test channel output from the test set is channeled to the network analyzer where it is compared in amplitude and phase with a reference signal. The resulting amplitude and phase differences are digitized and sent to the computer.

All automated test operations are overseen by the control and digital processor subsystem. This subsystem consists of an HP2116B instrumentation computer with 16,384 words of 16 bit/word core memory, and 48 input/output (I/O) channels, a teletype, and a high-speed line printer. All operator commands to the automatic test system are in the form of alphanumeric data. Input to the computer is from either the teletype or high-speed punched tape reader. Measurement data output is done on either the high-speed tape punch or the line printer. Operator communication

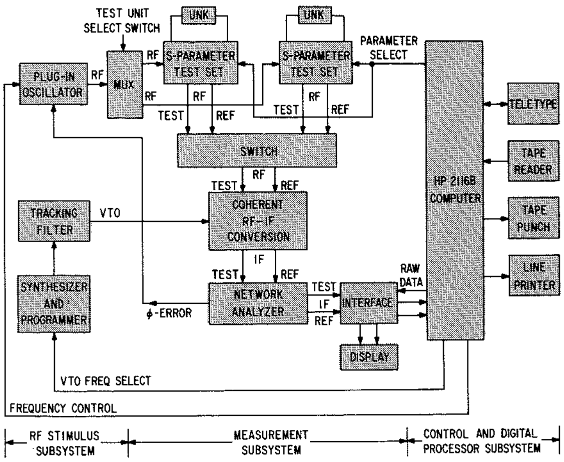


**Fig. 2 — Block diagram of HP 8542 network analyzer system.**

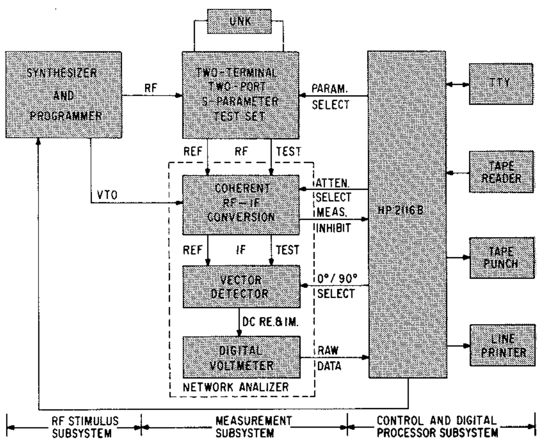


**Fig. 3 — Block diagram of HP 8543 network analyzer system.**

with the computer is fully interactive via the teletype terminal.

For measurements in the frequency rance of 100 kHz to 110 MHz, the HP8543 network analyzer system is used. It is similar to the HP8542 system and is shown in Fig. 3.

## Software

The versatility and ease of the use of the ATF is due, in large measure, to the system software. The software can be divided into four main classifications: utility software, measurement software, special software, and diagnostics.

### Utility software

Utility software is made up of those programs that are used in the construction of other programs. Under this heading come the Symbolic Editor, a program or text construction and editing program; the Fortran compiler; the assembler; the Algol compiler; the basic control system loader; the basic interpreter; and a number of other software manipulation programs. Most programs are written by first constructing a source tape in either Fortran or assembly language using the Symbolic Editor. This source tape is then compiled or assembled, as appropriate, resulting in a machine language relocatable tape. This relocatable tape, along with necessary subroutines and library functions, is loaded by the basic control system loader and a machine language object tape is punched. The machine language object tape can then be loaded into the computer and the program started.

### Measurement software

The bulk of the programs of the ATF come under the heading of measurement software. Included in this classification are all the general purpose measurement programs of the HP8542 and HP8543 network analyzer systems, and all the other measurement programs such as crystal filter tests, short-term stability measurements, and bit-error-rate measurement programs.

In general, the measurement programs operate in two sections. In the first, or calibration section, the system is calibrated by placing calibration standards at the test device ports. By comparing the measured results with the known theoretical results, system errors are found and stored in computer memory. In the second, or measurement section, the device to be tested is connected and measured. The raw data is corrected according to the system errors stored in the computer. Thus, the corrected data has the system errors removed and is a true representation of the test device. This corrected data is then manipulated mathematically as required to present the desired output (*e.g.*, *Z*-parameters, *Y*-parameters, reflection, return loss vswr, and gain). Because of their nature, some measurement programs such as short-term stability or bit-error-rate measurement require no calibration.

### Special software

Under the heading of special software comes specialized mathematical programs, demonstration programs, and assorted other programs not easily fitted in any other category.

### Diagnostics

The last software classification is at least as important as the measurement programs. This is the diagnostic classification. Programs in this group are used to detect errors, faults, or poor performance in the network analyzer system's hardware. While such errors could be traced by hand, the speedy, comprehensive analysis performed by the diagnostics is a great help in insuring performance and minimizing "down time" caused by hardware problems.

## Operation

For most tests, the test operation proceeds in four phases: setup, calibration, measurement, and display.

In the setup phase, the operator loads the correct measurement program to give the output data desired by the customer and sets up the system control panels to place the proper network analyzer under computer control. The operator then starts the program and enters the calibration phase.

In the calibration phase, the operator places known standards on the test ports of the network analyzer being used and instructs the analyzer via the teletype to perform certain operations. The purpose of this phase is to identify and measure system errors so that they may be removed from the measurements of the unknown device.

The third phase is the measurement phase in which the network analyzer applies rf stimulus to the device under test, measures the response, and corrects for the previously measured system errors. The corrected data is stored in the computer memory.

In the last phase, the display phase, the operator instructs the computer how to display the data (printout, plot, punched tape, Z-parameters, Y-parameters, etc.). The computer then performs the necessary math to convert the measured S-parameters to those called for by the operator and then prints or plots or punches as directed. Figs. 4 and 5 show, respectively, a sample printout and sample oscilloscope display of representative test data.

## Accuracy

When a computer is used to control and gather the measurement data, large amounts of corrections that would be time consuming by hand calculation can be quickly performed. The correction terms are stored in the computer's memory for fast access.

Two basic measurements are made on an unknown device. The first determines the input characteristics by sending a known signal from a 50-Ω generator into the device input port and measuring the amount of signal reflected from the device's input. This term is the input reflection coefficient and is also the $S_{11}$ term used in S-parameters. Previously obtained correction factors can be applied to this number to correct for variations in the coupling factor of the directional coupler used to separate the forward and reflected signals, and to correct for the directivity of the directional coupler and source impedance variations due to imperfect transmission lines and adapters.

The second type of measurement determines the transmission characteristics by connecting a known signal from a 50-Ω generator to the input and measuring the output signal across a 50-Ω load. This term is the transmission coefficient and is also the $S_{21}$ term used in S-parameters. Again, correction factors can be applied to correct for crosstalk between input and output ports, directional coupler variations in the output, and load impedance variations due to imperfect transmission links and adapters. Fig. 6 shows the system flow graph model for correcting the measurements.

The remaining two parameters, $S_{22}$ and $S_{12}$, are obtained by reversing the unknown and repeating the two measurements previously described.

When large transmission losses (greater than 40 dB) are to be measured, system noise can be a problem. Accuracy can be improved by averaging many readings and this decision is performed by the computer software. Phase accuracy also decreases with large transmission losses and multiple readings are used to increase the phase accuracy.

In measuring the reflection coefficient, values near zero (impedances near 50-Ω) are the most accurate. Reflection coef-

R C A AUTOMATIC TEST REPORT NUMBER ************* * 5956 * *************

4 DEC 1972

20 MHZ CRYSTAL FILTER.

FORWARD:

| FREQ | REFL | ANG | RTN LOSS | VSWR | GAIN | PHASE | DELAY |
|---|---|---|---|---|---|---|---|
| 19997.000000 | | | | | | | |
| | .8527 | 149.26 | 1.38 | 12.676 | -52.278 | -148.02 | .000000E+00 |
| 19998.000000 | | | | | | | |
| | .8333 | 133.40 | 1.58 | 10.996 | -36.878 | -169.71 | .882583E-03 |
| 19999.000000 | | | | | | | |
| | .6040 | 69.48 | 4.38 | 4.050 | -12.397 | 100.40 | .750308E-03 |
| 20000.000000 | | | | | | | |
| | .1868 | -170.49 | 14.57 | 1.460 | -4.965 | -114.77 | .750308E-03 |
| 20001.000000 | | | | | | | |
| | .6969 | -110.83 | 3.14 | 5.599 | -11.232 | 16.73 | -.634731E-03 |
| 20002.000000 | | | | | | | |
| | .8602 | -150.74 | 1.31 | 13.308 | -37.180 | -65.48 | -.822063E-03 |
| 20003.000000 | | | | | | | |
| | .8658 | -162.22 | 1.25 | 13.906 | -51.591 | -82.57 | -.138414E-03 |

Fig. 4 — Printout of bandpass filter characteristics.

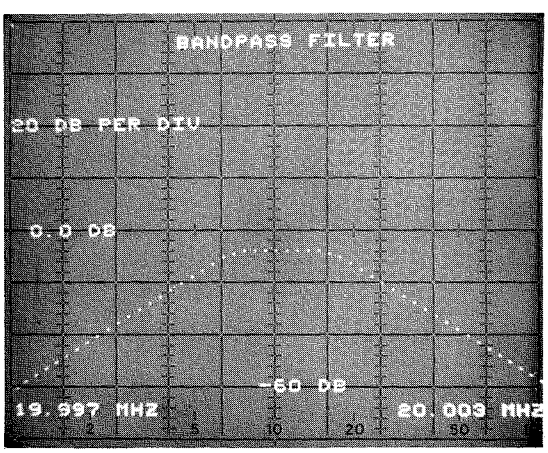


Fig. 5 — Oscilloscope display of bandpass filter response.

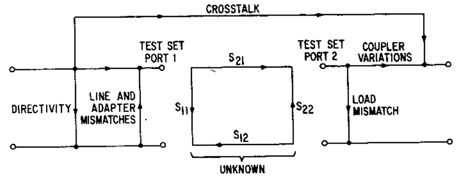


Fig. 6 — Test system model.

ficients near one result in good phase accuracy but poor magnitude accuracy, because the forward signal and the reflected signal are nearly equal and small errors can result in large errors in the real part of the impedance, although the reactive part still has good accuracy. Fig. 7 shows the amplitude and phase accuracies obtainable with the network analyzer.

### Applications and advantages

Included in the equipments and devices the automatic network analyzer has measured are Lunar Rover antennas, amplifiers, cables, diplexers, filters, phase inverters, transistors, and triplexers.

Many advantages result from using an automatic network analyzer for these tests: Accuracy equal to routine standards laboratory measurements can be obtained by the designer. Hundreds of readings per minute can be taken over a temperature range of −55°C to +85°C. Complex (vector algebra) error correction are applied to the readings to remove test equipment imperfections. General purpose programs control all measurements and calibrations. A wide range of outputs satisfies most users. The result of these factors is more thorough testing and the generation of complete records of each design.

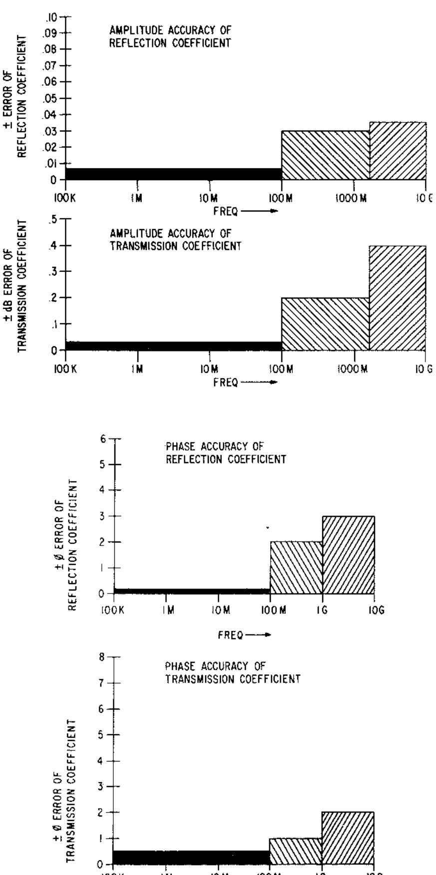


**Fig. 7 — (a) Amplitude and (b) phase accuracies obtainable with network analyzer.**

### Special test features

The third portion of the ATF is made up of a group of auxiliary test instruments which are under computer control. They can be connected with each other and with parts of the network analyzer systems, such as the frequency synthesizer, to perform certain special tests. These auxiliary test instruments include an HP8717 programmable power supply, an HP8405 vector voltmeter, a Systron Donner 1038 frequency counter, a specially constructed bit-error-rate test box, programmable rf attenuators, and assorted power supplies. Using these instruments, tests which cannot be performed on the network analyzer systems, such as oscillator short-term stability tests or the digital system bit-error-rate tests, can be setup and then performed under computer control. Like the network analyzer tests, these tests can also be performed over a temperature range of −55°C to +85°C.

### Noise power bandwidth

In investigating the effect of noise on a communications system, it often becomes necessary to know the noise power bandwidth of a system or, more often, of the bandwidth limiting component of a system. Since manual measurement of noise power bandwidth involves tedious calculations, in addition to a large amount of lab work, it is desirable to automate this measurement using the ATF.

Noise power bandwidth can be defined by reference to Fig. 8. The solid line is the frequency response of some device, *e.g.*, a bandpass filter. The ordinate scale is linear power gain, and the abscissa is linear in frequency. The dashed line is the characteristic of an ideal bandpass filter, the bandwidth of which is the noise power bandwidth of the actual filter. The noise power bandwidth, $B_n$, is found by finding the area under the response curve of the actual device and dividing it by the average power gain near the middle of the

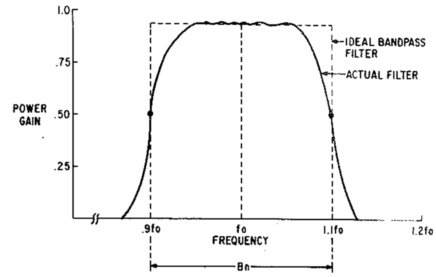


**Fig. 8 — Noise bandwidth illustration.**

passband. Thus, the areas under the response curves of the actual device and the "ideal" device are the same.

The measurement of noise power bandwidth by the ATF is done in two phases. A general-purpose measurement program is first employed to measure the test unit's voltage gain into matched source and load. This measurement is on a linear scale by virtue of the measurement method incorporated in the program. With the voltage gain at each frequency across the designated band available, a special-purpose subroutine calculates the area under the curve between the band limits of the specified measurement band. Then, using an "averaging bandwidth" specified by the user, this subroutine calculates an average mid-band power gain and divides this into the area to obtain the noise power bandwidth

To obtain reasonable accuracy by this method, it is necessary to specify a reasonably small frequency increment (1 to 2% of bandwidth over which measurements are to be taken) and to take measurements between points relatively far down the skirts of the device. Usually, measurements between the -60 dB points of the device provide reasonable results.

### Single-sided phase-noise-to-carrier ratio

As the requirement for spectral purity of signal sources becomes more acute, it has also become necessary to find increasingly accurate ways to specify spectral purity. One such method of specification currently coming into use is the single-sided phase noise to carrier ratio (SSPNC ratio).

The SSPNC ratio is defined as the ratio of power density in one phase-noise sideband, on a per hertz bandwidth spectral density basis, to total signal power. It

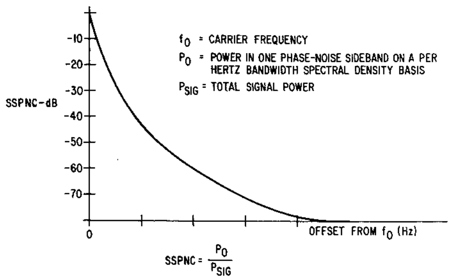


**Fig. 9 — Single-sided phase-noise plot.**

is usually plotted as a function of frequency offset from carrier frequency (see Fig. 9.)

The measurement method to be implemented will be an adaptation of a method presented by the National Bureau of Standards.[1] In this method, a VCO is phase-locked to the test signal source using a wide bandwidth phase-locked loop. If the loop bandwidth is wide enough, the phase detector output, over a short term, is proportional to the phase jitter of the test oscillator. Thus, the phase fluctuations of the test oscillator can be observed directly.

The phase detector is connected to the input of a programmable wave analyzer. Under control of the ATF computer, this wave analyzer tunes across a designated band of frequencies in discrete steps. At each step, the phase detector power output level is measured. This measurement then gives the phase noise power in the wave analyzer bandwidth (typically 10 Hz) at a frequency offset from the oscillator frequency equal to the frequency to which the analyzer is tuned. Since the wave analyzer bandwidth is known and the signal power level is easily obtained, the SSPNC ratio is easily calculated.

### Short-term stabiity measurement

Another method of specifying the spectral purity of a signal source is the short-term stability measurement of the source. This method is slightly less accurate than the SSPNC ratio discussed previously, but is easier to implement and is sufficiently accurate to be useful in many situations.

Short-term stability is usually specified in one of two ways. In the first method, a series of $N$ frequency measurements is made and the statistical mean, $F_m$, and standard deviation, $F_{SD}$, are calculated as shown below:

$$F_m = \sum_{i=1}^{N} F_i / N,$$

where $F_i$ is the $i^{th}$ frequency sample.

$$F_{sd} = \sum_{i=1}^{n} (F_i - F_m)^2 / N-1$$

The short-term stability or rms deviation, $F_S$, is equal to the standard deviation divided by the nominal center frequency of the source, or

$$F_s = F_{sd} / F_o,$$

where $F_o$ is equal to the nominal center frequency source.

The second method is to express the short-term stability as the Allan variance of a series of frequency samples. If $2N$ frequency samples are taken, then the Allan variance is defined as :

$$AV = \sqrt{1/2N \sum_{i=1}^{N} (F_{2i} - F_{2i-1})^2}$$

and the short-term stability, $F_A$, referred to the Allan variance is

$$F_A = AV / F_o$$

The ATF short-term stability measurement program is designed to measure both of the above types of short-term stability. In addition, the program also determines the exact center frequency to which the source is tuned, thus checking tuning accuracy.

In the ATF measurement system, the test source is mixed with a local programmable synthesizer of high stability (1 to 2 parts in $10^8$ in 10 ms.). The synthesizer is under computer control and, after being initially set to the nominal source frequency, is directed by the computer to search for the exact center frequency. When this is found, the synthesizer frequency is offset a certain amount and variations in this offset frequency are measured. All frequency measurements are made by a frequency counter operating under computer control and having as its standard the 1-MHz standard of the ATF. The accuracy of the short-term stability measurement done by this method is directly dependent upon the sampling time of the counter and the number of samples taken. The computer program and operating procedures allow accuracy to be traded off against sampling time and number of samples. Even so, accuracies of 6 to 7 parts in $10^{10}$ are obtainable in a few minutes' time.

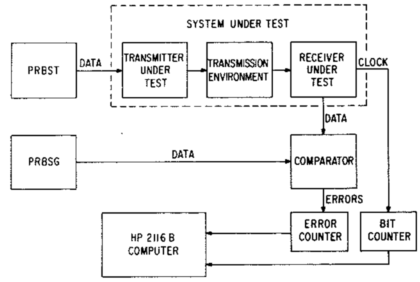


**Fig. 10 — Bit-error-rate test setup.**

### Bit-error-rate measurement

With the increasing importance of digital transmission systems for digitized voice and data communications, it has become necessary to measure the performance of such systems in the presence of random noise, pulse noise, and multipath signals. A good measurement of system performance is the bit-error-rate (BER) of the system which is defined as the total accumulated errors in the received bit stream divided by the total number of bits sent.

The BER measurement system incorporated in the ATF is shown in Fig. 10. The pseudo-random bit stream transmitter (PRBST) sends a fixed length pseudo random bit stream to the transmitter data input port. The bit stream is clocked at the baud rate for which the system is designed. On the receive end, the output bit stream, which is the same as the input stream except for errors, is run into a comparator circuit where it is compared with another pseudo random bit stream generator (PRBSG) that generates the same bit stream as the PRBST. The PRBSG has a built in variable delay so that the bit stream may be delayed to compensate for the delay of the PRBST bit stream that goes through the circuit under test. The comparator provides an output whenever its two inputs differ, thus, providing a way to count bit errors.

In operation, the output of the bit stream comparator is connected to a specially designed counter in the ATF, and the receive clock is connected to the main ATF counter. The two bit-stream generators are synchronized, and the program started. Once underway, the program can monitor the system for hours, if necessary and, when finished measuring, printout the total number of bits counted, total number of errors counted, BER, and log BER. In addition, the user can specify whether he wants a specific number of bits or a specific number of bit errors counted.

### Deviation from linear phase measurement

In the evaluation of the performance of amplifiers and filters for certain applications, it is necessary to know how far the amplifier's or filter's phase characteristic deviates from an ideal linear characteristic. While conventional measurement methods can provide a reasonably good answer in a reasonable period of time, it is useful to have this ability in the ATF, because it provides a more complete analysis of the test unit and requires no additional measurement. All required phase values are already present as a result of the general-purpose measurement program.

Deviation from linear phase is easily defined. Starting with a series of measurements of phase shift through a device at each of a number of different frequencies, the phase shift at a certain frequency $f_{ref}$, is chosen as a reference. A constant phase slope with respect to frequency $\Delta_\theta / \Delta_f$, calculated for this point. Then, the linear phase, $\theta_{lin}$, at any other frequency $f$, is given by

$$\theta_{lin} = \theta_{ref} + (f - f_{ref})\ (\Delta_\theta / \Delta_f),\ \text{where}$$

$\theta_{ref}$ equals angle at $f_{ref}$, and $\Delta_\theta / \Delta_f$ equals phase slope at $f_{ref}$

The deviation from linear phase is then defined as the difference between the actual measured phase shift, $\theta_A$ and $\theta_{lin}$ obtained from the above equation.

$$\theta_D = \theta_A - \theta_{lin}$$

where

$\theta_D$ equals deviation from linear phase.

The general-purpose measurement program measures the phase shift through a device at a number of user specified frequencies and stores the results. However, since the phase measurement equipment of the ATF is limited to phase angle measurements between 180° and −180°, the phase measurements must be made continuous before further processing. A special-purpose subroutine allows the user to specify the point at which the phase slope is to be calculated, makes the measured phase continous, normalizes the measured phase with respect to the phase at the reference frequency, and calculates the deviation from linear phase. The program output is the actual deviation from linear phase in degrees.

### Future plans

The usefulness of the ATF as an engineering tool is directly dependent upon the capability and versatility of the software used. To keep abreast of requirements for engineering development and breadbroad model tests, it is necessary constantly to improve, update, and expand this software. At present, the speed with which programs may be constructed, debugged, and put into service is severely limited by the constant necessity to handle large amounts of punched paper tape. Accordingly, it is expected that in the near future, the ATF will acquire a disc storage system. This will consist of an HP7900 disc-drive and controller, a direct memory access channel for the HP2116B computer of the ATF and the HP disc operating system software.

In the course of the ATF's business, customers have asked for hard-copy plots of data obtained for them by the ATF. Although such plots are available in the form of photographs of the data plotted on a 5-in., square-faced CRT, they are often unsuitable, either because of small size or because it is not easy to mark or draw on a photograph. Because of this market for hard-copy plots of data, plans are now underway to interface an HP plotter to the ATF. The interfacing will be relatively simple, involving only acquisition of the plotter, the corresponding I/O card, and the software required to drive the plotter.

An anticipated project that will open up a whole new field of uses for the ATF is the construction of a system simulation executive program. Such a program will allow a user to specify a theoretical system in an easily usable language. This system will then be entered into the ATF where it will be mathematically constructed. The user may then apply signals to the "system" and observe the results.

This executive program will consist of two main portions. The first of these will be a file of "building block" subroutines, some of which have been written by M. S. Corrington of the RCA Advanced Technology Laboratories. These subroutines are mathematical characterizations of system components such as mixers, detectors, and amplifiers. These subroutines will be the heart of the program because they will perform the calculations that characterize the system. The second portion will be that part which accepts the user's system description and from it determines how to connect the "building block" subroutines. This portion also checks for syntax errors and generally oversees performance of the system.

Development of this program will require extensive research into the capabilities and limitations of sampled-data system approximations to continuous systems. A sampled-data approach must be taken because of the discrete, incremental, nature of digital computer processing. Research will also be required into the area of compiler and executive program construction with a view toward incorporation of the latest methods.

### Other test facilities

Similar engineering test facilities have been established in Aerospace Systems Division, Burlington, Mass.; Electromagnetic and Aviation Systems Division, Van Nuys, Calif.; Missile and Surface Radar Division, Moorestown, N.J.; and the Microwave Technology Center of RCA Laboratories, Princeton, N. J. A factory test facility, Automatic Communications Equipment Tester (ACET) has been established by the factory in Camden. The easy availability of the ATF in the engineering department in Camden establishes automatic tests and procedures which can be carried over into use by ACET.

### Acknowledgment

The authors wish to give special credit to Edward J. Stevens, system analyst for the ATF, for his useful comments and suggestions in the writing of this article. His zeal and initiative have been a major factor in the successful operation of the ATF.

### Reference

1. Shoaf, J. H., *Specification and Measurement of Frequency Stability*, NBS Report No. 9794 (Revised), p. 10.

# Measurement of "popcorn" noise in linear integrated circuits

**T. J. Robe**

**Burst or "popcorn" noise in LIC's exhibits itself as a random, abrupt change in the output voltage, the duration of which can last from 1/2 millisecond to several seconds. These noise voltages are not regular in their occurrence and can often be absent when measuring spot frequency noise. Thus it was necessary to evolve an entirely different measurement system to ensure the selection of a very-high-gain device that is free from "popcorn" noise.**

THE ADVENT IN RECENT YEARS of very-high-gain operational amplifiers operating in the $1/f$ noise-frequency spectrum has placed emphasis on the need for very-low-noise devices. This need is particularly true for operational amplifiers which have either low-offset characteristics and/or offset-null capability.

The traditional methods used to select such devices involve the measurement of either spot or wideband ($\approx$ 10 kHz) noise figures in the $1/f$ frequency range (10 Hz to 10 kHz) at various source resistances. This type of measurement, however, only provides an indication of the average noise power at the measurement frequency and does not reveal the burst ("popcorn") noise characteristics of the Device Under Test (DUT). The metering circuits cannot respond fast enough to measure the effects of burst noise. Fig. 1a shows a photograph of typical burst noise as a function of time for an operational amplifier having poor burst-noise characteristics. This photo illustrates burst noise which is characterized by random abrupt output voltage-level changes that persist for periods from approximately 1/2 ms to several seconds. Additionally, the random rate at which the bursts occur ranges from approximately several hundred per second to less than one per minute. Furthermore, these rates are not necessarily repetitive and predictable.

Consequently, the nature of burst noise prevents its measurement by means of the standard averaging techniques. Instead, a technique to detect individual bursts must be used and a DUT must be under observation for a period in the order of 10 s to 1 min. Fig. 1b shows a photo of the output of a virtually burst-noise-free operational amplifier, the RCA-CA6741T.

## Test configuration

Some of the major questions relevant to the type of test required are:

1) What characteristics of the burst noise should be detected?
2) What test-circuit configuration is most suitable to detect these characteristics?
3) What are the "pass-fail" criteria?

There are three major characteristics of the noise burst which have an impact on the suitability of a device from the standpoint of applications: burst amplitude, duration, and rate of occurrence. Of these, burst amplitude and rate of occurrence are of primary interest to potential users of a particular device. Long-duration bursts (of sufficient amplitude) seriously degrade the performance of dc amplifiers; however, suitable devices could be selected by the rejection of any unit which produced even one burst during some prescribed test period. Therefore, an absolute measurement of burst duration is not a prime necessity.

The rate of occurrence, on the other hand, as measured by the burst count in a given test period could conceivably be considered as a variable of prime importance in the selection process. For instance, a burst-rate of 100/s is clearly objectionable in almost any low-level, low-frequency application, whereas the occurrence of only one low-amplitude burst in a one-minute period might be quite acceptable. Consequently, it is desirable to include flexibility in the testing system so that "pass-fail" criteria can be established on the basis of burst-noise count in some prescribed period of time. The test equipment described herein detects total noise ($1/f$ noise plus burst noise) bursts with amplitudes above a preset threshold level during a given test period and allows acceptance or rejection on the basis of the number of noise voltage excursions beyond the threshold level, in the selected test period.

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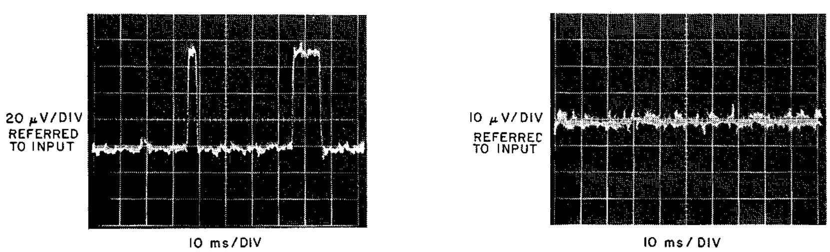


**Fig. 1 — (a) Photo of output waveforms for amplifier with poor burst-noise characteristics; (b) photo of output waveform for the RCA-CA6741T.**

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Another factor to be considered is the bandwidth of the test system. Excessive bandwidth allows the normal "white" noise of the terminating resistors and the DUT to obscure burst-noise occurrences and does not realistically simulate the low-frequency applications in which burst noise is particularly objectionable. On the other hand, a test circuit having excessively narrow bandwidth prevents detection of the shorter-duration bursts ($\approx 1/2$ ms) even if their amplitude is relatively high. A suitable compromise is chosen in which the system rise time permits a burst of "minimum" duration to reach essentially its full amplitude. Because the rise time and bandwidth of an amplifier are related by the equation:

$$BW \approx 0.4/t_r$$

the minimum bandwidth to detect a 0.5-ms burst is approximately:

$$BW_{min} = 0.4/0.5 \times 10^{-3} = 0.8 \text{ kHz}.$$

Consequently, a 1-kHz bandwidth has been selected as a reasonable one for a burst-noise test system and, therefore,

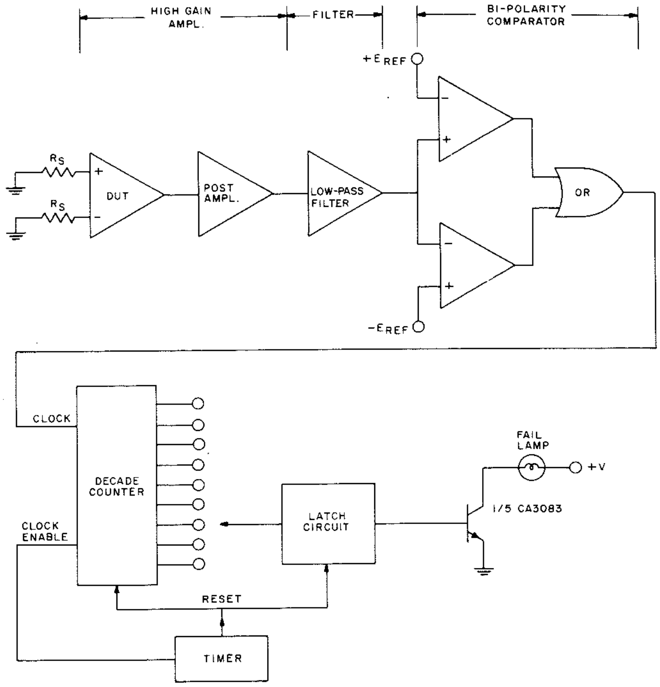



**Fig. 2a — Block diagram of burst-noise test setup.**

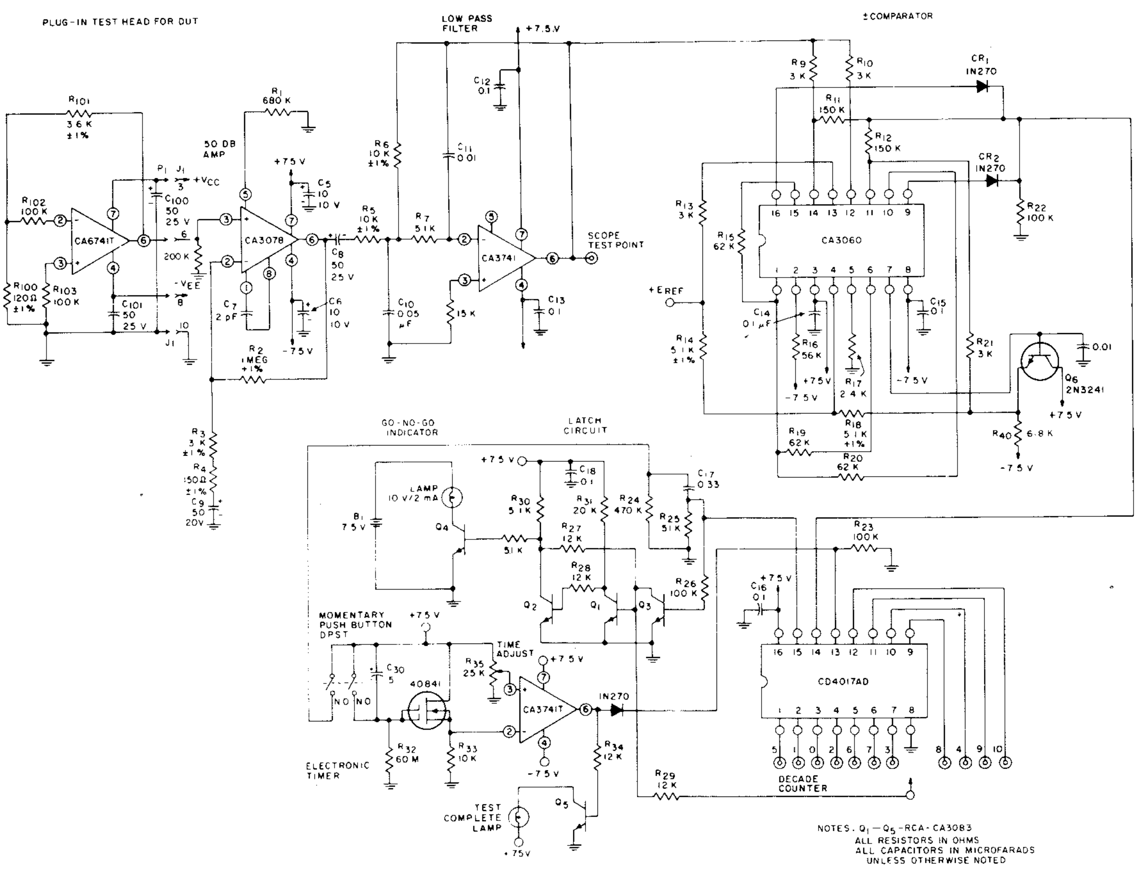



**Fig. 2b — Complete schematic diagram for burst-noise test set.**

prescribes the need for a low-pass filter in the system.

The test requirements outlined above can be implemented with the following circuit elements shown in the block diagram of Fig. 2a. Fig. 2b shows the complete system schematic containing the following components:

1) A fixed high-gain amplifier incorporating the DUT as the first stage to amplify the microvolt-level burst to an easily detectable level and a burst-noise-free unit as the second stage;
2) A low-pass filter to limit the test bandwidth to approximately 1 kHz;
3) A comparator to produce a fast-rise, high-level, single-polarity output pulse whenever an input burst-noise pulse (of either polarity) exceeds a preset (but adjustable) threshold level;
4) A counter to tally the number of pulses emanating from the comparator during the test period— a single decade counter is adequate;
5) A latch circuit which trips to the "latched" state when the count exceeds a preselected number (*e.g.*, 1 to *n*). The latch circuit, if tripped, energizes an indicator lamp;
6) A timer to control the period over which the counter is enabled. It should incorporate the capability to reset both the counter and the latch circuit at the beginning of each test period; and
7) Power supplies for the DUT and other auxiliary circuits.

### Test conditions

Some of the conditions which affect the burst-noise performance of the DUT include bias-level, source resistance ($R_s$), and ambient temperature ($T_A$).

The quiescent operating conditions in operational amplifiers are normally set by the magnitude of the positive and negative supplies. Many of the newer Op-Amp types, however, have bias-terminals into which fixed currents can be injected to set their performance characteristics. The RCA-CA3060, CA3080, and CA3080A operational transconductance amplifiers (OTA's); and the RCA-CA3078 and CA3078A micropower Op-Amps are examples of such devices. For best low-frequency and burst-noise performance, these amplifiers should be operated at the lowest bias currents consistent with the gain-bandwidth requirements of the particular application.

In the test for burst noise, the source resistance ($R_s$) seen by the input terminals of the DUT, is a key test parameter. Burst noise causes effects which are equivalent to a spurious current-source at the device input and, therefore, burst-noise current generates an equivalent, input, noise voltage in proportion to the magnitude of the source resistance through which it flows. Accordingly, to increase the sensitivity of the test system, it is desirable to use the highest source resistance consistent with the input offset current of the DUT. For example, an Op-Amp which has a 0.1 $\mu$A input offset current could realistically be tested with source resistance in the order of 100 K$\Omega$(10-mV input offset), whereas a 1 M$\Omega$ source resistance (100-mV input offset) could cause excessive offset in the output. For 741-type Op-Amps a 100-k$\Omega$ resistance is recommended.

Burst-noise generation in amplifiers is usually more pronounced at lower temperatures (particularly below 0°C). Consequently, consideration must be given to the temperature of the DUT in relation to the temperature range under which the device is expected to perform in a particular operation.

A test parameter of importance is the time duration of observation. Because the frequency of burst-noise occurrence is frequently less than once every few seconds, the minimum test period should be in the range of from 10 to 30 seconds.

### Pass-fail criteria

A test system built to accommodate the test philosophy outlined above has the ability to reject or pass a DUT on the basis of two variables: burst amplitude and the frequency of burst occurrence. The burst amplitude which will trip the counter can be no lower than the background $1/f$ noise peaks of burst-free units, otherwise normal background noise will fail the DUT.

The background noise peaks depend on the source termination $R_s$, the wideband $1/f$ noise figure of the DUT, and the test-system bandwidth. A good estimate of the normal background noise-peak levels can be computed from the definition of noise factor and an empirically determined noise-crest factor of approximately 6:1. The crest factor is the ratio of the maximum, peak noise voltage to the rms noise voltage. The noise factor is defined as the ratio of the total noise power at the amplifier output to the output-noise power due to the source resistors alone. In terms of the rms noise voltages at the input terminals of the amplifier, this is equivalent to:

$$\text{Noise Factor } (F) = \frac{(E_{NTi}^2)}{(E_{NRs})^2} \quad (1)$$

where $E_{NTi}$ is the total input noise-voltage; *i.e.*, the sum of noise generated in the source termination resistance and the noise generated by the DUT.

$E_{NRs}$ is that part of $E_{NTi}$ due to $Rs$ alone.

$$\text{Therefore, } E_{NTi} = (F)^{1/2}\,(E_{NRs}). \quad (2)$$

$E_{NRs}$ can be computed by using the well known expression for "white-noise" generated across the terminals of a resistor (R):

$$E_{NRs}\,(rms) = (4kTBR)^{1/2} \quad (3)$$

where $k$ equals Boltzman's Constant ($1.372 \times 10^{-23}$ j $^OK$), $T$ equals absolute temperature in $^OK$, $B$ equals noise bandwidth in Hz, and $R$ equals value of the resistor in ohms.

Thus, at a room temperature of 290° K

$$E_{NR}\,(rms) = 1.28 \times 10^{-10} \times (BR)^{1/2}$$

For example, a 100-k$\Omega$ resistor preceding a system with a bandwidth of 1 kHz will generate a noise voltage of

$$E_{NRs} = (1.28\times10^{-10})\,(10^3 \cdot 10^5)^{1/2} = 1.28\ \mu\,V_{rms}$$

Both inputs of an Op-Amp are usually terminated in $R_s$, hence it is necessary to combine the effects of both resistors to determine the effective $E_{NRs}$ at the input of the DUT. Because the noise voltages from these two resistors are uncorrelated, their voltages must be added vectorially rather than algebraically.

$$E_{NRs}(effective) = [E_{NR(s1)})^2 + (E_{NR(s2)})^2]^{1/2} \quad (4)$$

because $E_{NR(s1)} = E_{NR(s2)}$, when Rs1 = Rs2

$$E_{NRs}(effective = (2)^{1/2}(E_{NRs})$$

and for 1-kHz bandwidth at 290° K

$$E_{NRs}(effective) = (2)^{1/2}(1.28\mu V) = 1.81\mu V_{rms}$$

If, in this example, the DUT has a wideband $1/f$ noise figure of 4 dB (2.5:1 power ratio), at $R_s$ = 100-k$\Omega$, the total *rms* background noise-voltage at the input will be

$$E_{NTi} = (F)^{1/2}\,(E_{NRs}) \text{ (from eq.(2))} = (2.5)^{1/2}\,(1.81) = 2.9\ \mu V_{rms}$$

If a crest factor of 6:1 is assumed, the peaks of the background noise will be approximately (6)(2.9) = 17 $\mu$V peak. This voltage is the lower limit of the burst-amplitude rejection level. A reasonable threshold for burst detection and rejection might be 50-100% greater than this minimum value.

An alternate method used to set the burst-threshold limit involves a direct measurement (at the output of the high-gain amplifier-filter combination) using a storage oscilloscope or a "true rms" voltmeter. By this method the noise peak or rms noise voltage of burst-free units is determined. This measurement provides a good practical check on the accuracy of the computation outlined above. Selection of the acceptable number of burst counts in the test period is arbitrary, but dependent on the type of application intended for the DUT. To be acceptable in some critical applications, the DUT may not generate even a single burst pulse in a relatively long period of time.

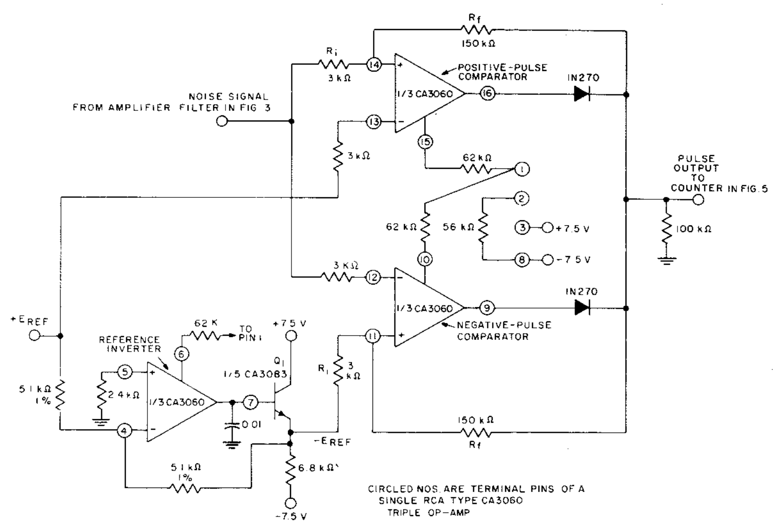



Fig. 4 — Schematic diagram of threshold-detecting comparator.

## Burst-noise test system circuits

### High-gain amplifier-filter

Fig. 3 shows the schematic diagram of the high-gain amplifier-filter which provides a fixed gain of 80 dB with a 12-dB octave roll-off above 1kHz. The gain-function is somewhat arbitrarily distributed between the DUT and post-amplifier: 30 dB and 50 dB, respectively. This distribution is based on the need for sufficient gain in the DUT portion to eliminate significant noise-signal contributions from the second stage while simultaneously allowing adequate loop-gain in each stage to provide accurate gain-setting with precise external resistors. The first stage is shown as a plug-in module so that any type of DUT configuration having 30-dB gain can be tested.

The capacitive coupling employed provides a low-frequency cutoff of about 1 Hz and eliminates the need for dc-offset zero-adjustments. The dc offset-voltage at the filter output is less than 5 mV which corresponds to less than 0.5$\mu$V error when referred to the noise input (an 80-dB gain is assumed.) Several seconds must be allowed, however, for the dc operating point to stabilize after the power is applied to the DUT.

### Bi-polarity comparator

Fig. 4 shows the schematic diagram for the threshold-detecting comparator. Because bursts of either polarity must be detected and converted to positive output pulses, two comparators are required: one having a positive threshold reference and the other having a negative threshold reference of equal magnitude. The RCA CA3060 triple OTA is convenient to use because a single package provides circuits for both comparators plus a reference inverter for the negative threshold reference. The positive feedback provided by the $R_f$ and $R_i$ connections produces a hysteresis effect with reference to the input switching threshold, (*i.e.*, the comparator does not return to its quiescent state until the input noise signal drops well below the initial threshold trip-level). This feature is necessary to prevent multiple triggering by the background noise signals superimposed on top of the burst-noise pulse. By this means, multiple counting of a single burst-noise pulse is avoided.

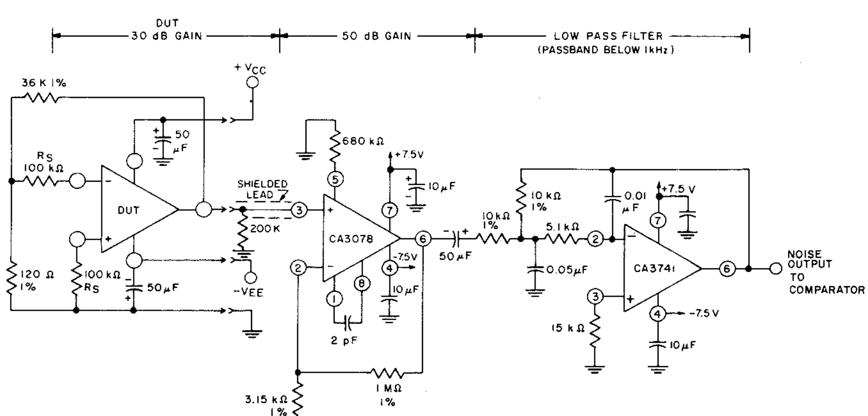



Fig. 3 — Schematic diagram of high-gain amplifier/filter.

The magnitude of the threshold reference voltage, $E_R$, determines the burst level which trips the comparator. If a voltage gain of 80 dB is provided by the amplifiers, a 200-mV reference voltage will enable the circuit to be triggered when a burst-noise pulse (whose amplitude is equivalent to the level of 20 $\mu$V referred to the DUT input) is present.

### Counter-latch-timer control circuits

The remaining circuits of the go-no-go burst-noise tester are shown in Fig. 5. The decade-counter is incorporated in a single

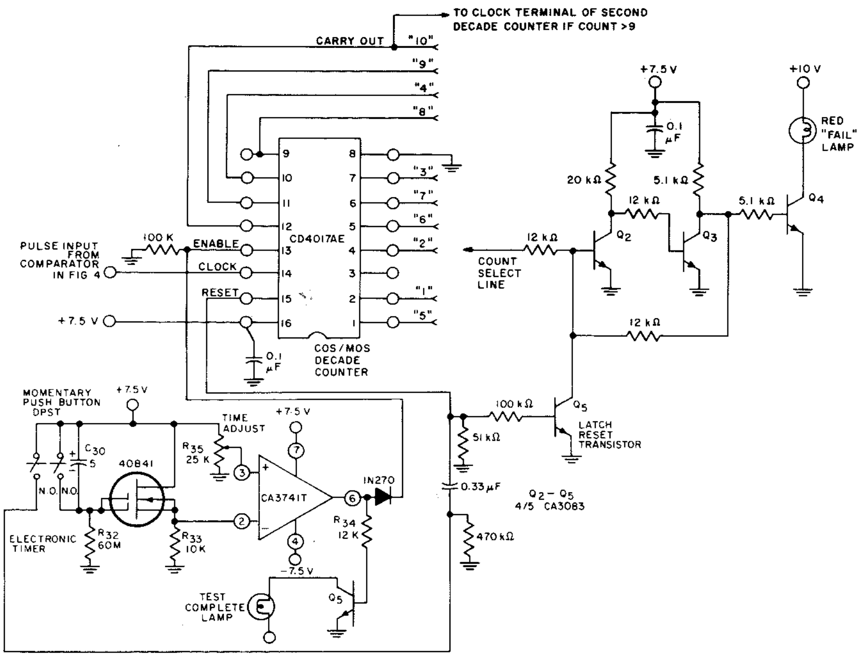



Fig. 5 — Counter-latch-timer control circuit schematic.

COS/MOS IC (RCA CD4017AE) which has clock, reset, and enable inputs, and an output terminal for each of ten count positions (0 to 9). A carry-out signal is available if the use of more than a single decade is desired. The clock-input signal must be positive-going and have a magnitude of at least 70% of the supply-voltage and a rise-time equal to or less than 15 $\mu s$. The comparator shown in Fig. 4 provides an output signal which meets these requirements.

Selection of the reject count is made by a pin-jack connection of the latch-circuit input-lead to the appropriate output terminal of the counter. Whenever the selected count-position voltage goes "high" the latch-circuit is switched to the latched state, and the fail-indicator lamp goes "on". The latch and lamp will remain "on" until the reset button of the electronic timer is switched to the "Timer On" position. This action provides a momentary reset signal to the latch, counter, and time circuits and places a continuous enable voltage on the counter for the duration of the test period.

## Spurious noise sources and their suppression

The very low voltage levels and the high source impedances normally used for burst testing render the system highly susceptible to external spurious noise sources. This problem is particularly serious if a test unit is going to be rejected for as little as one or two input burst-noise pulses exceeding 20-30 $\mu$V. The major sources of spurious noise encountered in the development of this test system were:

1) 60-Hz hum pickup,
2) power-supply transients, and
3) electromagnetic pickup of switching transients.

The 60-Hz hum is introduced by capacitive or inductive coupling or as power-supply ripple. Power-supply ripple is not normally a problem when testing operational amplifiers with regulated supplies because the Op-Amps generally have good power-supply rejection. This source of noise must be considered, however, when testing devices that do not have good inherent power-supply rejection. Capacitive or inductive coupling of hum can occur when 60-Hz line cord leads are within a few inches of the input terminals of the DUT. Precautions, such as proper lead dress and twisting of the 60-Hz leads, eliminate this problem.

Power-supply transients, as distinguished from power-supply ripple, can be of sufficient amplitude to introduce detectable noise pulses at the operational-amplifier input. Such transients are produced when other equipment on the same ac line is switched on or off. A typical power-supply rejection ratio for an operational amplifier is 50 $\mu$V/V (*i.e.*, a 1-volt transient on the power supply is equivalent to a 50-$\mu$V noise pulse at the DUT input). This example demonstrates that the test system cannot tolerate power-supply transients greater than approximately 100 mV, even when testing units with good power-supply rejection. Unless the power-supply is known to be free of such transients, a battery-operated system is recommended. Even when this system is battery-operated, "on-off" switching of nearby equipment introduces detectable transients into the system. These problems are eliminated by placing the test circuitry in a completely shielded enclosure with a hinged top for easy access to the test unit. The external noise problem is best solved by use of a shielded enclosure and a battery-operated power supply contained within the enclosure. Fig. 6 shows a photo of the circuit board layouts of the test unit.

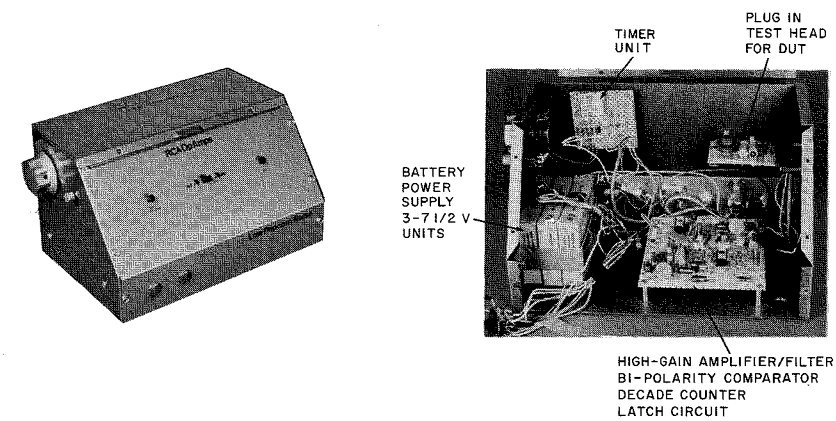
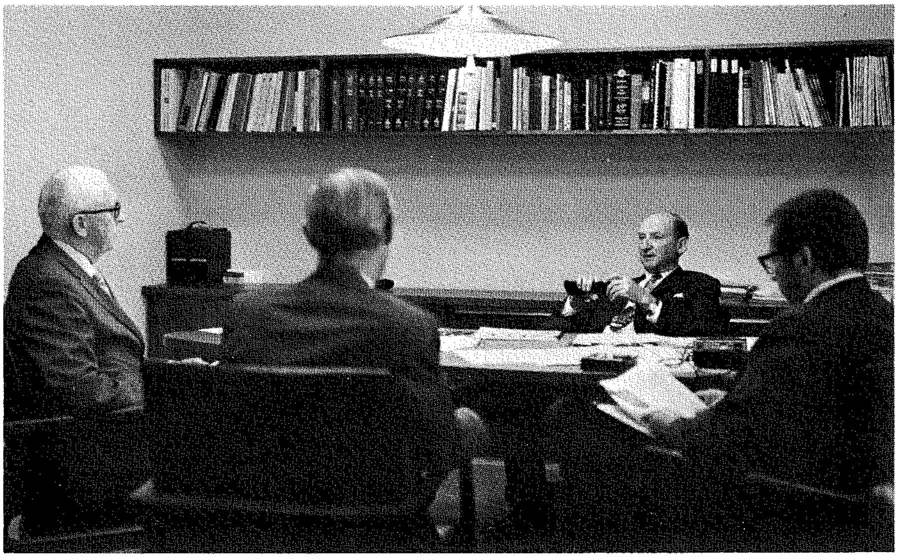



Fig. 6 — Burst-noise test set and circuit board layout.



Dr. Jan A. Rajchman answers question during interview conducted by W.O. Hadlock (left), C.W. Sall (center) and F.J. Strobl (right).

# The scientist as inventor and manager—an interview with Dr. J.A. Rajchman

**In this interview spanning Dr. Rajchman's notable career at RCA, he provides us with striking examples of imaginative inventions and conviction-inspired perserverance...and gives us a perspective of the scientist as both inventor and manager. But in either role—whether leading or invention—Dr. Rajchman pleads that both activities should be laced with a joyful spirit. Above all, he has been and remains a staunch optimist in the enterprise of innovation.**

This inverview with Dr. Rajchman was conducted by W.O. Hadlock, Editor, *RCA Engineer*; C.W. Sall, Technical Publications Administrator, RCA Laboratories; and F.J. Strobl, Editor, *RCA TREND*. Dr. Jan A. Rajchman joined RCA in 1935 and has been engaged in research since that time, first in Camden, N.J., then from 1942 in Princeton, N.J. with RCA Laboratories. In 1959 he became Associate Director, Systems Research Laboratories; in 1961, Director, Computer Research Laboratories; 1967, Staff Vice President, Data Processing Research; 1969, Staff Vice President, Information Sciences. In 1971 the supervision of RCA research laboratories in Zurich and Tokyo was added to his management role in Princeton, where he maintains the direction of an exploratory research group.

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## Early schooling

*Refresh us, Dr. Rajchman, on your early life and education.*

I was born in London of Polish parents. At an early age we moved to Geneva, Switzerland, where I had my early education including high school, of course in the French language. Later I attended the Swiss Federal Institute of Technology in Zurich, where I graduated in electrical engineering in late 1934 (the studies there being in German).

*How did you decide to come to America?*

This was the period of the great depression, and jobs were difficult to obtain for young graduates either in Europe or the U.S.A. In my case there was the further complication of being a Polish citizen (though I could have claimed being a British Subject by birth). I was a foreigner in Switzerland where I was educated. However, in a sense, I was lucky in that I knew what I wanted in life — that is to do inventive research work. I think I had a lot of enthusiasm and many ideas, including some on new ways of transmitting television. Also, I was very fascinated by Dr. Zworykin's publications on the iconoscope. So, at the age of 24, I decided to go to America and try to work for Zworykin at the laboratories of RCA. To me the laboratory of RCA was an industrial laboratory devoted to the concept of inventive research and was most appealing among the laboratories based on this concept being pioneered in America because of the audacity with which it was promoting electronics, then the newest of all technologies that promised to make television a reality.

With the help of my family I came to America as a classical immigrant. And like many before me, I am very grateful, as eventually I found in America not only the life work I was aspiring to but also a country I could call my own. But I am ahead of my story.

This was the Spring of 1935. Almost immediately I went to RCA in Camden, N.J. where I was interviewed by Dr. Irving Wolff, E. W. Kellogg, P. G. Cooper and C. M. Burrill. I was told that I was a fine young man but that there were no openings. The same was true in two other companies I contacted, perhaps with less fervor than RCA. Moreover, my English, dating from early childhood, despite some refreshers in high school as well as conversations with English-speaking people in Geneva, was rather poor. So I decided to register for the summer session at MIT.

One day (in August 1935 at MIT) I received a telegram from E. W. Kellogg advising me that there was an opening in the factory in Camden. I reported immediately and it turned out to be in the Testing Department headed by Phil G. Cooper, one of my interviewers, now Staff Patent Counsel. In that department very accurate condenser standards were established against which the variable condensers of superheterodyne receivers could be calibrated. This was done by bending the condenser plates by hand to change their capacity to match that of the standard. The job of the laboratory consisted in capacity measurements of very high precision. I was fascinated by the various ingenious techniques of bridging, heterodyning, etc., that could be worked out and found the assignment most interesting.

But still I wanted to work in Dr. Zworykin's Laboratory and telephoned him several times, always to no avail. It so happened that a new man, Lewis Clement, came to be in charge of the engineering department that included the research laboratories. I went to see him and soon discovered that he had just returned from France, somewhat a Francophile, so we talked in French. Shortly thereafter Dr. Zworykin called me to say I could have a job. On my first day, which was January 2, 1936, he asked me what I wanted to work on. I said, "Television, of course." He replied, "You have come too late, television research is all finished."

### Multiplier tube assignments

*Isn't that like shutting down the Patent Office in 1890 because all the inventions had been made?*

I know now that he meant that research on the iconoscope tube that his laboratory was engaged in was finished and that he did not mean that nothing else new in TV was to be done, quite the contrary. He tends to put ideas in a succinct positive way that I later understood perfectly well.

He assigned me to the multiplier tube. Previously he and George Morton and Lou Malter had worked out the magnetically focused electron multiplier tube. They found that it worked all right but the dark current was very high. That is, when there was no light, there was still an appreciable current. That limited its usefulness, of course. So, Zworykin asked me, "Why don't you look into the causes of the dark current and see if we can do anything about it?" That's what I did. Very soon I found that the magnetically focused multiplier was unpleasant to work with mostly because of the difficulties associated with the outside magnet. I became intrigued with the idea of making a tube focused entirely electrostatically, without magnets, and whose theoretical possibility was being established by Ed Ramberg.

The design of electron multipliers involves the determination of electron trajectories in the electrostatic field focused by electrodes of rather complex shapes. Plots of the electrostatic field and graphical methods for the trajectories permitted me to laboriously design the first working models, and this gave me a great thrill. Later I devised, together with R. L. Snyder who joined the laboratory, a model that consisted of rolling small steel ball bearings in a suitably stretched rubber membrane that simulated amazingly well the actual paths of electrons in the tube. The rubber model made it possible to design many working structures and was incidentally a sort of analog computer. Today, digital computers can be programmed to do a more accurate, though perhaps still slower job, of trajectories calculations. It is a great satisfaction to me that the designs I worked out in those days are still the ones used in today's commercial multipliers.

*What was your next assignment?*

Really the original assignment, namely, to find out the causes for the dark current problem. An important effect is due to the ionization of some inevitably remaining gas molecules in the space of the last stages. When the ions find their way to the first stage they produce secondary electrons that are multiplied by the enormous gain of the multiplier. It doesn't take very many of them to cause a catastrophic "ion feedback" effect. I suspected that this was the cause of our ills. I designed an intricate structure of dynodes in which any ion attracted toward the cathode would encounter a blocking dynode. This eliminated completely the ion feedback effect and explains why present-day multipliers have such seemingly contrived shapes.

There are other causes of the dark current. Their study provided a key for reducing the dark current and had besides other interesting implications. Eventually the whole subject became the subject of my doctoral thesis. After a summer study in Switzerland, in the Fall of 1938, I passed my doctoral examination at the Swiss Institute of Technology in Zurich and presented the work on the multiplier tube. Interestingly enough the presentation was in English — though I offered to speak (poor) German or French.

*Did this end your work with multipliers?*

When I returned, we considered various applications of the multiplier tube. One application was for a spectrophotometer that we built in the laboratory. Still another application was for scintillation counters about which I want to say a few words.

At that time physicists measured cosmic rays by means of Geiger counters. They were looking for a more convenient instrument and were intrigued by the extremely high gain of multiplier tubes. There were many suggestions for tubes with thin windows and other expedients that would allow incoming particles or radiation to start electrons on the photocathode. We suggested to all inquirers at the time to simply use a sealed-off photomultiplier, as is, with some phosphor on its face to convert the incoming particle or radiation into visible radiation. We sent samples of powder phosphors and tubes to various persons, as I remember, among others, to Van Allan. The phosphors were synthesized by H. W. ("Lefty") Leverenz. This arrangement is known today as a scintillation counter. It rivals and, I believe, perhaps even surpasses in usage the Geiger counter. Unfortunately we never wrote up the idea of the scintillation counter. We simply helped the scientific community with what we had.

*Then, are you the father of the scintillation counter?*

I cannot say for sure because I don't know whether I was the first to think of it, although those with whom we corresponded at the time had first heard of the idea from us.

Before we leave the subject of photomultipliers I would like to relate a story that is not without irony. During World War II, sources of pure white noise were needed for radar jamming applications and it turned out that the photomultiplier—that low-noise device par excellence—was most convenient for the purpose. Mass production of the tube resulted, as tubes and replacements were needed throughout the world, and after the war there was a huge war surplus. Low-cost availability of the photomultiplier induced many instruments manufacturers to incorporate that simple device as a key element in their product and hence created a scientific market for the tube. Today we enjoy at RCA the majority of the world market share of the business.

*This brings us near to the date of World War II; how did this affect the direction of your work?*

Even before Hitler invaded Poland, it was clear that the Germans had air-superiority. Anti-aircraft guns were not adequate to shoot down airplanes because, the "directors" or mechanical calculators, just could not make the calculations quickly enough to direct the gun. We were approached by Col. Simon from the Frankford Arsenal, who with great far-sightedness, asked us to consider whether electronics could provide the necessary speed. I was assigned to the problem and that is how I first got into computers.

At first I worked on analog devices that included arithmetic units and arbitrary function generators but soon I got discouraged by the difficulty of obtaining the required accuracy. From then on I worked on digital devices. Of course the urgency for computers grew as the hostilities started in Europe and even more so when the U.S.A. became involved. Our efforts increased almost from the beginning and soon were split into two groups. One was headed by Art Vance on analog devices that eventually ended with project Typhoon. The other group was concerned with digital devices, my area of interest, and included George Morton, Leslie Flory, and Dick Snyder.

The digital approach was recognized from the beginning to be a longer-range endeavor, possibly with ultimately more promise. It has to be remembered that in those days only the vacuum receiving tube had gain and non-linearity, which are the two essential characteristics of elements necessary in electronic digital circuits. Because of its size, power consumption, and cost it could only be used sparingly. Our first work was with counters and arithmetic units. We devised binary counters and shift registers of various types. Also we devised arithmetic units that used shift registers, as well as other types in which the two input terms of the arithmetic unit reacted with one another to produce the resulting sum or product by a direct interaction in a matrix fashion. Many of these ideas led to rather fundamental patents.

In all of this work we were greatly concerned by the necessity of using a large number of tubes, and in two important devices succeeded in greatly reducing that number.

*What were they?*

One was a vacuum tube for performing binary arithmetic, which we dubbed the "computron," in which there were many beams each deflected to a few discrete positions where they bombarded floating targets internally connected to deflectors of other beams, in such a way that the potentials on the final targets represented the binary number corresponding to the sum or product of the inputs on the tube. In a sense we were developing "integrated vacuum technology" consisting in a single tube, with a few hundred interacting cells. Despite enthusiastic support from the government, we soon concluded on our own that the idea was too complex for the techniques then available.

The other idea turned out to be of great importance in the development of digital computers. It amounted to what would be called today a read-only memory, and that at the time we called a "function or code generator". It consisted of a large matrix of resistances connected by rows and columns, the presence or absence of a resistance at any intersection denoting a "one" or "zero". The idea was extremely simple, though seemingly implying a monster short circuit between all inputs and outputs. Models with many thousands of resistors were the first read-only memories in the computer art until about a decade later when semiconductor diodes became sufficiently economic to be used in similar matrix read-only memories.

*What happened next?*

The construction of a complete computer was possible by the techniques we had developed, but despite the resistive matrix that did only one job, it still required many thousands of tubes. Clearly this was not acceptable for field use but might be tolerated for a laboratory installation. At the time, lengthy computations were urgently needed for ballistic tables and the government asked us to undertake the building of an electronic calculator for performing them in a reasonable time. Unfortunately the Laboratories chose to turn down this offer, chiefly because of the fear that any installation with the required 20 to 30 thousand tubes would never operate. I greatly regretted that decision. I then spent some time counselling with the Moore School of Engineering, University of Pennsylvania, who was awarded the job and eventually built ENIAC. I transmitted most of our know-how, notably information on the resistive matrix read-only memory which was adopted as an important technique in that machine.

*Did you then stop working on computers?*

Yes. For a year or two I worked with Bill Cherry on an idea we had for using the betatron as a generator of high frequencies. The concept proved to be limited by the capabilities of space charge that can be captured in the betatron. Our analysis of that limit won us some renown at the time.

*What came after the betatron?*

I came back to computers in the following circumstance. All our previous work in computers had been followed by a most prominent government consultant, Dr. John vonNeumann, from the Institute for Advanced Study at Princeton. He became the most fervent proponent of the stored program computer, an idea that had evolved as the problems for which the ENIAC was designed were changing. The idea of the stored program permits the computer to be universal rather than having to be specialized for each problem. It is taken for granted today as most great ideas are.

In 1945 or 1946, von Neumann decided to build a stored program computer at the Institute and asked RCA Laboratories to undertake the research toward the memory necessary for such a machine. We agreed, thus I was back in computers and started on what turned out to be a long-term involvement in the memory field. Also it provided me with the unusual opportunity of an intimate association with the dynamic personality of Johnny (as he was universally called) vonNeumann, whose great accomplishments in many fields made him justly world famous.

It was then that I developed the Selective Electrostatic Storage Tube. In this tube there was a matrix of discrete elements that could be addressed by a matrix of controlling electrodes such that the selection of any element was very dependable because it resulted only from switching the right wires. Also the memory action

was inherently bistable in nature. Thus the tube represented the first truly digital and random-access high-speed memory and made no compromise to reach that ideal. It was also an "integrated vacuum tube" device as was the computron. It had a storage capacity of only 256 bits, small in today's standards. RCA made several hundred tubes at Lancaster that gave excellent service in several machines for many years.

At that time, which was the late forties, I embarked into a totally new field for me, namely, magnetics. While working on the Selective Electrostatic Storage Tube, and even perhaps before, I thought that a matrix of magnetic cores with hysteresis would be the ideal solution for a memory. When I saw a square hysteresis loop of a permalloy in some article, I conceived the idea of the coincident current core memory. I was not only convinced this was the answer but immediately started to work on it. At first I had the feeling that individual cores in large numbers would be too onerous to handle and wire individually and therefore I first started to consider so-called "integrated magnetic structures". As these did not operate too well, we wired single cores and found that they did work well and surprisingly enough did not require too much labor to work with. At first these were metallic ribbons but soon the materials group developed ferrites with square loops and we were pressing tiny cores on converted aspirin tablet presses. As you know, the idea of the core memory was independently thought out by Forrester and in that period there was a parallel development of the concept at MIT and eventually a patent controversy with us.

*Dr. Rajchman, in view of the importance of these projects, did you have many associates working with you at the time?*

As a matter of fact, very few. This is a matter I would like to come back to in a moment when we discuss the managerial aspects of my activities. If you will permit, I will continue just for awhile in a technical vein.

We developed working core memories, first with only 256-bit words, then with ten thousand — the myriabit. Also, we tried to interest the Product Division making TV yokes in the manufacture of cores, but they were more attuned to producing tons of ferrite than to millions of milligram cores. My own interests were still along the line of integrated structures and we made ferrite plates with an array of holes each performing the job of a core. This was successful and by then the company, already in the core business, but in a special department created for the purpose, did in fact make some developmental models.

However, a by-product of the research on the ferrite apertured plates turned out to be more interesting than the original goal. We found an interaction of flux between adjacent holes, that in the original application was of course very objectionable, but that could be exploited on its own right. This was the origin of the transfluxor, or multiaperture cores, that was a new logic device with digital as well as analog properties both for switching and storage. For example it could act as a magnetic latching relay without moving parts. The new device created a great deal of interest and magnetic logic became a widely studied and researched subject. Many applications, particularly in industrial controls, were found and are still in use today. However, the spectacular success of the transistor that had its peak at about the same time, eclipsed magnetic logic. Incidentally, the device permitted us to make a flat panel display device for television. There was a transfluxor controlling an electroluminescent cell at each location. The device was complicated and had only 40 lines; nevertheless it was a demonstration of principle in the year 1958. It is interesting to note that a significant number of transfluxors are still used today. In the U.S.A. alone, where they are used mostly for non-destructive read-out memories and ultrareliable industrial controls, the annual business in equipment is about two million dollars, of which a tenth is in cores alone.

We worked on other types of integrated magnetic structures such as the laminates. But here, I might stop talking so much technology and let you ask other questions.

**From research to management**

*Why don't you tell us how you evolved from being an inventive researcher to*

*research management and perhaps make some general comments on that subject.*

Here I may make, parenthetically, a general remark about our profession. The educational system emphasizes competition and individuality, the scientific professional ethic maintains scrupulously the singularity of authorship and gives a premium to initial publication, and the patent system emphasizes the singular genius of invention. The resulting orientation of young scientists is naturally a very individualistic attitude toward research. On the other hand, working in the laboratories of an institution of some size, be it industrial or academic, the human values of cooperation, mutual interaction, and organization skill obviously become extremely important. The cooperative spirit necessary for the success of a group enterprise often requires a certain effacing of individual stardom. There is thus a problem, new and often constituting a sort of dilemma for every individual evolving through his career, and old for the institution. Most individuals recognize sooner or later, consciously or otherwise, this reality and find their own solutions. The test of a seasoned laboratory is to know how to blend constructively the values of individual genius and group cooperation.

As many before me, I have experienced the great thrill in conceiving an idea and actually implementing it myself, a thrill that I imagine inventors share with artists. I enjoyed also the subsequent leadership of one to a few persons, involving of course still a dominant technical aspect but already bringing in the thoughts and aspirations of others.

But these remarks put me ahead of my story. As it happens, at the time of the Selective Electrostatic Storage Tube and core memory, our effort was very small. I had only one engineer, Milton Rosenberg, in the group, and help from other groups, notably in the tube construction group, Paul Herkart, and materials synthesizers for cores, Bob Harvey, Bob Weisz, and Pete Wentworth. Also occasional student engineers from Scandinavia or interested engineers from our plant in Camden helped. The importance of memory was simply not understood in the company in those days when even the computer itself was struggling to be taken as serious business. It was the sheer enthusiasm of our group and section that sustained the project. The effort was clearly too small. In comparison for example, MIT had at the time an effort at least one order of magnitude larger than ours.

Gradually, however, I acquired a larger group, the company became involved in computers, and I became involved in management. One of the important events in that evolution was a project for ultra-high-speed computers — Project Lightning — that the government sponsored at RCA and other companies. I was put in technical charge of the project at the Laboratories. Since this involved many people and a great deal of interaction between the government and eventually also the Computer Division, this gave me an excellent experience and also a taste in running a large enterprise. For the first time I could not possibly follow and understand all technical details. Thus I was squarely faced with a classical problem of management, *i.e.*, making decisions based on values other than technical

*How long did you work on that Project?*

Project Lightning lasted from 1957 to 1962 at RCA, but by 1960 or 1961 it was mostly in the Computer Division.

*What happened next?*

In 1961 I became Director of the Computer Research Laboratory. As you know, by then, RCA was fully committed to the computer business and the Laboratories decided to orient a substantial part of its research toward this new growth field of the company. We recruited many new members of the staff. We expanded the research to encompass logic and memory techniques based on semiconductors, magnetics, and superconductors. Also, we started research in the non-hardware part, that is in computer theory and software.

I was extremely busy building up the laboratory, following the projects, keeping abreast of the field, keeping in touch with the Computer Division, etc. Also, of course, I took part in the management of the laboratory as a whole.

I was entering a most exciting period of my life that consisted mostly in working with a group of enthusiastic men who by now were all younger than I. There was a lot of planning and discussing, some counselling in a growing enterprise that we were all fervently interested in. Among them were Group Heads, Jerry Herzog, Nat Gordon, Rabah Shahbender, Bernie Lechner, Saul Amarel, Les Burns, and later Bob Lohman, and many most brilliant scientists and inventors. Of course my concern was mostly with the Computer Division and with the division under various names that was responsible for solid state circuits. The more administrative aspects of management that I recognize as very important in their own right, did not attract me as much as the more fundamental aspects, that is, whereto is the enterprise to be steered. I was and am becoming increasingly more interested in that complex issue.

*Dr. Rajchman, you have had dual roles of scientist and manager. Which has meant more to you?*

As you can see from what I have said, I had a most exciting experience with both.

In management, I obviously find greater scope for my activities and greater rewards. I also find most rewarding, though often difficult, a fundamental demand of good management, namely that of facing up to complex issues and following up in a forthright manner the conclusions that were reached. I also have a lot of sheer fun in that work.

To me one of the most important elements has been the people with whom I worked. Often I am gratified when I think that I have contributed to the successful careers at RCA of many younger former associates of mine.

*What happened next in your career?*

In 1968, in one of the Laboratories' reorganizations, I was appointed a Staff Vice President. In September 1971, RCA decided to withdraw from the general purpose computer business. As you can imagine, this was a shock to me, being the first employee to do research in the field. Also, it obviously had a profound effect on the Laboratories. In the ensuing reorganization, which is the present situation, I retained a group on optical storage in Princeton and became responsible for our overseas Laboratories in Zurich and Tokyo.

*What fields are you trying to conquer now?*

Conquest is a big word. As it happens, in our group on optical storage, we believe that the inventions of the laser and holography have opened for the first time the possibility of making a storage device with the mass capacity of discs and yet with the accessibility of electronics and thus fulfill an ideal that was desired from the very beginning in the computer art. We have been working toward that goal for several years and have made considerable progress. Recently we have demonstrated a small working model. However, there are still serious unsolved problems, mostly with respect to the storage medium. Solutions for these may well come from material work and fundamental understanding of basic phenomena. If successful, we see this memory, as an eventual product on its own right or else part of various information systems that RCA could be manufacturing, though we have not pinpointed either market or appropriate product division. The project is an example of a high-payoff, high-risk project, requiring a combination of great scientific knowledge and inventive spirit. In that, I believe, it is particularly well suited to our Laboratory.

*What are your thoughts on the roles of the overseas Laboratories?*

Each of these two laboratories has a fine staff that has done excellent scientific work. They have earned a reputation not only in their own countries but throughout the world. My mission is to couple their work more intimately with that done in Princeton and to orient it toward more direct application within the interests of the company. I believe that the great satisfaction in combining scientific knowledge with the inventive spirit is universal and will find a fertile soil in our overseas laboratories. Indeed it has already been a growing tendency. A recent example of this is the work on holography in Zurich that has resulted in the Holocard identification system and several other practical applications.

*Dr. Rajchman, would you mind answering a few more general questions? Let us start by asking you which among the more than 100 patents you hold you consider the greatest.*

I am not sure how to answer your question. I believe that the most valuable among my patents are those relating to magnetic memories and magnetic devices as well as perhaps some computing devices. I cannot say that these were necessarily the closest to my heart as I have always had a fascination for simple and elegant ideas regardless of their importance. Naturally, also, I was most keen on my latest idea, and perhaps still am today. With the perspective of time, I am aware of some of the many factors that contribute, often more than the idea itself, to its eventual pay-off.

*What about the strained relationship between society and technology?*

This is a complex problem about which it is hard to comment in a few words. Like most scientists I firmly believe in the ultimate goodness of science and its applications. In the span of life of the last two or three generations the benefits of technology with respect to our material being have been so manifest that their detailed spelling is almost trite. Think only of the fact that the fight for food and shelter is no longer mankind's main preoccupation, that major epidemic diseases have disappeared and average life span has considerably increased, that the required labor for "essentials" has been greatly lightened, leisure increased. Opportunities to travel, to communicate, to educate one's self, and generally lead enriched lives have fantastically changed. Also I believe that rational enlightenment and science have dispelled superstitions and prejudices and have been conducive to a more kind and tolerant relationship between men. Moreover, there really is no choice, as we could simply not handle the problems presented with our present population without the help of today's technology. For example, without it, the mortality rate for those "under 30" would not be any better than the miserable level of the second century.

Of course these enormous changes toward progress, were brought about in dynamic processes that produced many ills. Some are present today. But it would be myopic to look at such ills as pollution, traffic jams, deafening trucks and buses, comic errors in computerized bills, occasional blackouts, etc., without considering them in their true perspective.

Of course the remedies for these ills, some more serious than others, reside in more technology or perhaps more correctly in the right technology, but clearly not in the simplistic attitude of negating technology.

I realize that much of the alienation referred to is among the young. Perhaps this is due to the fact that younger men have not witnessed any stupendous changes toward progress themselves, and yet are seeing some of the worst effects of pollution and misuse of fine technology, as well as that of overpopulation. One sad result is a lack of interest in college enrollments in fields relating to science and technology.

*What about the social role of the scientist-engineer under these conditions?*

Again far from a simple question. Generally I believe that the scientist-engineer has a special social responsibility to explain impartially the technical aspects that invariably are involved in most of our issues. He should also participate in the issues.

In these strained times it also behooves the scientist, perhaps the mature scientist, to apply cooly analytic thinking to hot issues and thereby not only clarify them but also bring the tone of their debate to be rational and constructive.

*You are a member of the National Academy of Engineering. Is it taking an active role in any of these problems?*

Yes, of course. As you know, the Academy is concerned with the broad questions of the interaction between engineering (*i.e.*, applied science or technology) and society. It is called on to give authoritative technical judgments to help various branches or agencies of the government. It undertakes various studies. For example, it has studied the problem of energy, that is, which of many possible sources of energy should be developed to take care of the growing needs of the country. Another example was a study of traffic safety. Still another, more recent, was a study on behalf of Congress on the pollution of automobile engines. I can cite many more examples. These studies have considerable influence, as they are often the basis for policies or laws.

*Has the Academy of Engineering looked into the computing field and have you been involved in any studies?*

As a matter of fact yes, the Academy had several studies, one in which I participated. As it happens right now I am about to be on a review panel.

*Do you have any fear of the social effects of the computerized world?*

Ever since I worked on computers I was convinced that the enhancements to man's intelligence provided by the computer are bound to be beneficial. Of course by now the computer has been so prodigiously successful that there is no need to elaborate. On the other hand, I have been bothered many times by the thought of improper mass use of computers; as examples, invasion of privacy or as a tool of a dictatorship. I shudder at the thought of computer-efficient gestapo files and understand the natural suspicion of many in oppressed countries who see inefficiencies in administrations as their best guaranties of liberty. Unfortunately I don't see any technological solution to that problem, the only remedy is the constant vigilance and the intransigent demand of rights of enlightened and free citizens.

*We have wandered into many fields. As a last question, Dr. Rajchman, what are your thoughts as to the future of electronics itself.*

In our own field of electronics, we have suffered from our past spectacular successes. In a span of most everyone's memory, we have created not only revolutionary concepts and devices but industries that have changed completely our mode of life. Therefore anything less than a new breakthrough of great proportions no longer appears par for the course. Furthermore, we have become mightily sophisticated. From all of this it would be quite erroneous to conclude, however, that electronics has reached some sort of plateau and is no longer a dynamic field. Quite the contrary. As an example, the distribution of selectable information giving prodigious access to most everything of interest in everyone's home or office has been widely and justly touted as the next great electronics breakthrough.

Furthermore, technological extensions of our capabilities by orders of magnitude will almost certainly imply the openings of brand new applications. This is true of the extension of frequency bandwidth possible in optical communication. Even more so would be a reasonably priced storage device capable of large mass recordings and random retrievals in extremely short times, as attempted through our optical techniques, or any other techniques.

Perhaps more significant as a whole are applications of electronics to other fields. For instance, in medicine there are imperative needs that can be met through electronics, and yet relatively little has been done so far. The difficulty there is to find the right business approach, a difficulty that does not seem to be insurmountable. Another field is that of the automotive industry and electronic aids to safety, for example, that is just starting.

Finally I would like to say that skeptics and objectors to R & D support have always existed and will always exist in one form or other, so that they really do not matter that much, as long as the practitioners of R&D have a sufficiently deep inner conviction of vigorously pursuing their aim and have a real dedication to their art. The result will be inventions and innovations for the ultimate good of us all.

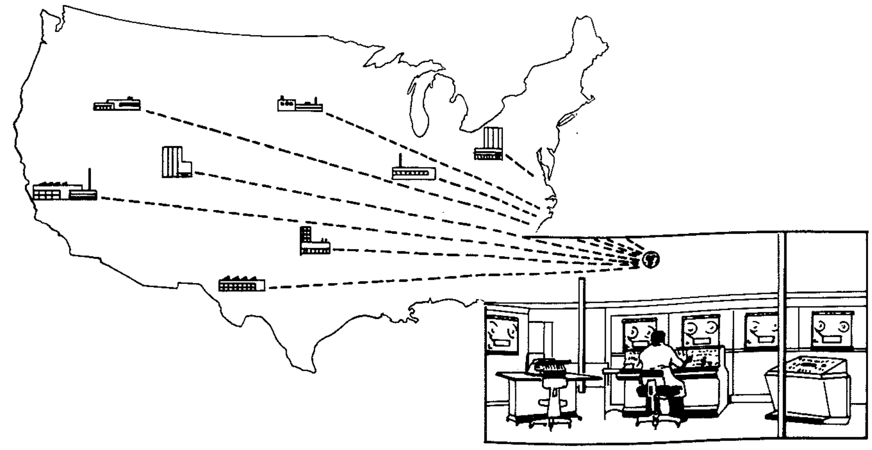
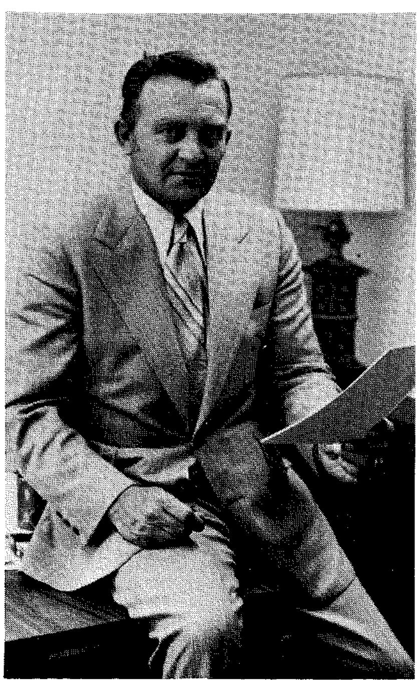


Fig. 1 — On-line communications.

# Joint use service a new business venture

C. G. Arnold

**Modern businesses spend 1/2 to 1-1/2% of total annual revenues on communications and a significant portion of this amount is spent on data communications. Further, it is predicted that use of data communications will grow 30% per year through 1980. Data communications costs can be reduced by taking advantage of tariffed services that now exist. For example, joint use of voice-grade channels by several companies can result in combined savings greater than 30%. RCA is currently launching a new business program to provide this service to business communications users and to reduce its own data communications costs as well.**



**Charles G. Arnold,** Director, Network Management and Joint Use Services, Communications Systems Division, Cherry Hill, N.J., received the BSEE from Pennsylvania State University and completed graduate work in EE at Stevens Institute of Technology. From 1942 to 1956 he worked at Bell Telephone Laboratories where he participated in the development of radar, communications test equipment and coaxial and radio transmission systems. In 1956, Mr. Arnold joined the Surface Communications System Laboratory of RCA in New York where he first was responsible for the Systems Design of the AN/GRC-50 Radio Relay System. During 1958 he was Project Manager of the MM-600 System Development Program, a high-capacity, microwave, radio-relay system for common carrier appliations. In 1959, he was named Director of System Engineering on the Minuteman Command and Control System, the first ever developed to remotely monitor and launch ICBM's in hardened unmanned silos. In 1966 he became Manager, Systems Engineering Department of the Communications Systems Division in Camden. In 1969 he was assigned to Corporate Staff to develop new business opportunities in the field of communications. He holds two U.S. patents and has published several papers. He is a member of Eta Kappa Nu, Tau Beta Pi, Phi Eta Sigma, Pi Mu Epsilon and Phi Kappa Phi and a Senior Member of the IEEE.

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In September 1971, Robert W. Sarnoff, Chairman of RCA Corporation, said that RCA would concentrate significant efforts "in the development, manufacture and marketing of specialized data communication systems for application in such areas as government and defense, communications networks, and especially designed business systems." The Corporate Marketing and Planning Staff under this policy direction has analyzed many new business opportunities in the above fields. From these analyses a new RCA business opportunity called "Network Management and Joint Use Service" emerged and was recently approved by Corporate Management for initial implementation.

This opportunity is based on AT&T Tariff (FCC No. 260) which covers, among other services, the provision of

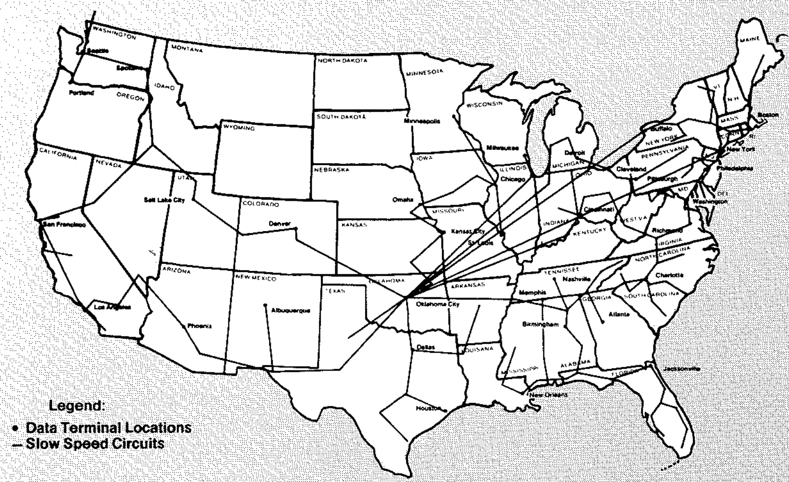


Fig. 2 — Slow-speed network - user A.

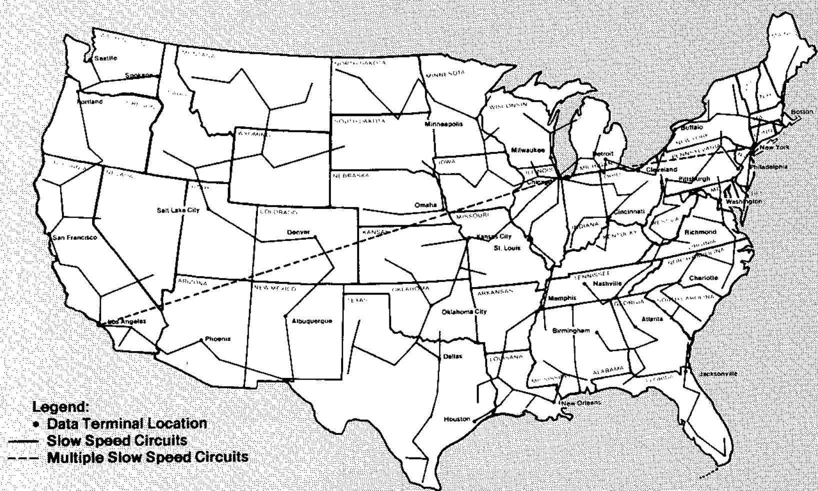


Fig. 3 — Slow-speed network - user B.

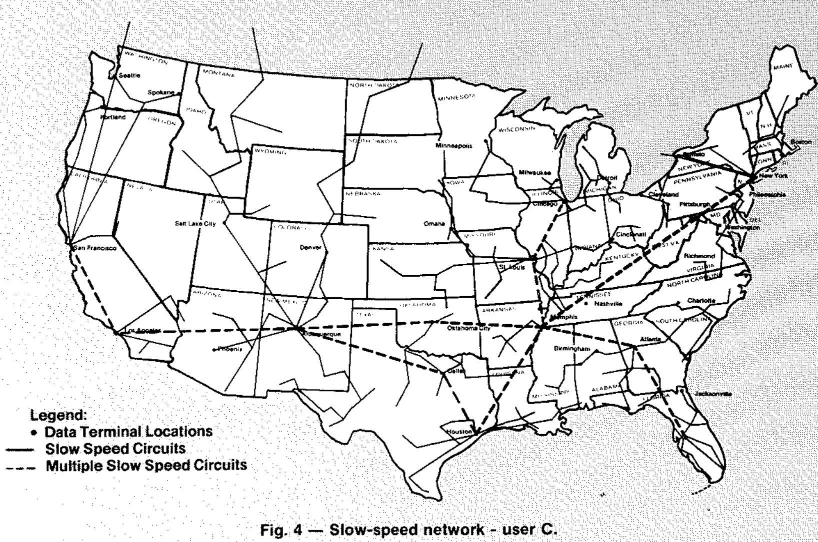


Fig. 4 — Slow-speed network - user C.

data communication services. The tariff provides for joint use or sharing of a dedicated, voice-grade, interstate circuit by two or more companies between any two points in the United States. The cost of this service is than allocated among the participating users in accordance with their percentage of use.

## Capacity of voice-grade circuits

A voice grade circuit, nominally 4kHz in bandwidth can be used for many slow speed circuits (in excess of 150 75-bit-per-second (b/s) circuits with available techniques and equipment, and theoretically as many as 400). Approximately 10,000 b/s is generally accepted as maximum usable data rate on a voice-grade line. By time divsion multiplexing, a mix of data rates varying from 45 to 4800 b/s may be combined into a single high-speed bit stream. Despite the high capacity of the voice-grade circuit, its tariffed cost is only approximately twice that of the 75 b/s circuit. Clearly, the allocated cost per slow speed circuit on a heavily loaded voice-grade line is much reduced from that of separately leased single slow-speed circuits.

## Industry needs

Industry now requires extensive on-line communications from remote locations to executive offices or computer centers (Fig. 1) and this need is growing. Such service has the highest growth rate, 30% annually, of any segment of the communications industry.[1] A. L. Conrad, President of RCA, noted in a recent address that, "Less than 10% of all data entry presently arrives at the computer by electronic communications. More than 90% depends on hand labor and postal service for delivery."[2] The needs of industrial users vary from a single circuit a few miles long to 100 circuits which may span the continent. In general, no single user has sufficient demand to utilize the full capacity of a dedicated voice-grade circuit from all his data input points. Consequently, he leases single slow-speed circuits to these location.

The RCA Corporation and its subsidiaries have large slow-speed data requirements that spread throughout the nation. Yet, like other corporations, we cannot justify the capacity of a voice-grade circuit to all locations. Marketing surveys and network design analyses clearly indicate that joint use of facilities for data services would provide significant cost reductions to a group of users.

## Role of RCA

For joint use to be a workable and worthwhile activity, several basic tasks must be performed.

1) Multiplexers and associated equipment must be provided at each end point of the broadband circuits to combine and separate slow-speed channels for local distribution to users' premises.
2) Maintenance must be provided on a short-reaction-time basis in case of failure in joint use equipment or transmission facilities.
3) The requirements of a group of unrelated users must be integrated into an optimized network to adequately load the broadband circuits and gain maximum savings.
4) The administrative tasks of integrating and operating such an activity and the leasing of common carrier facilities and allocating their costs must be performed.

These tasks are all service oriented. RCA Global Communications, Inc. has now been selected to organize an activity whose role will be to perform these services. Few companies have the qualifications to fully satisfy all these requirements. RCA's position is unique in this respect; having communications as its charter business; having several major operating units currently in the communication business; having a nationwide service organization; having the internal need for extensive data communications; having the technical capability to do commuication equipment and network designs; and, perhaps most important, having the business interest and corporate management support that will allow such a venture to get started and thrive.

## Business criteria

This business opportunity must satisfy the usual criteria of any business:

- Is the product a good one?
- Are there customers who will buy it?
- What is RCA's competitive position?
- Is it built on an RCA strength?
- Is there a high initial investment?
- Is there a satisfactory probability of profitability?
- Does it enhance any of our current business activities?

In addition, there are unique aspects involving the regulatory bodies in the government. Compatibility of our operational plans with the governing tariffs is a must. The Federal Communications Commission and the American Telephone and Telegraph Company have carefully reviewed our plans and indicated no present objections. Careful analysis of all the above factors indicated a significant business opportunity for RCA.

## Network design

Key in the development of the business opportunity was the capability to develop an optimized network design. For illustrative purposes, the national slow speed data networks of three typical large users are shown in Fig. 2, 3, and 4. Each line in these networks represents a slow-speed circuit. In order for users to gain a significant saving, several such sets of requirements must be integrated into a single broadband network with multiplexers and other associated equipment located at properly selected cities. Clearly, a network which is optimal for one user may have serious shortcomings for other users. Consequently, the optimal network must be designed to do a good job of satisfying the requirements of a group of users. Both technical and business factors control the system design. A typical network, one generated from a group of actual user requirements is shown in Fig. 5. It contains 35 cities and 49 voice-grade links. It has a capacity of almost 1,000,000 miles of slow-speed circuits. It will support the needs of 20 to 30 large users and many small ones. At each multiplexer city, local slow-speed circuits (not shown) connect to the users' premises. Whether or not a city or link is included in the network is determined by two economic factors:

1) Is there sufficient load to provide savings for users?
2) Is there sufficient income for RCA to justify its implementation?

It was discovered early that the task of developing such a network by manual methods was onerous, time consuming, and ineffective. Hence, computer programs were developed to support the network design task. Not only did computer programs shorten the task, they also insured a more economical network and, therefore, maximized the savings for the users. Topographical aspects of the problem as well as many cost computations are handled automatically.

A characteristic, inherent in any joint-use arrangement, is that a change in one user's requirement has some cost impact on all other users who are associated with that portion of the network where the change is made. During the business planning period, many such changes occured. User's requirements were added to, and deleted from, the network many times. Aided by the computer programs, such changes were made and evaluated on a current basis. Manually, days of effort would have been involved and the likelihood of errors would have been high. It is expected that such changes will occur routinely in an operational activity and computer support will be mandatory.

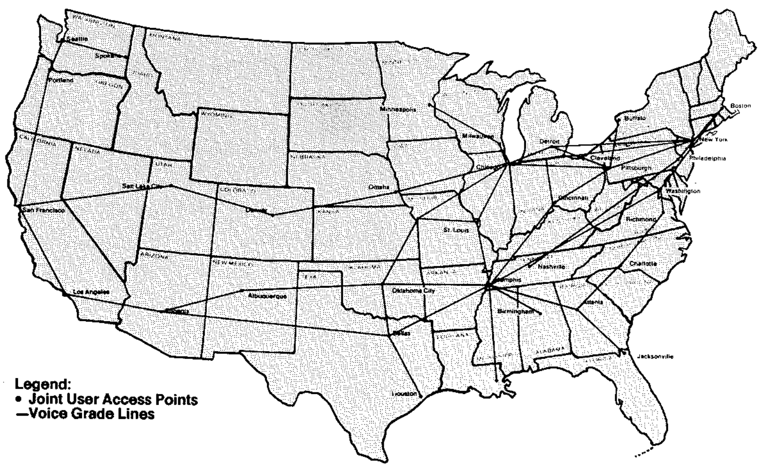


Fig. 5 — Joint-use network.

Some computer programs developed to support the preoperational efforts are listed below:

1) Establishment and optimization of voice-grade network
2) User circuit network assignments
3) User's allocation of tariffed service costs
4) User's traffic between selected cities
5) Optimization of user's system
6) Joint use revenue computation

These programs have supported the business planning period, and are being expanded to support a large operational network. Additionally, programs are being developed to cover new functions, such as:

1) On-line performance monitoring and diagnosis,
2) Performance statistics and analysis,
3) Service outage computation for user credit,
4) User backlog requirement analysis and identification of need for additional Joint Use cities,
5) Joint Use Inventory and Maintenance control, and
6) Financial analysis and data base for billing and receivables.

Major support is being received on these tasks from the Systems Research Laboratories at the RCA Laboratories.

In addition to their application to the Joint Use Project, these programs may prove useful to other RCA divisions as well as to other major business communications users. The possibility of developing a communications systems consulting business based on the knowledge and experience of the Joint Use Technical Staff will be explored in the future.

## System performance monitoring and control

A significant feature of the current network design is the monitoring and control arrangement. Both equipments and circuits are performance monitored 24 hours a day. A simplified schematic, Fig. 6, shows the arrangement provided at each of the multiplexer locations. As many as 24 individual, remotely identified alarms are available for each set of equipment on a 4-wire circuit. The most important capability of this monitoring and control system is that it realiabily locates a trouble in either the common-carrier portion of the network or in the joint-use equipment. Such information is critical because it determines whether Bell System maintenance force must make the repair or RCA. Identified trouble alarms are automatically transmitted to a national control center, attended 24 hours a day, via the dial network. The dial network is used so that a failure in the Joint Use system does not cause faulty operation of the monitoring system. All field maintenance activities are controlled from the control center. It will also be used as the central contact by users for trouble reporting and for coordinated maintenance activities. This arrangement should relieve one of the major headaches that large data communication users now have — trouble isolation in extensive multi-circuited systems. As systems grow larger and more complex, as all pundits predict, such problems can only get worse.

It is proposed that in a large Joint Use Network, fault information will be fed to an on-line computer that will register and diagnose troubles following comprehensive and pre-established routines. In this manner, trouble isolation will be automatic and maintenance tasks will be significantly reduced. With this approach, faults will not only be identified, but often corrected before the user is aware of an outage. The extent of monitoring and control provided for RCA's Joint Use System is unprecedented in the commercial communications industry.

## Joint User benefits

The user costs for participating in the Joint Use arrangement are divided into two elements: 1) The network management fee, and 2) The allocated costs of the tariff services from the common carrier. The network management fee, which covers RCA costs and profits, is further divided into two portions. One is based on the number of circuit miles a user has in the network, and the second, the number of places (access points) where a user's circuit enters or leaves the voice-grade network. Unit costs for both mileage and access points decrease as total user requirements increase. For a given set of user requirements, the network management cost is a fixed amount. The user's allocated share of the voice-grade line varies, of course, with the load on the broadband circuit. If the voice-grade line contains five slow-speed circuits, then the cost per circuit is 1/5th of the total. If, on the other hand, the load is 75, the cost per circuit is 1/75th of the tariff cost.

Savings in the Joint Use arrangement versus the leasing of individual slow-speed services will vary between 20 and 50%. Fig. 7 illustrates the relationship between the cost of service in a joint-use arrangement and single slow-speed service versus distance. In computing the cost of the Joint Use Service, a load of only thirty 75 b/s channels was assumed. If the load is greater, the cost per channel is, of course, reduced and users' savings are increased.

There are many companies who have annual bills for this kind of service in excess of $100,000. Consequently, the dollar magnitude is sufficient to warrant serious consideration of Joint Use. In addition, as discussed earlier, the provision of the unique monitorng and control system assures better service.

Some users are now using dial-up systems and paying on a per-call basis because of the higher cost of a dedicated service. With the reduced cost available through Joint Use, they may find the dedicated service no more expensive than dial, and may wish to switch to a dedicated system to gain the advantage of improved service. In such cases, each user's requirements would have to be analyzed on a customized basis.

## Initial implementation

There are challenges in getting a Joint Use Program started. No user wants to be first. Also, a load of 15 to 20 circuits on a voice-grade line is required to assure significant savings for the users and a profit for RCA. Furthermore, a user must be assured of continued participation of other users in order that his savings can be expected to continue. The first problem was solved by guaranteeing a prospective user that a voice-grade link will not be implemented until an adequate group of users is under contract. Assurance of a stable situation is accomplished by including a minimum of one-year term in the contract, which each user must sign. Thus, the user has a guaranteed maximum cost for at least a one-year period. If changes should occur after this time, such that the load decreases to a point where it is uneconomical for the remaining users, they would be permitted to eliminate their services from this portion of the system.

Though it is clear that a mature Joint Use market will support a large national system, including probably more than 50 cities and many voice-grade links, it is not possible initially to obtain customer contracts with savings for all. Hence, it was decided to start with a five-city system as shown in Fig. 8, with service beginning in the second quarter of 1973. As the business matures and more users join the activity, additional cities and voice-grade links will be implemented to support the additional requirements.

## Future new business opportunities

The communication industry is now in the midst of change. The Carterphone decision allows foreign [*foreign* meaning non-common-carrier supplied] equipment to be connected to common-carrier networks. The growing competition in domestic common-carrier services will influence tariffs significantly in the next few years. It is not expected, however, that foreseeable tariff changes will nullify joint-use economies. In fact, it is possible that these factors, along with the introduction of domestic satellites and new terrestrial technologies, will make Joint Use arrangements more attractive. Recent announcements by one of the carriers pursuing the domestic satellite field, state that joint use tariffs will be offered on bandwidths as large as a full satellite transponder. Such offereings would expand the Joint Use market opportunity many fold.

RCA's interest in Joint Use was based on the merits of that business opportunity. Another reason, however, for Corporate interest is that this business provides an opportunity to work closely with industrial communication users and thereby be cognizant of additional new product and service opportunities in the communications marketplace. Future decisions on new business ventures can, therefore, be based on a well founded knowledge of customer needs.

## References


1. "The Data Communications Market", Frost & Sullivan Report, December 1972.
2. Quotation from Mr. A. L. Conrad's keynote address at the International Communications Association 25th Annual Conference May 7-12, 1972.


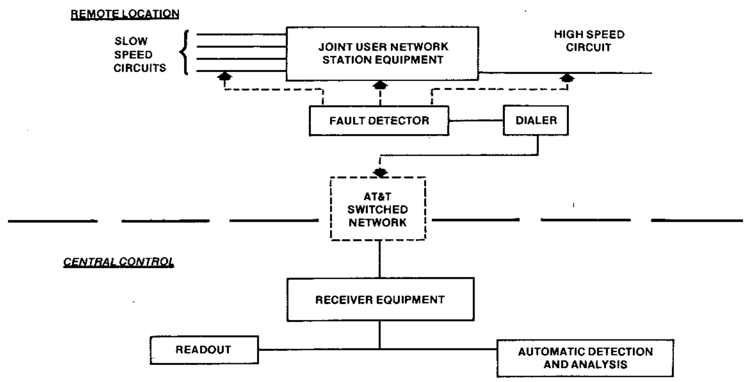


**Fig. 6 — Network performance monitoring & control system.**

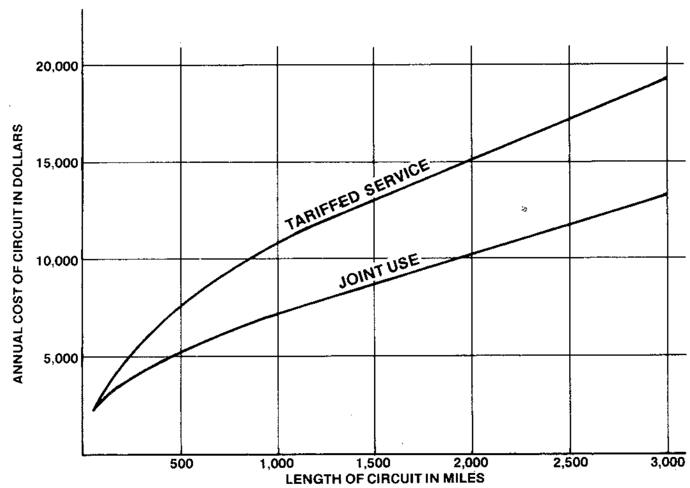


**Fig. 7 — Cost of single 75-bit per second circuit as function of length.**

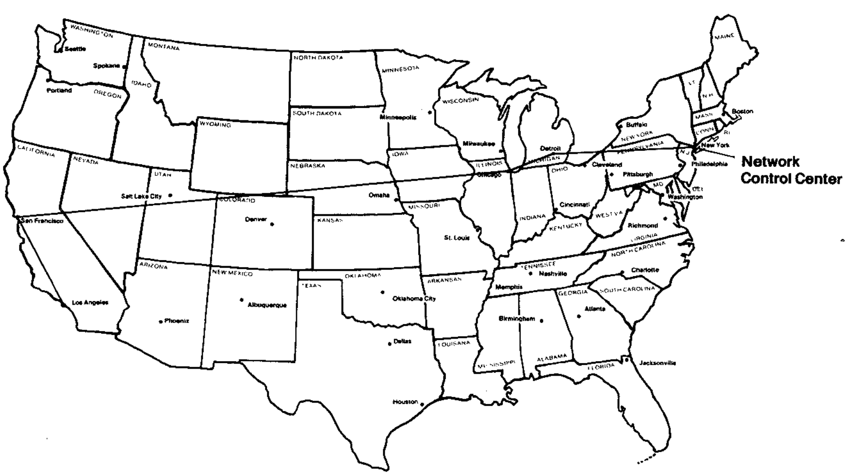


**Fig. 8 — Initial 5-city network.**

The Engineer and the Corporation

RCA Engineering Conference; May 1973

# Interdisciplinary planning—the staff role of Research and Engineering

Dr. J. Hillier

*Editor's note:* **Reproduced here is Dr. Hillier's presentation during the opening session of the recent RCA management engineering conference at Treadway Resort Inn, Lancaster, Pa. His thoughts underscore the vital role of the technical community in long-range strategic planning - and also highlight the challenges to utilize the skills and abilities of activities throughout RCA in making such plans truly interdisciplinary in nature.**

FOR THE NEXT FEW MINUTES, I have the pleasant task of describing the activities of the Research and Engineering Staff which, in terms of the present organization chart, includes my individual activities and those of Dr. Webster and the Laboratories and of Mr. Rosenthal and his organization including the Engineering Staff.

**Dr. James Hiller,** Executive Vice President, Research and Engineering, RCA, Princeton, N.J. studied at the University of Toronto, where he received a BA in Mathematics and Physics in 1937, MA in Physics in 1938, and PhD in Physics in 1941. Between 1937 and 1940, while Dr. Hillier was a research assistant at the University of Toronto, he and a colleague, Albert Prebus, designed and built the first successful high-resolution electron microscope in the Western Hemisphere. Following this achievement, Dr. Hillier joined RCA in 1940 as a research physicist at Camden, N.J. Working with a group under the direction of Dr. V. K. Zworykin, Dr. Hillier designed the first commercial electron microscope to be made available in the United States. In 1953, he was appointed Director of the Research Department of Melpar, Inc. returning to RCA a year later to become Administrative Engineer, Research and Engineering. In 1955, he was appointed Chief Engineer, RCA Industrial Eleclronic Products. In 1957, he returned to RCA Laboratories as General Manager and a year later was elected Vice President. He was named Vice President, RCA Research and Engineering, in 1968, and in January 1969 he was appointed to his present position. Dr. Hillier has written more than 100 technical papers and has been issued 40 U.S. patents. He is a Fellow of the American Physical Society, the AAAS, the IEEE, and Eminent Member of Eta Kappa Nu, a past president of the Electron Microscope Society of America, and a member of Sigma Xi. He served on the Governing Board of the American Institute of Physics during 1964, 65. He has served on the New Jersey Higher Education Committee and as Chairman of the Advisory Council of the Department of Electrical Engineering of Princeton University. Dr. Hillier was a member of the Commerce Technica Advisory Board of the U.S. Department of Commerce for five years. He was elected a member of the National Academy of Engineering in 1967.

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## A job description

After considerable thought I decided that the best way to present this would be to "talk" through a job description I wrote for myself a few years ago; one that is still quite valid. While I call it a job description it is not in the format of our standard personnel job description—rather it is a straightforward statement of what I think we should be doing, based primarily on what I think the company needs to have done. Basically I see myself and the Engineering Staff interacting at four major interfaces:

1) With top corporate management and corporate staff functions.
3) With RCA operations in all the divisions and subsidiaries.
3) With the Laboratories.
4) With the outside world of government, academia and competition.

While there are obviously a great many specific activities that occur through the four interfaces, all my actions are guided by one straightforward and general objective to keep the technical *and business* activities of RCA closely and properly coordinated. While there is rarely any dispute, at least intellectually, concerning the validity of this objective nor of its importance to the corporation, I am disappointed to realize that this basic role of Research and Engineering is still not always appreciated by the people with whom we interact. Now let me be more specific and discuss the four interfaces one by one. The first I listed was our interaction with top management and the corporate staffs.

### Interaction with top management

We have several responsibilities in this area. Without question the one with the highest priority is our participation in long range strategic planning for the corporation. Research and Engineering is particularly involved in the high technology aspects of the company.

In my opinion, long-range strategic planning for a diversified company such as RCA can be done only by the Chief Executive Officer and the Chief Operating Officer, complemented by staff executives who are at one time specialists—marketing, research and engineering, manufacturing, finance, etc.—but also generalists who are capable of understanding the interaction of their disciplines with all the others. The chief officers also must have data input compressed with good judgment. The staff executives provide a significant part of that input.

Obviously, this is a continuing day-by-day process and has little of the formality we normally associate with planning.

In passing, I assume it is obvious to all of you that "planning" like "research" is a pervasive activity that occurs in all acctivities in a corporation from the top management — to the planning to produce products at a profit and meet production schedules. I believe that we often suffer from the poor communications engendered by using the word "planning" without proper identification or qualification.

A second high-priority responsibility of Research and Engineering, relative to top management, is the objective appraisal of engineering programs in our divisions with particular emphasis on the divisions' long-range plans. Basically, we are charged with giving an independent answer to the question: Are the engineering programs in the division plans adequate to support the long range business growth that is invariably shown in those plans? The answer is particularly important since it is recognized that adequate engineering is essential to the success of those plans — and yet the engineering program is only rarely spelled out in the final presentation of business plans.

Here, we in Research and Engineering have to walk a fine line. On the one hand we want to be helpful to the divisions in obtaining approval for their plans. On the other we must maintain our integrity and credibility with our bosses. Obviously when the engineering programs of a division are in good shape we have no problems. On the other hand when our judgment leads us to a negative appraisal we must make sure we present our findings to the division management and discuss the problems before we provide a report to our superiors.

Another responsibility relative to top management is in the advance sensing of problems of corporate-wide significance—particularly (for Research and Engineering) when the impending problem has a high technical content or involves engineering in some broad sense. Our responsibility also must go beyond the sensing and lead to the formulation of recommended actions either to avoid or solve the problem.

Finally, in this category, I still feel that there is always need for greater interaction between the Research and Engineering staff and the other corporate staff activities, even though the situation is enormously improved over a few years ago.

Many of you have heard me discuss the fundamental changes that have occurred in our world of high technology—the fact that technology is no longer in short supply—the fact that the "easy" market needs are largely satisfied—and that these changes have put us in a position where the emphasis in research and development must be directed toward specific needs of the market place—and for that matter toward the needs of society. In addition to this general situation we still have the specific situation where it appears that any new consumer service must be entrepreneured by a corporate activity.

All of these obviously require the closest possible cooperation among the Research and Engineering, marketing, manufacturing and other staffs. Research and Engineering must continue to take initiative in this effort.

### Interface with the divisions

Now let me turn to the interface between Research and Engineering and the operations. Here there are many roles for us to play. We are advisors, objective and (I hope) constructive critics, communicators, representatives and champions to both engineering and general managements of the divisions and subsidiaries. The one thing of which I hope we can never be accused is of being "second guessers."

I believe our prime obligation with regard to the divisions is to understand their engineering programs and the related business significance in the greatest possible depth.

The better the understanding we have built into us, the more accurately we can represent the division's position in corporate meetings and discussions and the more we can feed back to divisions any corporate trends and attitudes of significance. Now to be a little more specific, here is a listing of the areas of particular interest to us and on which we believe we should have a good dialogue:

1) We are interested in making sure that new business opportunities in each division are given proper consideration. By that I mean there should be exposure and explanation at the corporate level instead of submerging them as was sometimes our habit in the past, particularly when the immediate profit impact appeared to be negative. The climate in RCA has changed and corporate management is very receptive to a well prepared proposal for a new business opportunity.
2) Advanced development activities for ongoing product lines in the divisions is a high priority item in Research and Engineering's list. We firmly believe that we must keep our maturing businesses healthy since, as I pointed out last year, these are the businesses from which we expect to obtain the profits to enable us to invest in the future.
3) Our third interest is in the quality of our product design engineering for manufacturing. RCA has a long-standing and fine reputation for being a good development organization. However, our developmental skills yield profits in our commercial businesses only after our developments have been product designed so they can be manufactured at low cost and can provide the promised performance to the customer with high reliability.
4) Given a reasonable understanding of the engineering programs of the divisions, and their business significance, we are in a position to make sure that the Laboratories provide the proper kind of support.
5) The last specific item on this list is our interest in stimulating a better and perhaps more formal analysis of competitive products. We continually pressure for more objective and more complete analyses rather than merely defending our own engineering and belittling that of our competitors.

In addition to reviewing, discussing and prodding the division engineering effort in these different areas, we have some other less-defined activities such as becoming involved in the coordination of several divisions on multi-divisional projects, correcting duplication of engineering effort when it appears unnecessary, and on occasion, causing some cross fertilization between divisions.

In addition, Mr. Rosenthal's Corporate Engineering Services groups provide some centralized services that would be ineffective and subcritical if handled individually in the divisions—Corporate Standards, Frequency Bureau...and several activities aimed at upgrading the professionals in the divisions are the major ones.

Putting this all together you can see that Research and Engineering's interaction with the divisions is extensive. We implement this through day-by-day contacts and by discussions of specific projects and problems, supplemented by our annual engineering reviews.

Incidentally, as the time for these reviews is rapidly approaching, I might say a few words about my thoughts for this year. We are hoping to reduce the formality of these reviews substantially and increase the informal discussion of the *relationship* between the engineering programs and the business strategy of each division. I find that listening to a day-long description of engineering projects, schedules and budgets has about as much impact on me as reading a telephone book. An in-depth discussion of market needs and opportunities, and of engineering's plans and problems in responding (including manpower and financial) is what we really want and can use to best advantage in the corporation.

### Interface with research

My third interface is that with the Laboratories. Since Dr. Webster reports to me this is an easy interface. Quite seriously though, Dr. Webster and I are in constant communication and moreover seem to think along remarkably parallel paths. I depend on Dr. Webster and his Laboratory Directors and Group Heads to maintain their own direct communications with the divisions. My inputs indicate that that situation is continually improving.

I look on the Laboratories as providing certain major resources and services to the corporation. Since I believe most of you are familiar with them I shall simply list them in my order of priority.

1) To provide the technical support for the generation of new business opportunities. This has two facets—where the new business opportunity is based on a technical breakthrough—and where it is based on a market opportunity that requires a breakthrough. The Laboratories operates in these prime modes for both the divisions and subsidiaries and for corporate programs.
2) To provide present and future support for the divisions and subsidiaries. I happen to believe we have the best electronics consultant Laboratory in the business. We have skills in many disciplines that are not likely to be supported in specific divisions. Through the Laboratories' day-by-day interactions with the divisions, it can also develop a good "feel" of how to deploy its resources to provide future opportunities for the divisions.
3) To do good basic research that is both relevant to RCA and at the same time gives us access to corresponding work in other institutions. Through this route we can often anticipate trends in technology by several years.
4) Our somewhat special situation provides a number of important supplemental opportunities—for recruiting top technical personnel into the corporation, augmenting RCA's technical image, etc.
5) To play a significant role in providing basic patents and other support for licensing and technical aid agreements.
6) Finally, we are continuing to attempt to find possible roles where we can provide technical support for the non-electronic subsidiaries.

I could spend all my time discussing this in detail. Let me say only that the policies implied by these several functions have been operating for about eight years and have now resulted in substantial changes in the relationships between the Laboratories and the divisions. One example: the formal meetings of ten or more years ago that were set up to review the research needs of the divisions invariably generated a "shopping list" of "yesterday's little engineering problems." Today with the greatly improved informal discussions, the lists of research needs of the divisions that are generated about once a year are lists of true research for the future—not always as far in the future as we think they should be—but certainly in the right direction.

### Interface outside RCA

My final interface is with the world outside RCA. This is a very diffuse, complex interface where all of us interact to some extent. Interactions with the FCC, EIA, standards organizations, universities, many government regulatory agencies, etc., are all part of our daily efforts.

### Engineering staff

The Engineering Staff has undergone substantial evolution during the past few years. We have deliberately trended away from technical specialists to what I loosely call "technical generalists." Primarily we select new people on the basis of a good technical background but also require that they have either the experience or the potential for appreciating the relationship between business and technical problems.

We no longer consider the Staff Engineer a career position but rather as an experience broadening assignment of from two to five years. The position provides the incumbent with a broad exposure to RCA businesses from a reasonably neutral base and at the same time provides exposure to many activities of the company in which he could play a useful management role in the future.

All of this is just a rather long-winded way of saying that we expect turnover in our staff and, furthermore, we can provide an excellent opportunity for advancement for some of *your* bright young people. In case you think I am naive in expecting you to offer Mr. Rosenthal any of your bright young people, let me remind you that there are occasions where your brightest and most ambitious people find their advancement to be too slow and will inevitably leave for "greener pastures." A good engineering manager can sense this and also recognize that it would be better to retain the man for RCA than lose him altogether.

### Summary

In giving this very brief description of the Research and Engineering activities, I have probably erred in the direction of making it appear to be a neatly wrapped package. It is not, of course; it is diffuse, complex and ever-changing. In the real world, there is a lot of Brownian movement, but by having a clear understanding of our role we can at least hope to introduce a drift in the right direction.

RCA Engineering Conference; May 1973

# Interdisciplinary planning — unexploited opportunities for electronics technology

Samuel Weber, Executive Editor, *Electronics* Magazine

*Editor's note:*: **Reproduced here in its entirety is Mr. Weber's presentation made at the Management Engineering Conference in May 1973. We believe his basic concept; that electronics consists of a collection of industries selling to each other and to every other kind of business, as well as to the consumer; will be of interest to engineers at RCA. The end result of such business interplay is described as comprising an electronics technology market (ETM). Mr Weber graphically pictures the numerous multi-billion dollar markets of the future.**

Most of what I am going to say is not really new, but I do hope it will stimulate you to look at the future of electronics, which is really your future and my future, in new constructive ways.

My topic, the future, is something we are all interested in, whether we like it or not. This meeting is an acknowledgment of the future just as all planning acknowledges the future. And you share with me a common situation: we're both in a business where most of the failures seem to result from inadequate long-range planning. As examples, the demises of Colliers, Saturday Evening Post, Look and recently Life seem to have happened because their managements had no workable concept of the future, and then panicked when the future became the present. I leave it to you to name their counterparts in the electronics field.

Another thing I'm sure that the management of *Electronics* magazine has in common with RCA engineering managers is that we do a lot of thinking and worrying about where electronics technology is going and where it *should* go. I'd like to share some of our conclusions with you. Let's begin by characterizing the present situation.

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**Samuel Weber,** Executive Editor of *Electronics* Magazine, worked as a design and development engineer before joining *Electronics* in 1958. He was associate managing editor from 1964 to 1967. After a year as chief editor of *Electro Technology*, he returned to *Electronics* in 1968, and moved into his present position in 1970. Mr. Weber has a BSEE from Virginia Polytechnic Institute, and has done graduate work at Brooklyn Polytechnic Institute and CCNY. He is the author of many articles and three books on electronics. He is a member of the IEEE.

## The present situation

Electronics is not an industry at all. Rather, it is a collection of industries (like the computer industry, the semiconductor industry, the interconnection and components industries and so on) who sell not only to each other, but to just about every other kind of business, as well as to the consumer.

This collection of industries also share an electronics technology marketplace. The degree of growth of this marketplace depends on how well we can penetrate it in every area of human endeavor. If we define objectives properly and make those objectives happen, we will achieve stupendous growth. If we sit around and wait for things to happen — as many seemed to do in 1970 and 1971 — a high growth rate just won't occur.

We are entering a period of a few years duration where marketing is probably more essential than science. This does not mean that we must not continue to support strong R&D efforts. It means that for the near term we have available many alternative technologies now, which, with the proper investment and a major engineering effort will cause an acceleration in their application where they are not being used significantly today.

## Proliferation opportunities

We believe that the electronics technology marketplace will grow primarily through proliferation of our technology into all kinds of applications where it does not exist today — or at least is not an important factor. For convenience in thinking about this concept, we divided the whole proliferation opportunity into these 5 rather arbitrary categories:

1) *Replacement* includes things like electronic calculators, where an electromechanical technology has been replaced. Other current examples include watches, cameras, typography, electronic point-of sale terminals, etc.
2) *New needs*: Primarily these arise through some government edict. All of a sudden, the law says you've got to do something, and there's no way to do it except electronically. Obvious examples would be automotive, safety, pollution, crime, etc.
3) *New markets* refers to entirely new electronic products or systems which create their own demand as soon as they become available. Two-way CATV, Picturephone, VTR's and microwave ovens are examples.
4) *Productivity* represents the single largest opportunity for proliferation. There is a tremendous backlog of need for electronics-based systems which can improve the productivity of our workforce. Most of these will be computer-based.
5) *Overseas markets*: We expect overseas electronics markets to continue to grow at faster rates than the U.S. market. That's because, in addition to the other four factors occurring, there are unsaturated traditional markets and a need to catch up.

## Defining the future

There are three additional thoughts about envisioning the future for your consideration:

1) *The near-term future*, and by that I mean 10-20 years, is very much tied to the way we live and work. In effect, most of our major growth opportunities involve the consumer in one way or another.
2) *Longer term*, our future is related to the energy crisis — or energy shortage — and how that gets solved — if at all.
3) *No prediction*, or trend extrapolation, no matter how bullish can really do justice to the opportunities that lie ahead. The 30-year potential of the electronics technology market is truly staggering. There are some people running around Wall Street now who think that electronics is not longer a growth business and that its future is staggering in the same sense of the word. Words like "maturing" and "consolidation" are used to describe the next several years. I cannot find any evidence or logic to support that idea. Gentlemen, the electronics technology marketplace stands today on the threshold of truly fantastic growth. And that growth will be solid, because it will come from the sale of products, systems and services that are really needed and wanted by society.

## Consumer growth areas

Some of these consumer-oriented growth areas I will cite involve a lot of statistics. Please don't hold me to their accuracy, and it isn't important that you remember them. Their order of magnitude indicates that there are some major opportunities out there for you to exploit. The numbers happen to be in U.S. market terms, but they could just as easily apply worldwide.

## The electronic person

Let's begin with you and me — the personal consumer — the electronic person (Fig. 1). There are about 205 million Americans, and last year they averaged $200 per head on clothes and personal furnishings. Essentially none of this was spent on electronics. The census people say there will be 230 million of us in 1980. Let's assume this prediction is about right, and that the bill goes up to $250. The kind of question we could ask ourselves is: How do we get $10 of that? That would be a U.S. market of 2.3 billion dollars — perhaps 4 or 5 billion worldwide.

THE ELECTRONIC PERSON

| | 1972 | 1980 |
|---|---|---|
| PEOPLE | 205 MILLION | 230 MILLION |
| CLOTHES & FURNISHINGS | $200 PER | $250 PER |
| ELECTRONICS | ZIP | $10 ? |

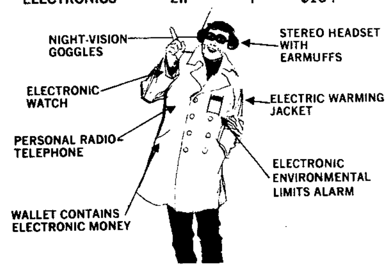


Fig. 1 — The electronic person.

Lots of people wear earmuffs in cold weather. Personally, for those cold winter walks up 6th Avenue, I'd like to have an electronically-controlled electric coat which would hold constant temperature no matter what the wind-chill factor was. Also, some people are beginning to fight noise pollution in cities by wearing acoustical protectors. Why don't we package stereo radio in there too?

We are probably going to have a lot of legislation on environmental limits, and I can foresee a federal-aid program so we can all buy an electronic-environmental limits alarm.

The night-vision technology is almost entirely military now, but with mass production we ought to be able to bring the price and weight down to the reach of everybody who doesn't want to stop playing golf when the sun sets. The revolution in electronic watches is already underway, and by 1980 I doubt

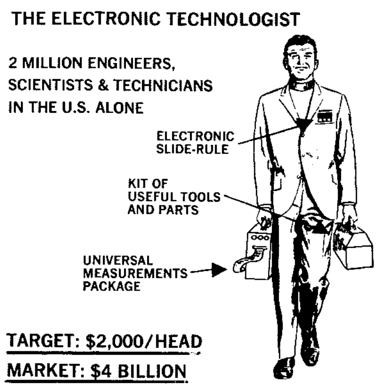


Fig. 2 — The electronic technologist.

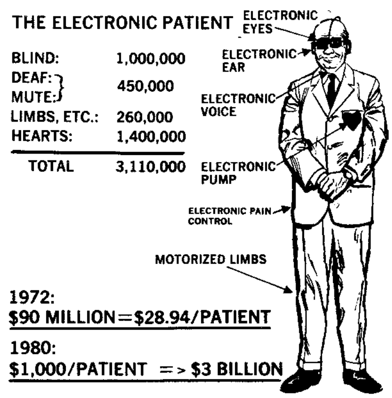


Fig. 3 — The electronic patient.

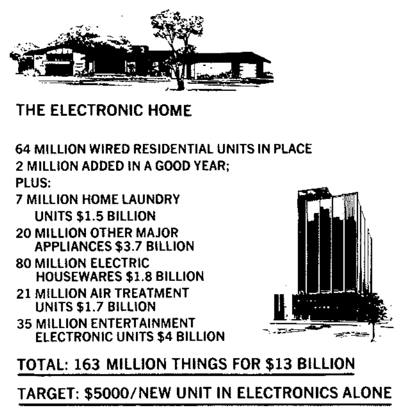


Fig. 4 — Opportunities in residential housing.

that any timepieces will be non-electronic. If so, there will be about 300 million electronic watches sold worldwide in 1980.

Today, only a few people can afford to make phone calls from their cars, much less their pockets. But this is another major long-range opportunity. And, of course, as electronically-read credit cards become the dominant medium of retail exchange, other markets such as banking, and vending will accelerate their expenditures for electronics.

The point of all this is that there is an opportunity. We don't know how big it is. But we ought to start thinking more seriously about how to crack the clothes and furnishings markets and what share we can get.

## Specialty consumers

Specialty consumers are those who, by virtue of their vocations or hobbies, constitute additional markets for electronics. The technologist is one of those specialty consumers.

There are about 2 million engineers and scientists of all disciplines in the U.S. today (Fig. 2). Until recently, when an engineer bought electronics, it was primarily as a purchasing influence within his own company, and spending money that was not his own.

Then along came the H-P 35 electronic slide rule. This experience should make us all sit up and notice this market opportunity. H-P sold 75,000 units in a little over a year at 400 dollars apiece. Why not, for example, a universal electronic measurements package, with which the engineer can make just about any kind of measurement required, within some accuracy limits, in just about every technical discipline? I think you could sell a few. Or how about analyzing the routine tinkering needs of all engineering disciplines and come up with a comprehensive kit of electronic modules a man can use in his cruder experiments? It doesn't really matter what the market figures really are; they are big enough to support the effort if you can figure out what will sell.

There are literally dozens of specialty consumer markets. Another example concerns the 850,000 nurses who will be active in the U.S. by 1980. We ought to be able to sell them to the tune of $200 each for some kind of combination electronic pager and pulse pressure temperature recorder. There are 400,000 physicians who need some stuff too, and 130,000 dentists with sore feet. Maybe we can do something for them.

## Electronic patients

Another class of specialty consumer who warrants special comment is the electronic patient (Fig. 3). There are 1-million Americans who are either legally blind or have very severe sight loss; 450,000 are legally deaf, or mute, or both; 260,000 people are missing limbs; and, another million have limbs that don't work; 1.4 million people have had 1 or more heart attacks; and, nobody knows how many people are in severe pain. In 1972, the market for electronic prosthetic devices totaled $90 billion — mostly in hearings aids and pacemakers. Here is an opportunity to push developments along and do well by doing good.

## Electronic home

Turning to another kind of opportunity, let's look at residential housing (Fig. 4). There are 64-million wired residential units in the U.S., ranging from single-family dwellings to units in high-rise apartments. In a good year, 2-million units are added, at an average cost of $15,500. This adds up to a residential construction market of $31 billion. On top of this, home owners and renters buy another $13 billion of appliances, for a total expenditure of $44 billion. It seems to me that sometime in the future a $10 billion market for electronics in new construction could be a reality, but we

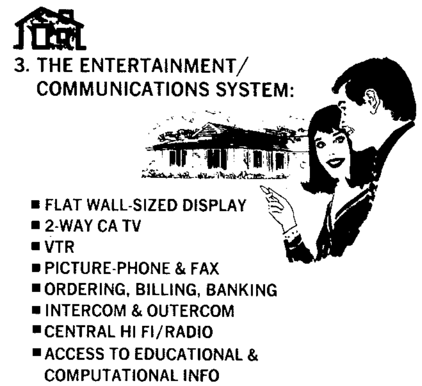


Fig. 5 — The entertainment /communications system.

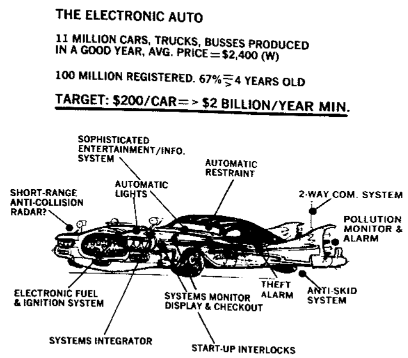


Fig. 6 — The electronic auto.

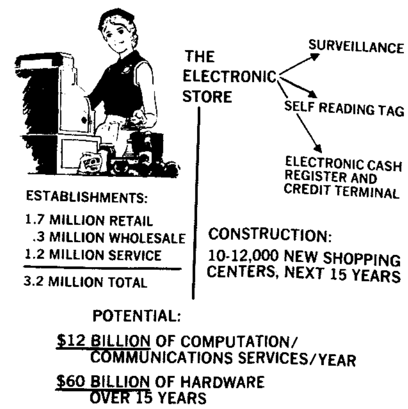


Fig. 7 — The electronic store portends great potential.

obviously can't accomplish this just by selling electronic controls for ranges and eggbeaters. So, how could we? One way, I think, is to look at residential construction as a systems market.

## Systems approach

If we take a systems approach, there are probably 3 kinds of systems that can be sold, and *wired-in* at the time of construction:

1) The *production* system includes laundry, ranges, microwave ovens, hot and cold storage mixing and blending, compaction and disposal. With the right kind of design, it should be possible for your wife to dial-a-breakfast, set the timer, and have your eggs, toast, and coffee delivered on scheduled untouched by human hands. This may sound farfetched, but so did television.
2) The *home management* system would include heating; cooling and water conditioning; fire, rain and intruder controls; lighting and timing; garage door control; meter reading; and systems monitoring. The system would probably be computer-controlled on a centralized basis.
3) The total system would tie together all the communications and entertainment terminals into a single system (Fig. 5). It would probably — as all 3 systems would — have to permit modular replacement and upgrading of the system as a whole.

Over the last 20-30 years, there has been relatively little progress made in residential construction. The right kind of systems approach could give us progress and open up a substantial market for electronics technology.

## Electronic autos and stores

So much has been written about the automotive electronics market that I don't want so spend much time on it here, except to say that a $2 billion annual market is not at all out of the question by 1980 (Fig. 6).

Another problem of great interest is the electronic store (Fig. 7) for retail distribution. Electronic systems are rapidly replacing the old cash-register/money-changing systems. The current inventory of retail, wholesale, and service establishments constitute a retrofit market in which the pace of new construction on shopping centers alone portends great potential.

The principal electronic systems will include surveillance — such as CATV and pilferage alarms, and merchandise tags that can be read by machines and point-of-sale hardware. This is basically a systems-engineering opportunity.

## The electronic office

If your office workers are anything like mine, they are *very* unproductive. They are not unproductive because they want to be, but because we as managers have not been willing or able to find them better tools to make their time more productive.

The electric typewriter performs only a small fraction of the work that should be performed by an efficient stenographic system terminal, yet 900,000 are sold every year. My guess is that at some point in time the electronic content of offices is going to be so large that desk manufacturers will either be in the electronic systems business or will be out of business.

A floor plan (Fig. 8) suggests some of the gear that will be installed in offices of the future. I should point out that salaries of office workers and costs of floor space will continue to rise, which will in turn aid in the economic justification for purchase of office productivity systems.

## Billion-dollar tidbits

Automatic vending is big business, and will continue to be a growth market for

THE ELECTRONIC OFFICE
PRODUCTIVITY IS THE PROBLEM

OFFICE MACHINE MARKET IS ≈ $7 BILLION/YEAR
OFFICE FURNITURE IS $900 MILLION
900,000 ELECTRIC TYPEWRITERS SOLD/YEAR
2 MILLION EXECUTIVE & SECRETARIAL DESKS SOLD/YEAR

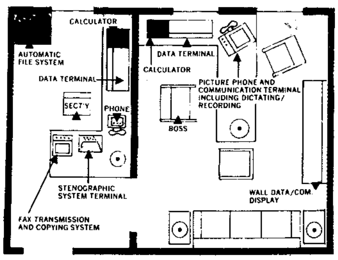


**Fig. 8 — Floor plan for the electronic office where productivity is the key.**

our technologies, with about 500,000 units installed per year. A major growth force will occur when credit vending becomes a reality.

Another obvious growth market is the postal service, which will spend $2.4 billion over the next few years to install automation equipment. This equipment will, of course, be primarily electronic.

Our friend the nurse is using outmoded equipment again. There are nearly 2-million hospital beds in the U.S., and it seems to me that we ought to be able to nail down $100 each in monitoring and entertainment systems. Hospital expense per patient-day has gone from $8 to $45 in just 20 years.

The railroads are in a lot of trouble, but they still buy about 50,000 freight cars in a good year. Railroads also have a million and a half cars in the inventory, and their problem is that they don't know where the equipment is located. You may be familiar with the new experimental automatic car identification system that's being tested; it consists of special labels on cars which can be read by trackside scanners. There's a good deal of economic justification for such a system, because a 10% increase in car utilization will save the railroads $200 million a year.

## Industry

The industrial/establishment is my last tidbit, but it is hardly that. All I can do is mention it in passing, because the electronics opportunity here is so large that it could be the subject of several speeches. But just briefly:

- There are 315,000 industrial establishments. Sell each 1 of anything and you have a big unit market.
- Capital outlays run over $20 billion per year, including a billion for machine tools. The electronic content of these outlays must rise.
- Industry has a $30-billion annual problem in materials handling, which we ought to be able to help solve.
- The annual pollution-control bill by 1975 may be as high as $18-billion, and a major part of that will be measuring and monitoring.
- The $150-billion payroll must be made more productive, or industry will choke on it.
- The $100-billion in inventories must be managed better, and
- Industry's $20billion in R&D expenditures (by and large) are not addressed to these problems, but our R&D should be.

I said at the outset that the short-term electronics market opportunities would be very much a function of the way we live and work. The examples I used to illustrate this point are by no means the only ones, but I did try to hit those that look major.

## The energy crisis

Looking at the longer term, it appears that the energy crisis and how it is solved (if at all) will play an important role in the development of our markets. The newer energy sources will require more electronics. For example, it will take more instrumentation to gasify coal than it does to drill for natural gas. If we get into more exotic forms such as breeder reactors, nuclear fusion, and solar power it will take even more.

Perhaps even more significant, we may be forced by energy shortages to have a communicating society rather than a traveling one. This would mean, for example, that you don't go to the office regularly — you communicate from your home. You don't fly to trade shows, and you don't turn out for learned dissertations like this. You participate through conference hook-ups. You don't even call on customers — you negotiate on the "boob-tube" and confirm your proposals by fax.

This may sound farfetched, but the fact is that even at today's fuel costs there is a good deal of economic justification for building a communications apparatus that would enable us to do the kinds of things I'm suggesting.

For example, passenger vehicles in the U.S. consume about 65 billion gallons of fuel per year — a retail value of $26 billion. Nearly 75% of the energy content of this fueld is wasted — or about $19 billion. We can afford to start cutting that loss.

Whether you look at the costs of fuels as they become scarcer, or the cost of alternative power sources or the trade-balance implications of running short of domestic oil reserves, or the environmental impact of continuing to be the world's biggest free-spenders of energy, you will keep coming back to the idea that a communications-based society will be upon us before we know it.

## Summary

I'd like to summarize my presentation by simply recapping the following points:

1) Anybody who thinks electronics is not a growth market should be locked up. Anybody who thinks it is maturing — in, for example, the automotive industry sense — just isn't paying attention. There is much more opportunity for growth today than there has ever been.
2) Much of this growth, however, will come at the expense of existing technology positions and it must therefore be forced to happen. Much of it will also come from areas in which our marketing people and even our engineers are not expert. So, a strong, well-funded market-development program will be necessary to close with the opportunities that are there for the taking.
3) Unless everybody is crazy, 1973 will be a very good year. This means that our managements will have more discretionary dollars than usual. I'd suggest that 1973 would be a good year to establish the kinds of development programs needed to identify and get going on some of the longer range opportunities available to us.
4) And finally, I want to stress that marketing is much too important to be left exclusively to marketing people. As you can see in all the potential markets I have described here tonight, there is a large engineering and development content. If you, as engineers and engineering managers are not heavily involved right now in market development, then I believe you are not headed into the future.

RCA Engineering Conference; May 1973

# Interdisciplinary planning — Description and Summaries

The Engineer and the Corporation

W. O. Hadlock, Editor

**The information in this article has been compiled from information provided by the speakers and from recordings made during the Corporate Engineering Management Conference. Some of the summaries included herein are limited in scope and content because of the nature of the conference. Additional information may be available from the conference speakers. Credit for the tape recording is due G. B. DiGirolamo and L. A. Gagliardi of Engineering Education. Photography was furnished by Bruce Hull of Electronic Components.**

A CORPORATE ENGINEERING Management Conference, convened at the Treadway Resort Inn, Lancaster, Pa., May 9-11 adopted as its theme the need for early and continuous companion planning throught RCA...requiring the effective use of the combined talents of corporate business planning and market research, as well as associated engineering activities.

More than 160 individuals participated, including members of top corporate and division management groups, market planners, product specialists, chief engineers, managers, and research directors throughout RCA concerned with the effective application of RCA's technical resources. The three-day conference was sponsored by Research and Engineering.

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Final manuscript received July 25, 1973.

### Interchange of ideas

In welcoming the attendees from approximately 20 RCA divisions, Dr. James Hillier, Executive Vice President, Research and Engineering (who served as session chairman for the opening day), emphasized that a major objective of the meeting should be a free interchange of ideas concerning new products and new markets, as well as an effort to discover new potential in the established skills and facilities.

Throughout the three-day program, time was made available for individuals and groups to confer on the challenging problems faced in bringing appropriate and profitable products utilizing RCA technology to the marketplace. Major roles of Research and Engineering, Patents and Licensing, and Quality and Reliability Assurance were reviewed.

### Innovations discussed

Recent innovations such as the RCA Video Disc System, new color receivers employing precision-in-line color tubes and negative matrix color picture tubes were described; the color tubes were displayed in side-by-side comparison with the best that the competition has to offer. Also presented were several examples of successful entrepreneurship such as the TCR-100 Professional Video Tape Cartridge Recorder, and solid-state devices employing new COS/MOS technology.

### First-day session

Highlighting the first-day session were presentations by R.C. Butler and L.J. Farley, representatives of corporate finance and planning groups, who reviewed RCA's performance in 1972 and described projections for 1973 and beyond to 1980 that augur a continued annual business growth well above Gross National Product rates. Latest Corporate business plans, also indicating a strong annual profit growth rate, were describ-

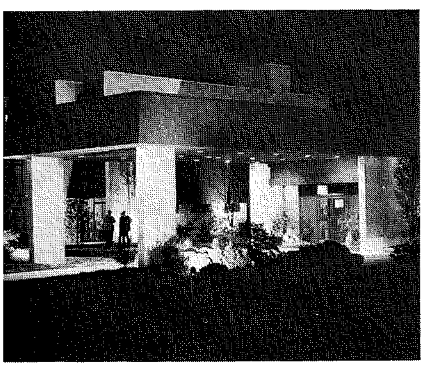


**Fig. 1 — Nighttime view of the Treadway Resort Inn at Lancaster, Pa., where the 1973 Corporate Engineering Conference was held.**

**Fig. 2 — Conferees in discussions during breaks between sessions.**

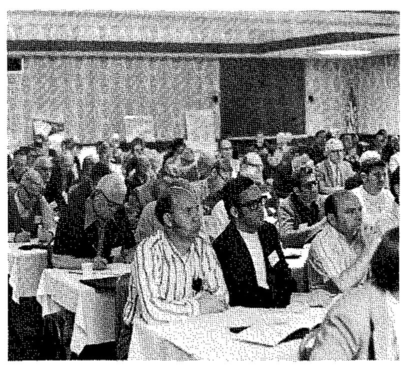


**Fig. 3 — Typical classroom scene where conferees hear one of many presentations given during the 3-day session.**

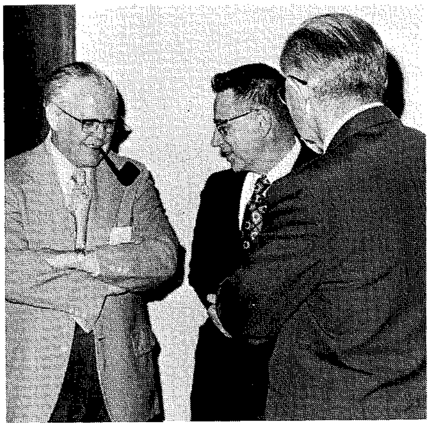


Fig. 4 — Dr. James Hillier, Executive Vice President, Research and Engineering (left) served as Conference host and chairman for session I; he is shown during a discussion with Dr. H. J. Woll, Division Vice President, Government Engineering — and W. R. Isom, Chief Engineer, RCA Records.

ed. Most significant among the new business programs cited are SelectaVision, domestic satellite communications and the Alaskan telephone expansion, and integrated circuits. Electronics continues to be the major factor in RCA's business, and it was noted electronics still would account for more than two-thirds of total sales in 1980 for RCA and its subsidiaries.

The key to continued business growth was reported to be the contributions of Research and Engineering in problem solving, contributions of new product ideas, and the evaluation and projection of new products in terms of the consumer. Other essential factors described were: provision of product quality superior to that of competition, assurance of increasingly closer relationships among the Laboratories, the divisions, and staff activities. Such liaison will continue to improve the communication of management goals and objectives and will become an even greater factor in the future.

## Research and Engineering role

Dr. Hillier concluded the first-day morning session with a review of the role of Research and Engineering throughout RCA (his complete article appears in this issue). Dr. Hillier gave tribute to the wide-ranging skills and the existing technology available within the RCA technical community. At the same time, he stated that the most challenging goal may be to provide an accurate assessment of market acceptance for specific technical products or services and to devise an appropriate route by which RCA could address the markets.

To achieve success, and supporting the theme of the conference, Dr. Hillier encouraged close liaison between marketing and engineering on a broad scale.

He outlined the primary Research and Engineering Staff job description as one requiring interaction among four groups: 1) Corporate Management and Staff, 2) the divisions, 3) the Laboratories, and 4) activities outside RCA including Government and the general scientific community. In all cases, technical and business objectives must be closely related.

In each of the above four major groups, Dr. Hillier stressed that the thread of long-range-strategy planning and the objective appraisal of engineering programs must be ever present...and that there is always need for greater interaction between Research and Engineering, other staff activities, and the divisions. It was pointed out by Dr. Hillier that new technology is no longer in short supply, yet advanced development must nurture maturing businesses; business opportunities and product ideas are welcomed and must be given proper consideration; we must not submerge them. Dr Hillier agreed that although our design and development groups have a good reputation, we must not deliver developmental models to the customer. RCA products must operate perfectly from the beginning. Opportunities for the future were pictured as including rapid and explosive growth in an electronics technology market that will be largely information based; computation and communication will increase both here and abroad. Dr. Hillier emphasized an often overlooked point that many economic considerations must include the cost of disturbing existing systems, of training people, and of making effective transitions.

## Role of patents

For the afternoon session, J.V. Regan Staff Vice President, Patent Operations

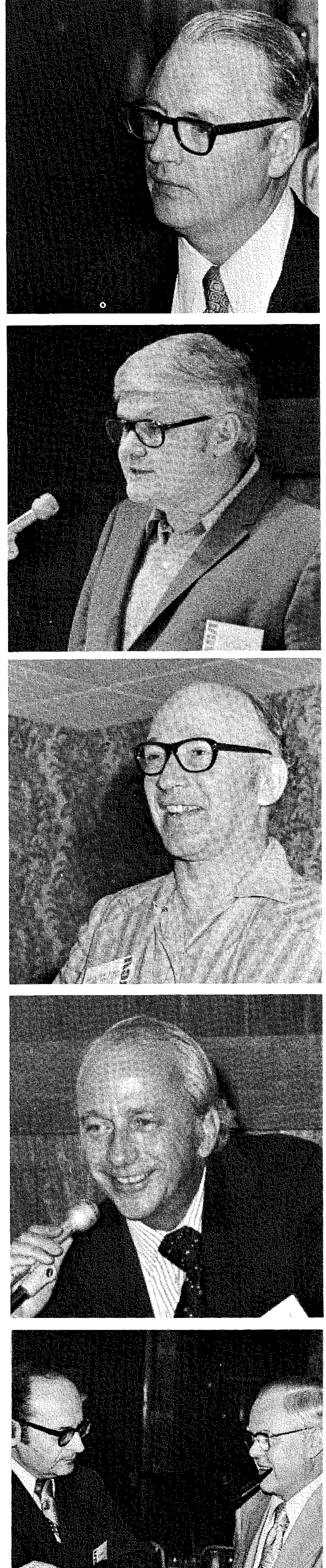


Fig. 5 — Top to bottom: J. V. Regan, Session II Chairman; E. M. Hinsdale, Session III, Chairman; H. Rosenthal, Session V Chairman; and W. M. Webster, Master of Ceremonies for the evening dinner session, introducing the banquet speaker, Samuel Weber, Executive Editor of *Electronics* (shown at right during discussion with Dr. Hillier).

Fig. 6 — Front entrance of RCA's facility at Lancaster, Pa.

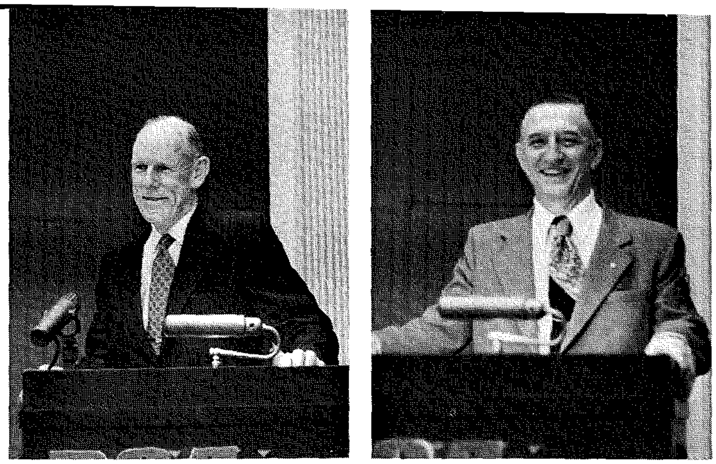


Fig. 7 — C. E. Burnett, Division Vice President and General Manager of the Industrial Tube Division (shown at left welcoming conferees), served as host for the tour of the industrial Tube Division activities in Lancaster, Pa. C. P. Smith (right), Director, Industrial Tube Division Operations, during briefing of conference groups, prior to their inspection of the Industrial Tube Division facilities at Lancaster.

served as Session Chairman. He; E.M. Whitacre, Director, Patents, Consumer Electronics; and S.S. Barone, Vice President, Licensing reviewed: "Trends in Industrial Property Protection of Inventions and the RCA Inventor Recognition Program." "The Relationship of the Chief Engineer and his Patent Attorney" came in for major attention. Emphasis was also given to the need for the documentation of patent disclosures by RCA engineers as a major contribution to the continuing success of RCA as a world technical leader. Engineering managers were encouraged to employ new ideas together with the support of the members of Patent groups to ensure that patent protection is obtained for these new ideas. Mr. Barone concluded that the goals of Research and Engineering and Patents and Licensing functions comprise a common cause to assure RCA's success.

## Electronic technology markets

Climaxing the first-day session was the reception and dinner after which Samuel Weber, Executive Editor of *Electronics* delivered a talk on "Unexploited World Wide Opportunities for Electronics Technology" (his entire talk is published in this issue).

Mr. Weber stated that the RCA Corporate Engineering Conference is an acknowledgment of the importance of the future, just as all planning acknowledges the future. A basic concept portrayed is that there is an electronics technology market (ETM). Electronics is not an industry, but rather a collection of industries that sell to one another, and to just every other kind of business, as well as to the consumer. Another basic concept put forth is that the pace of technology is outstripping our ability to market it.

## Potential is staggering

The future potential of the ETM over a 30-year period is truly staggering: Mr. Weber stated that by 1980, it is conservatively estimated that an annual amount much greater than $10/person will be devoted to electronic watches, personal radio-telephone, environmental alarms, night-vision goggles, etc.; for the 2 million or more electronic technologists, it is targeted that expenditures of $2,000/head for electronic equipment will gross a $4-billion market; for the 90 million patients requiring medical electronics aid, he estimated that $3 billion will be spent in 1980; for the 1980-style electronic home, about $5,000 will be spent on each new unit to cover electronics products ranging from microwave ovens to trash compaction and systems monitoring; automatic ordering, billing, and banking are still other systems involving electronics; in the electronics entertainment area, flat-wall TV displays, two-way CATV, VTR, and picturephone are expected.

The electronic office, the electronic auto market, and the electronic store are other potential billion-dollar markets. Other billion-dollar tidbits are electronic vending machines, electronic postal services, hospital bed monitoring and entertainment, and electronics in railroading. When one couples these business opportunities with the $200 to $300 billion to be spent by 315,000 manufacturing establishments, and when one factors in the impact dollarwise of the energy crisis on electronics, during the next 30 years, the totals become astronomical.

The key is growth (not maturity) through market development starting now, 1973. Mr. Weber in closing emphasized: "If you, as engineers and engineering managers are not heavily involved right now in market development, then I believe you are not headed into the future."

## Second-day session

On Thursday, E.M. Hinsdale, Staff Engineer, and Session Chairman introduced the topics of Quality and Reliability from a designer's as well as a consumers' point of view. He outlined some of the trends toward higher and higher reliability goals for consumer electronics products. T.C. Jobe, M.O. Pyle, and R.M. Cohen presented programs pointed specifically at improving reliability and quality in consumer electronics products, and in solid-state devices for commercial and government products. High-reliability design guides for use by product engineers were described in which proven-in design procedures provide assurance of long life and high quality with minimum downtime for the customer. In addition, each design program is monitored carefully in the field and feedback provides inputs for a constant updating of such design guides.

In assuring high performance of Solid State Division devices, the program objectives concentrate in two user categories: 1) consumer electronics, and 2) the industrial, military, and aerospace fields. Here again the trend is to design for reliability as opposed to the outdated "test it in" approach. Step-stress testing (a test consisting of several stress levels applied sequentially, for periods of equal duration, to a sample), applications emphasis, investigation of failure mechanisms, and the effects of thermal-cycle acceleration factors are considered as they apply to reliability.

In conclusion military and consumer markets were described as requiring different approaches, though beneficial spillovers result to each field. Suppliers of high-volume consumer products for TV and automotive applications need a better means of evaluating and justifying higher initial costs when these can be more than offset by the OEM's savings in warranty costs. The techniques and advances in designing for greater figures of merit for both government and commercial products were described in detail by the speakers.

In concluding the Thursday morning session, D.J. Parker explained that, in Government Communication Systems, a new form of contracting is anticipated in which production equipment will be bought on the basis of life-cycle cost. Mr. Parker gave a complete picture of product life-cycle cost of a typical product. Total life-cycle cost is the sum of the acquisition cost of the radios, plus the initial logistics cost, plus the recurring cost. Each of these items is composed of a number of recognizable elements. Since many of the elements are variable and interrelated, the proper strategy for winning the production contract without losing one's shirt requires a certain amount of "gaming."

## Industrial-tube tours

On Thursday afternoon, the attendees were given a choice of attending separate discussions and meetings, or of touring the Lancaster plant. About sixty people visited the Industrial Tube facility at the Lancaster plant. The tour was under the direction of C.P. Smith, Director, Industrial Tube Division Operations and Hans K. Jenny, Senior Technical Advisor. C.E. Burnett, Division Vice President and General Manager, welcomed the group and C. P. Smith briefed everyone on what would be covered during the tour. The Lancaster plant provides about 1million square feet of floor space to the Industrial Tube Division and its services and to the Entertainment Tube Division; there are about 3,000 employees. Products include vidicons, silicon intensifier tubes, isocons, photomultipliers, photodiodes, solid-state lasers, image tubes, and power tube products involving glass and ceramic transmitting tubes, laser systems, klystrons, and special coaxitrons and high-power tubes for government application, Microwave devices and the Parts Manufacturing activities are other functions of major importance.

The following key technical personnel from the Industrial Tube and Entertainment Tube Divisions conducted several groups of visitors on informative tours of eleven different activities within the plant: W.S. Lynch, T.E. Yingst, G.Y. Eastman, H.A. Kauffman, C.W. Bizal, C.H. Groah, W.T. Kelley, A.M. Morrell, A.E. Hardy, R.A. Nolan, R.H. Hynicka, and E.K. Madenford.

Descriptive lectures on industrial tube products of interest were given during the course of each tour by the following engineering, engineering management, and manufacturing personnel of the Industrial Tube Division.

E/O Systems (camera, frame freeze, IPA)
...by H. R. Krall

SSEO (IR diodes, injection lasers)
...by R. Glicksman

Charge-coupled imaging devices
...by R. L. Rodgers

Low-light-level TV
...by E. D. Savoye

Color camers
...by R. G. Neuhauser

ADEPT & Phasor (Photomultiplier Processing)
...by R. C. Pontz

Parts Works
...by J. J. Spencer

Large Power Tubes
...by F. G. Hammersand

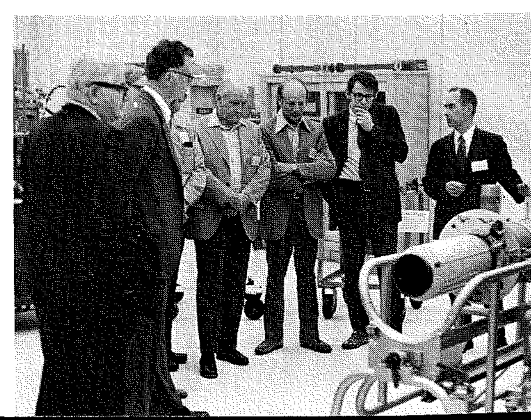



**Fig. 8 — A Series of photos taken during the tour of the Electronic Components plant at Lancaster: The views feature existing Industrial Tube facility expertise used in the development and fabrication of special industrial tubes ranging from color camera tubes to super-power amplifier tubes used in high-power government applications.**

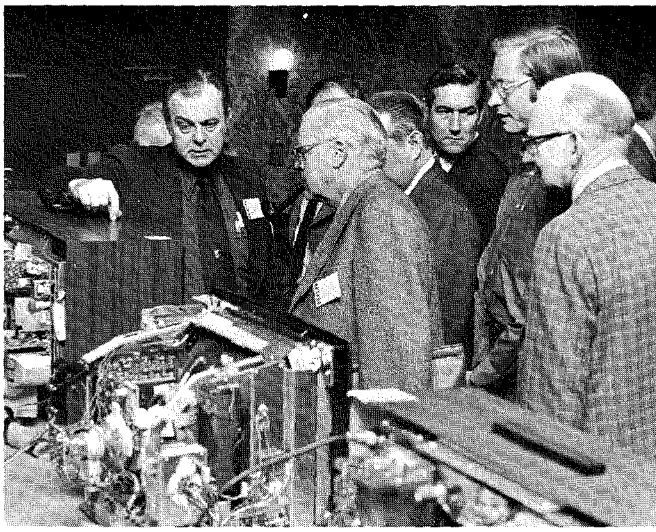


Fig. 9 — C. W. Thierfelder, Division Vice President, Manufacturing, Entertainment Tube Division explains details during a demonstration of the new precision in-line color tv picture tube. These new advanced tubes (of various sizes) were displayed in several models of RCA color tv receivers in comparison with competitive systems.

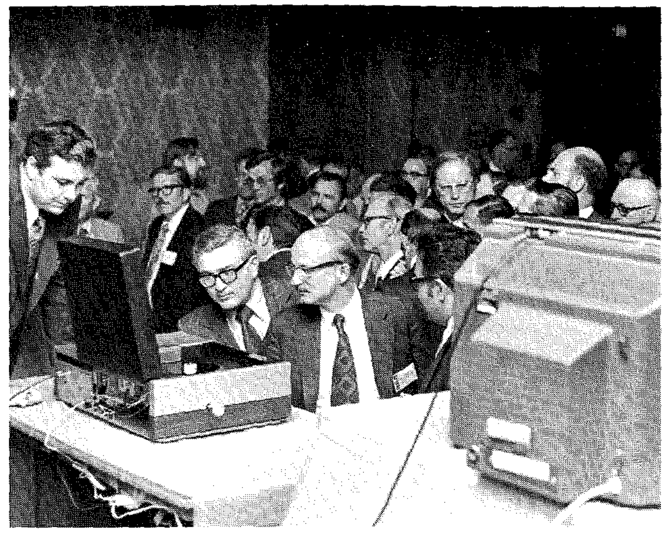


Fig. 10 — Conferees during a demonstration of a Video Disc System.


Fig. 11 — D. Callaghan, Manager, Engineering, Parts and Accessories, holds a remote-control indicator during a demonstration of the RCA Mini-State TV Antenna System.

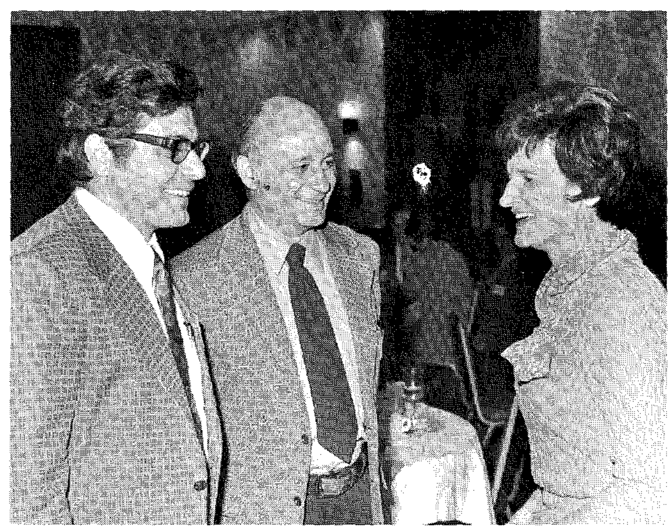


Fig. 12 — Left to right: L. A. Gagliardi and G. B. DiGirolamo (of the Engineering Education Activity) provided the audio and visual facilities during the 3-day session; and D. E. Hutchison, Administrator, Staff Services, Engineering, Research and Engineering, handled conference arrangements.

Modules
...by R. E. Reed
Regular Power Tubes
...by J. T. Mark
Gas lasers
...by R. W. Longsderff

## Video Disc system

Thursday evening, progress on a Video Disc System was described and demonstrated by D.S. McCoy, Division Vice President, Development Engineering, Consumer Electronics. The Video Disc System was displayed, and high-quality pictures were produced on modern RCA home TV color receivers. Following the demonstration, a question and answer session was conducted.

The playing time is expected ultimately to be 30 minutes per side. This capability is expected to be an important factor in the acceptance of a video disc system by the consumer market. Also, the excellent time-base stability of the system permits playback through unmodified TV receivers already in the field as well as future models.

The Video Disc was described as a 12-inch vinyl disc of standard record thickness that can be pressed on both sides by standard audio presses; however, because of the sub-micron size of the information elements present on the disc, Video Disc manufacture requires a great deal of care, great attention to cleanliness, more attention to mixing and consistency of the components of the discs, and more attention to centering because of the requirements for time-base stability. In addition to video information on the disc, high-fidelity audio in sterophonic and even RCA's 4-channel discrete sound can be included.

The Player was described as having a rotational speed of 450 r/min; for sensing of the signal on the disc, the player uses a capacitive pick-up technique and a special pick-up arm mechanism to correct for time-base instabilities.

Dr. McCoy concluded that the major goal is to produce a low-cost player as well as a low-cost disc to gain consumer acceptance of the product.

### Third-day session

For the closing-day session, H. Rosenthal, Staff Vice President Engineering, served as Session Chairman. C.W. Thierfelder, Division Vice President, Manufacturing, A.J. Torre, Manager, Applications Lab., and D.D. VanOrmer, Manager, Picture Tube Development Engineering (all of the Entertainment Tube Division) gave a detailed description of the new precision-in-line picture tube development

The technical advances represented by the in-line techniques were described as setting the pace for the industry; and all manufacturers of picture tubes, including the Japanese are considering the adoption of these techniques which provide more precise control of the paths of electrons than heretofore possible. Numerous matrix and non-matrix RCA TV color picture tubes were displayed in RCA color TV receivers of varying screen sizes...and several employed variations of the precision-in-line fabrication techniques. These receivers were compared with the best that competition has to offer. Questions concerning the new developments were invited by the speakers

### Entrepeneurship

The TCR-100 Video Tape Cartridge Recorder and COS/MOS devices, two technical products exemplifying engineering entrepreneurship, were then described. The first, the "TCR-100 Video Cartridge Recorder Engineering and Marketing Teamwork in Action," was explained by A.C.Luther, Chief Engineer, Broadcast Systems and H.H. Klerx, Manager, Broadcast Planning. A history of the introduction of the TCR-100 in 1969 and its evolution through its present status in 1973 was given. The setbacks and successes experienced during this period were enlightening from the standpoint of engineering-marketing teamwork.

A unique "close-hand" study of eight TCR-100's placed in actual daily broadcast-station operation provided valuable feedback to engineering and design groups for the further perfection of product quality and reliability. In this teamwork program, much experience was gained in "what to do-and-not-do" for future product design programs. In conclusion , the speakers mentioned that 114 of the TCR-100-s have been shipped and RCA has excellent prospects for many more sales.

Harry Weisberg, Manager of MOS Integrated Circuit products described a program in SSD which has resulted in the development of a promising new market for COS/MOS devices for use in a number of automotive applications, such as auto seat-belt interlocks and cordless digital clocks. Also cited were the consumer watch and clock and TV market, and the military-aerospace areas with the requirements of high-reliability devices.

Mr Weisberg pointed out that RCA chose to start COS/MOS production with standard circuits for logic applications. Now, COS/MOS memories in the form of 1 256-bit memory are being produced and larger memories will be announced in the future. Also it was emphasized that the low-power requirements of COS/MOS devices, with subsequent minimization of cooling requirements and improved packing density, open up many new areas for COS/MOS technology and products.

Mr. Weisberg also credited an intensive customer education program with getting the new, complicated COS/MOS multi-product area launched so quickly. And, finally, Mr. Weisberg stressed the need for engineering management to be alert in adjusting the organization to fit the requirements of time.

### Summaries

The conference was organized and arranged by H. Rosenthal, Staff Vice President, Engineering, assisted by Doris Hutchison, Administrator, Staff Services, Research and Engineering. Topics presented at the meeting are listed at right. Summaries and descriptions of these subjects are included in the pages that follow.

*Session 1 — J. Hillier, Session Chairman*

**Welcome**
**... by J. Hillier**
**"RCA's Performance in 1972 and First Quarter 1973"**
**... by R. C. Butler**
**"Overview of Corporate Plans"**
**... by L. J. Farley**
**"Research and Engineering"**
**... by J. Hillier**

*Session 2 — J. V. Regan, Session Chairman*

**"Trends in Industrial Property Protection for Inventions" and "the RCA Inventor Recognition Program"**
**... by J. V. Regan**
**"The Chief Engineer and his Patent Lawyer"**
**... by E. M. Whitacre**
**"Research & Development—Patents & Licensing — A Common Cause"**
**... by S. S. Barone**
**Dinner Speech — "Unexploited World Wide Opportunities for Electronics Technology"**
**... by S. Weber, Executive Editor,** *Electronics*

*Session 3 — E. M. Hinsdale, Session Chairman*

**"Consumer Electronics Quality and Reliability"**
**... by E. M. Hinsdale**
**"Reliability Program for Consumer Electronics' Product Design Engineering"**
**... by T. C. Jobe**
**"CE Quality Control Programs"**
**... by M. O. Pyle**
**"Quality Control and Reliability Assurance at SSD"**
**... by R. M. Cohen**
**"Product Life Cycle Cost: The AN/ARC—163"**
**... by D. J. Parker**

*Session 4 — Tour of Industrial Tube Division Plant, Lancaster*

*Session 5 — H. Rosenthal, Session Chairman*

**"Precision In-Line Development"**
**... by C. W. Thierfelder, A. J. Torre, and D. D. VanOrmer**
**"TCR-100 Video Cartridge Recorder — Engineering and Marketing Teamwork in Action"**
**... by H. H. Klerx and A. C. Luther**
**"Technology to Products to Profits"**
**... by H. Weisberg**

# Description and summaries (cont'd)

## A Corpcrate View

The first session of the Corporate Engineering Management Conference consisted of three presentations by executives representing RCA Finance and Planning, and Research and Engineering. Current performance, the future outlook, and the technical role in interdisciplinary planning were reviewed.

### RCA performance — 1972 & first quarter 1973

**Robert C. Butler,** Vice President
Financial Analysis
RCA Corporation
New York, N.Y.

The Program for the first day was opened by Robert C. Butler, Vice President, Fiannacial Analysis, for RCA who gave a slide presentation covering RCA's performance in 1972, and the first quarter of 1973. The highlights of Mr. Butler's talk were:

In 1972, RCA recorded a net profit of $158.1 million, which represented $2.05 in per share earnings and a 23% improvement over the 1971 level.

In looking at a five-year earnings trend, RCA achieved its "highwater" mark in earnings in 1968, with profits of $179.1 million equivalent to $2.37 a share. Earnings dropped off sharply in 1970 to $1.38 per share. However, a consistent earnings improvement has been maintained since that time.

The major portion of the earnings growth in 1972 came from the Home Products and Other Commercial Product and Services as earnings in this segment rose $12.6 million or 16.7%. However, in percentage growth, Vehicle Renting and Other Related Services was the leader with a 63.4% ($6.4 million) earnings increase over 1971.

In the Home Products and Commercial Products and Services segment, there were numerous factors contributing to the $13 million growth in earnings:

*Banquet Foods* set a sales and earnings record in 1972 with the introduction of new dinner and dessert products and an expanded distribution system.
*Coronet Carpeting* also achieved sales and earnings records in part, reflecting the manufacturing efficiencies and styling variations permitted by a new sophisticated dying process.
*The RCA Service Company* established a sales and earnings record due primarily to increased color tv systems leasing and service, a growing teletype leasing and service business and expanded Data Systems service.
*Consumer Electronics* recorded improved earnings reflecting increased industry volume and more favorable results in the Audio product line which were partly offset by a decline in color tv market share.
*Electronic Components* moved ahead in sales and earnings reflecting the favorable market in color tv.
*The Solid State Division* improved operating results significantly with expanded automotive requirements for solid state circuitry and the major growth in solid state tv.

In the Broadcast, Communications, Publishing and Education segment of RCA's business a modest decline in publishing and education services in 1972 was substantially offset by a solid earnings gain at NBC and increased volume in International Telex and lease-channel business at RCA Globcom.

Earnings increased $6.5 million in Vehicle Renting and Related Services principally due to improvement in Rent-A-Car and Hertz equipment rental.

Revenues and profits declined in 1972 in Space, Defense and Other Government business as a result of reduced expenditures by the Department of Defense and NASA.

For the first quarter of 1973, RCA recorded earnings of $41.7 million or $.54 per share on a record first quarter sales volume of $1.01 billion. This was an earnings growth of 15% above prior year.

Strong advertiser demand in Broadcasting and increased International Message volume produced significantly higher performance in the Broadcasting, Communications, Publishing and Education segment.

Rent-A-Car, Truck and equipment rental operations registered substantial gains in the Vehicle renting segment.

Strong consumer demand continued to reflect itself in the improving results in the Home Products and Other Commercial products and Services group.

As noted earlier, RCA's record earnings year was 1968, with earnings of $2.37 per share. Based on the 1973 first quarter results, it is quite possible with a continuing favorable economic picture that RCA may meet or exceed its prior earnings record.

### Overview of Corporate Plans

**L. J. Farley,** Staff Vice President
Business Planning
RCA Finance and Planning
New York City

In the planning department, we believe that the future for RCA really looks quite good. I would like to share with you some of the reasons why we think so.

One way to look at RCA, a large and complex company, is to examine the markets we reach such as domestic, international and new businesses.

On the domestic side of the house, total RCA operates in about 30 distinct and separate markets. We make forecasts, each division makes a forecast, and the economic department makes a forecast. Each one is studied very carefully. Our overall evaluation is that RCA's domestic markets will grow collectively and that RCA's participation in the growth of those markets will be above GNP rates over the next five years.

So, the domestic markets, which account for a large portion of RCA's total business generally look good. Now, if you stretch your imagination a little bit, and say we can maintain our market share, there is no reason why we also couldn't maintain our profit margins in those markets.

Therefore, on a going basis, all other factors being equal, our profit should also grow at somewhat above the GNP rate for the next five years.

Now, also consider that we have excellent opportunities for margin improvement. For example, there are 5 key operations in RCA which broke even in 1972 and accounted for almost a billion dollars of revenue. In 1971 those same businesses were on the loss side of the ledger. So there is a turnaround going on. The next step is to get those five businesses in the next 5 years to earn a normal profit margin.

If you combine the healthy outlook for RCA markets with the opportunities that exist for margin improvement, that translates into a very solid potential profit growth rate.

On top of that, we have to take into consideration what we are going to do in the way of new products and new businesses. RCA is making investments both in terms of capital expenditures and in terms of P&L expense every year in the area of new business at a significant level and we plan to continue at a significant level. These investments promise to yield a good return.

Lastly, if you look at the complexion of the company, you will find a much broader earnings base to work with, brought about by our acquisition policy. A number of the 30 markets mentioned earlier such as vehicle renting, frozen foods, and home furnishings are very high growth-rate markets. Acquisitions should be made in markets that are healthy and growing and RCA has done this.

However, those new markets are certainly not everything. The basic part of RCA's business has been, is, and will continue to be in the electronics and communications areas. We must be very successful in these areas if RCA in total is to be successful.

In 1963, we expect that the electronic and communications areas will account for about 75% of revenues and by 1975 through 1980 about two-thirds. The outlook for these areas is good. Various independent agencies forecast in the near term about 10% growth in the total electronics industry domestically; through 1980, the growth is expected to be in the 8% or 9% area.

With respect to new business programs, there was a marked increase in the revenue and the profit numbers that were included in the 1973 plans for new businesses. The efforts to try and be more specific in our planning with respect to new businesses did pay off. New businesses planned represent 20% of the growth that we should see over the next five years. And of this 20%, most is in electronics and communications - the traditional business areas.

Some of the most significant new business programs that are in the long-range plan are, of course, SelectaVision, domestic satellite communications and the Alaskan telephone expansion. And then you have all of the Solid State activities; integrated circuits, packaged circuit functions, and COS/MOS devices. These new businesses should provide about $200 million in revenues by 1977.

Consumer Electronics is expected to be an area of large dollar growth during the next five-year period, a significant increment coming from SelectaVision. We expect a big increment from Hertz and Banquet and from NBC. We also expect substantial increments from Solid State and Global Communications, Records, Service Company and Coronet. More moderate increments will come from Electronic Components because of the nature of the market they are in and the problems they are facing. Commercial Systems and Government Systems, Random House and Cushman & Wakefield will have good growth rates, although the absolute increment they contribute is not big.

Over the next five years, we look forward to adding some $2 to $2.5 billion of revenue to RCA's $4 billion of revenue for 1972.

We believe that adding $2 to $2.5 billion really is achievable. RCA today is quite different than the RCA of several years ago. And one of the big things, of course, which has been talked about so much has been the divestment of the computer operations...also, there have been 18 other divestments of smaller operations in the last four or five years. And, there have been acquisitions. So, you have a different company today than you had five years ago.

One of the things one does in "strategic planning" if to look at strengths. It constantly comes back that one of RCA's major strengths is engineering ability.

In utilizing this strength, we must get all of the product quality possible so that all products are at least as good or better than competition. Secondly, we've got to have product innovations. If we get substantial innovations which consumers can recognize, we should be better in the marketplace. As a result, we would not only grow at the rate our markets are growing, but we will grow faster. And finally, we must come up with new products and new businesses.

If those engineering feats are accomplished, we're going to achieve that $2.5 billion revenue rise over the next five years. We in the planning activities hope that you're successful.

# The Role of Patents

The second session concentrated on the status and trends of inventions at RCA and worldwide. The role of patents as related to the engineer, the chief engineer and to RCA Corporation was cited. The function of Patents and Licensing activities was discussed.

## Trends in industrial property protection for inventions

**J. V. Regan,** Staff Vice President
Patent Operations
Patents and Licensing
David Sarnoff Research Center
RCA, Princeton, N.J.

I appreciate the opportunity to discuss the subject of inventions and patents in the context of increased worldwide competition. Of particular interest at this time is the role of patents in high technology exchange in view of the increased multinational manufacture and sale of high technology products.

The primary purpose of a patent system is to help establish an orderly marketplace for the distribution of new technology involving inventions and innovations. This distribution or exchange occurs both domestically and internationally. For example, the patent system provides a common set of rules for setting boundaries between technology which is private and technology which is in the public domain; these rules also assist in determining the outcome between inventorship contests involving private parties. It is easy to imagine the chaos that would result if there were no patent or equivalent system defining the rights and responsibilities between the parties involved in technology exchange.

There are other types of protection available for intellectual property such as trademarks, copyrights, and trade secrets. The choice of protection is determined by the type of property and other factors. It should be noted that trade secrets are complementary rather than alternative to patent protection. That is, you can have patent protection on the innovative aspects of a process and at the same time trade-secret protection on certain non-inventive aspects of the same process. Also, you can have both patent and trade-secret protection on the inventive aspects of a product or process up to the time the product or process becomes available to the public, as by use or sale, or the first patent application is published.

In a usual case, the first publication of the patent application is about 18 months from the time of first filing. However, the trade-secret mode of protection does point up the distribution problem concerning high technology exchange. This is the problem of matching up the people who need the technology with the people who have the technology developed and available. On the one hand public disclosure of the trade secret, whether intentional or not, causes the secret to automatically self-destruct. On the other hand, the patent system requires a full disclosure of the invention before protection is given. The subject of patenting computer software inventions is still somewhat unclear. This is part of the current dilemma in providing adequate protection for computer software. None of the present forms of protection seems entirely consistent with the nature of computer software.

### International protection

Patents also help to open export markets for our new products where such products are already protected by patenting in the market countries. In most foreign countries, the patent right in a country gives the patent owner the right to manufacture in that country; hence having an improvement patent is of assistance in reaching a reasonable licensing accomodation with a dominant patent owner. The trend of issuance of US patents by foreign-based firms has accelerated sharply. This means that we are going to have many more foreign-origin patents to consider in the manufacture of our products in the US. There has been a rather dramatic increase of new US Japanese patents. In fact, the Japanese have now passed the UK Nationals in issuance of patents in the US; in Australia, they have also passed the Americans in the number of issued patents. The Russians are also becoming active in the licensing area in the US and other Western countries, and we expect them to support this activity with additional filings during the coming years.

International protection for industrial property is provided primarily by means of the Paris Convention of 1887 and its subsequent revisions. There are a number of important treaty developments under discussion. By means of the Paris Convention, access is given to the domestic patent system of one country to citizens of any other convention country. The access is on the same basis as that provided to domestic residents. All industrial countries, including Russia and the East European countries, are members of the convention.

### Patent Cooperation Treaty

A number of new treaties are under discussion. One is the Patent Cooperation Treaty, which was signed last year in Washington by seventy countries. President Nixon sent the treaty to the Senate last year for advice and consent. This treaty is aimed at reducing the administrative burden of the various patent offices involving the examination of counterpart applications concerning the same inventions. One figure estimates about 60% of the internationally filed applications are counterparts. For us, one of the most salient points of this treaty is the extension of time from the present twelve months to twenty months for handling foreign filings.

### European convention

A second treaty under discussion is the convention establishing a European system for the grant of patents. We believe the long-range effect of the European convention will be very significant. Under this treaty, a single patent having a 20 year term will be granted by the European Patent Office to be located in Munich. However, infringement will be dealt with under the respective national laws. The proposed European patent law under this convention was approved in June, 1972, and the final draft will be discussed at a diplomatic converence to be held in Munich this year.

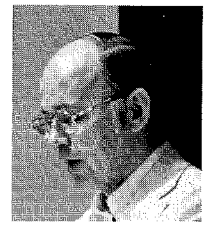
### Common market convention

The third treaty being considered is the common market patent convention which would extend the European patent coverage by granting a single patent effective in all common-market countries without variation for individual national differences in their substantive laws. No election of countries within the EEC is permitted. Both the proposed European patent and the common-market patent are compatible with the articles of the PCT.

These international treaties, if ratified, will go a long way toward making international patent protection more available and simpler than at present wehre numerous and somewhat different national systems must be considered with respect to obtaining protection for the same invention.

## The chief engineer and his patent lawyer

**E. M. Whitacre,** Director
Consumer Products
Patent Operations,
RCA David Sarnoff Research Center
Princeton, N.J.



**The engineering staff has been most helpful to patent operations in the past, and you have an outstanding track record in invention and innovation.**

The patents supporting current agreements for the most part cover inventions made between five and twenty years ago. It takes us roughly about that long to get the invention into application form and then the applications matured into patents. Most of the important industrial countries have an examination system and we have applications pending which were filed in the United States in 1951. The inventions you make today will become effective as patents in about five years.

### New patents

We have had some exciting prospects for new products with solid patent protection. Product innovations such as the video disc, videovoice, the 110-degree color system including the PST yoke, the precision *in-line* color tube, solid-state tv cameras, and the work on linear and LSI integrated circuits are outstanding developments.

### RCA patent system

Traditionally, within RCA, patents have been one part of a four-part interactive system which includes management on the one part, engineering on the second, patent operations on the third and licensing on the fourth. The fundatmentals of the system are the essence of simplicity. Management makes decisions regarding expenditures to support projects to develop new products or improve old ones. Engineering develops the new products or improves the old ones and in so doing, makes inventions and develops know-how. Patent operations obtains patents for the inventions and advises regarding the potential know-how. Licensing negotiates patent licenses and technical-aid improvements to provide royalty income which may be regarded as part of the return on the original investment. This systems approach at RCA has been directed toward the establishment and maintenance of a leadership position in selected business areas protected by patents. Patents on improvements may also be the basis for cross licensing agreements.

### Protection for RCA inventions

In many instances, our competitors are trying to solve the same problems we are. To be first, prevents a competitor from getting a patent through what is known as a patent-interference preoceeding. Many of you have been involved in that. Some of the things that tend to defeat protection of RCA inventions include the failure to submit patent disclosures on inventions. This sounds simple. But, the problem is that everyone is busy, the pressure is on to meet engineering deadlines and frequently the patent disclosure gets put off. Fortunately, few engineering managers exhibit a lack of patent consciousness. When this condition does occur, the attitude permeates the entire group. The solution to this on the manager's and the engineers's desks; pick up the telephones and call your patent attorney. He will be ready, willing, and able to assist you so that you can meet your priorities without sacrificing the invention. Another problem is failure to advise patent operations of new technical development programs. This should not happen in a corporation dedicated to the communication arts, but sometimes it does happen. Some important programs from a patent standpoint, have been so secret that patent operations was the last to know.

Another practice which tends to defeat protection for RCA inventions is the release of written material prior to patent review. There are corporate and divisional review procedures for publications and presentations to prevent the loss of valuable patent rights. Oral disclosure or demonstration of new products to outsiders prior to patent review should also be avoided. Offering new products for sale prior to patent review could be another deterrent. Here again, divisional standard procedures call for patent review prior to offering a new product for sale.

### Adverse patents

Adverse patents are those owned by others that apply to our products. Fortunately, those who are followers have substantially more exposure to adverse patent liability than do the leaders. The problems created by adverse patents are that the adverse patentee has a right to exclude others from making, using and selling the product patented and may opt not to license you.

Assistance is available to engineering in avoiding adverse patents. After an adverse patent has been identified and evaluated, your patent attorney can assist the technical staff in finding suitable alternatives. This is a give-and-take proposition in which the patent attorney and technical staff explores the options available.

### Advance disclosures

At the other extreme, vendors sometimes wish to disclose items in an advanced development stage to benefit from your inputs. Such gratuitious disclosures should be carefully avoided no matter how much you would like to see them unless a release is obtained or it's clear the information is available to all comers. There are many variations on this theme between the two extremes, but if you find a situation you are not clear about, call your patent attorney. The liability for patent infringement can be substantial. Remember that even unpatentable information from outsiders can form the basis for a claim against the corporation. After all is said and done, the best way to avoid adverse problems is to develop and maintain a position of leadership in your product area.

### Patent assistance

Patents and licensing is organized to assist you with respect to all patent and future patent matters; we have resident counsel at the following locations: Camden, N.J., Joe Tripoli; Indianapolis, Paul Raspusin; Lancaster, Leroy Greenspan; London, Ian Smith; Princeton is the main office and there are numerous attorneys there; Somerville, Henry Schanzer. We are represented in Washington by Rolan Linger. As a suggestion, you may wish to have one of our patent attorneys speak to your new employes about patent matters and the responsiblities with respect thereto. As a matter of fact, it might not be a bad idea for some of the old timers too. Upon request, we will provide an attorney who will make an appropriate presentation to people in your organization at your location.

## Research and Development — Patents and Licensing — a common cause

**S. S. Barone,** Vice President, Licensing, RCA, New York City

RCA's basic licensing philosophy stems from its historical background. RCA was first organized in 1919 at the behest of Assistant Navy Secretary, Franklin D. Roosevelt, who saw the importance of having an American wireless telegraph company controlled by Americans. In order to be able to operate the company, we had to unfreeze the patent block which then existed and enter into license agreements both with American and European companies. Under such agreements, rights were granted to the Europeans on RCA inventions for radio purposes made prior to 1945. These arrangements were in conjunction with wireless telegraph traffic agreements which RCA had to conclude with the European companies in order to conduct its business as a common carrier of international wireless telegraphy. Licensing, therefore, was essential to RCA's very existence.

Our licensing philosophy is to obtain patent protection on RCA inventions both in the United States and abroad and to offer licenses to all manufacturers of products covered by RCA patents in the major industrial countries.

RCA licenses are on reasonable and non-discriminatory terms. They are all non-exclusive and contain no restrictions either as to quantities, prices, territories or anything else.

Factors in a successful licensing program are, first of all, technology (which after all is the product sold in the license agreement), the well earned image of RCA as a pioneer in electronics and good relationships with our licensees. Such relationships must be maintained on a management to management basis, both in negotiations and in factory and laboratory visits. All of these, however, depend on research and development. Without it there can be no licensing program.

It is imperative that a strong research and development effort continue and that those engaged in the effort have a consciousness of invention so that disclosures are filed with Patent Operations when inventions are made. Research and development personnel should be encouraged to file disclosures and assured of the company's interest in receiving them.

The Research and Development personnel of RCA can look forward to an exciting technological future. Much good work will be done in the television area, in the area of consumer information systems, in the general display area, in automotive electronics and countless other electronic applications. There is no doubt in my mind that solid-state technology is at the very heart of the electronics future.

Top management of RCA as well as Licensing will continue to support the company's research and development efforts. The over-all good of the company depends on research and development. RCA has been and will continue to be technologically oriented.

# Quality and Reliability

**Session three covered the gamut of quality control, reliability and product life-cycle costs for RCA products. The consumer's point-of-view becomes the designer's goal in presentations by reliability and quality control engineers from several operating divisions of RCA** *(Note: session four was devoted to special group meetings and to a tour of the Industrial Tube plant at Lancaster, Pa.)*

# Consumer Electronics quality and reliability

**E. M. Hinsdale**
Staff Engineer
Research & Engineering
RCA, Indianapolis

**To introduce this morning's session, I will review the subject of Consumer Electronics quality and reliability — and hopefully set the stage for the speakers that follow.**

Historically, consumer products have been designed for the most cost-effective features that will also provide enough performance and reliability to be competitive. There is always a fine line between cost and what will make the customer happy. In recent years, though, we have been moving more in the direction of accelerating the quest for quality.

Initially, in earlier designs, many components were stressed to the limit and consequently had a relatively high failure rate. In planning the product in those days, the initial cost to the customer was a major consideration in the design cycle. One had to be competitive; but, then the Japanese came along and did a little better job in the quality and reliabilty area. Consequently, U.S. manufacturers (including RCA) have been pushing to enhance their position in these areas.

Consumer Electronics introduced a 12" solid-state black-and-white television set in 1965, which was the first RCA commercial solid-state television receiver. It was designed to be a deluxe performing set which was costly. We were in a learning phase, and reliability probably was not much different than the tube or hybrid receivers.

### Recent programs

In late 1968, the first solid-state color receiver was introduced, and then in 1969 it became apparent that the reliability hadn't increased substantially over the preceding hybrid sets. As a result, engineering initiated studies on causes of failures and what could be done about them. In 1970, Consumer Electronics initiated the one-year warranty purchaser satisfaction program for solid-state receivers. This provided the opportunity to measure the reliability under actual field operating conditions. Further study of the reliability problem was conducted in 1970, and this led to the establishment of the product analysis and control laboratory in early 1971 under Thornley Jobe's direction. His primary mission, which he will discuss next, has been to develop procedures for cost-effective design tradeoffs and component specifications. Along with increased emphasis on reliability from an engineering viewpoint, the quality control programs have been accentuated. Milt Pyle will discuss that phase of Consumer Electronics activity.

### Engineering role

Engineering quality starts with a model master plan developed by product management. The inputs that product management uses come from sales, engineering, market research, their own intuition, and perhaps product management understanding. The resultant model plan is issued some 76 weeks prior to the product introduction. This plan describes each television receiver by the model number; the quantity to be made; the target cost; the cabinet initial design configuration, whether it is plastic, wood, or otherwise; and the kinescope size and pertinent characteristics. The chassis type and the tuner mounting assembly, which includes the uhf tuner, the vhf tuner, and the customer controls, are specified along with other pertinent features in the master plan. A summary of the information contained is outlined in Fig. 1.

| | |
|---|---|
| • **MODEL NUMBER** | • **CHASSIS** |
| • **QUANTITY** | • **TMA** |
| • **TARGET COST** | • **UHF TUNER** |
| • **CABINET** | • **VHF TUNER** |
| • **KINE** | • **FEATURES** |

**Fig. 1 — Master plan: model specification.**

The engineering cycle is complex for such a relatively simple product because of the many requirements. The number of building blocks for the 1973 color master plan are shown in Fig. 2. There are 15 uhf tuners and 17 vhf tuners which are used to make 47 tuner mounting assemblies. Nineteen chassis and 17 kinescope types in nine screen sizes are combined with the various tuner mounting assemblies and various cabinets to generate 133 models. The quantity of each model ranges from a low of about 1000 to a high of 110,000. The total number of all models will be well over one million color tv sets next year.

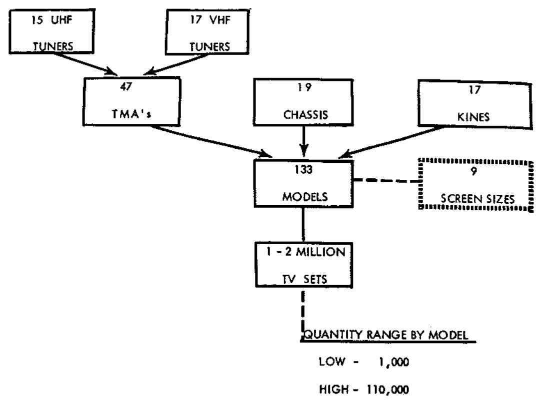



**Fig. 2 — 1973 color plan.**

The model development cycle for a new chassis with a new plastic cabinet is about 76 weeks as shown on Fig. 3. The "turnover" is the "start-counting" time when product planning delivers the model specifications to engineering. At this time, feasibility has been proven and no new developments such as a precision in-line kinescope or other new components can be developed. The 76week cycle is just hard-nosed, cost-effective, design engineering to achieve the desired product.

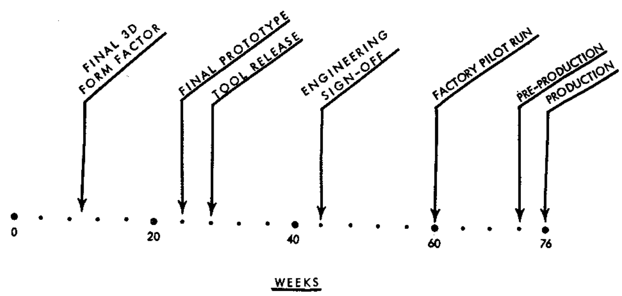



**Fig. 3 — Model development cycle: new chassis, new plastic cabinet.**

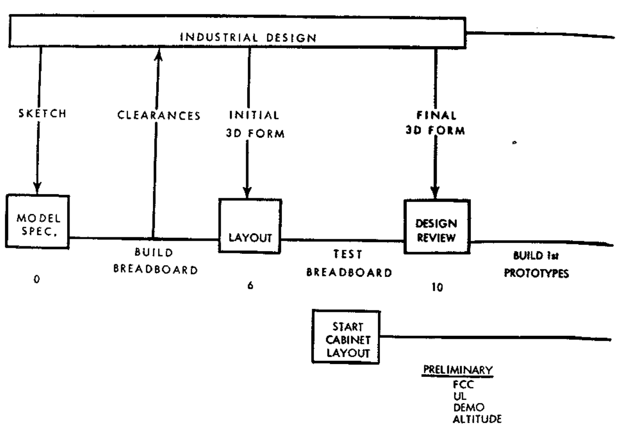



**Fig. 4 — Model development cycle: weeks 0-10.**

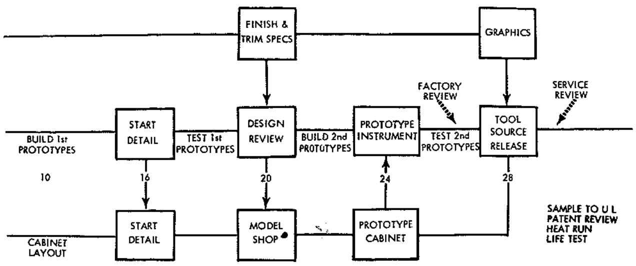



Fig. 5 — Model development cycle: weeks 10-28.

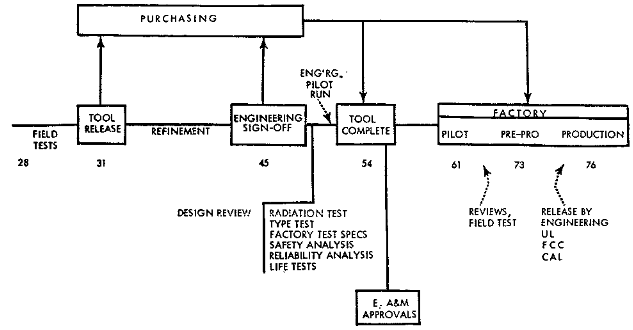



Fig. 6 — Model development cycle: weeks 28-76.

Some models require less than this 76 weeks, and many of them are relatively simple. There are also instances of receivers which have required more than 76 weeks, particularly when there is tooling involved for a new component. An example of lesser time requirements would be a previously-designed chassis, which requires no extensive long-range tooling.

The first ten weeks of the development cycle, shown on Fig. 4, require interaction between industrial design and engineering. industrial design and engineering work together and develop the clearances and arrive at a suitable configuration. Then, there is a test breadboard and the final form is gone over by the product planning group, engineering, and industrial design in the 10th week.

### Manufacturing — engineering liaison

During the 10- to 28-week period, Fig. 5, engineering builds several progressively improved prototypes and, at the same time, is working on the cabinet. In the 24th week, final prototypes are started and, in the meantime, the cabinet layout is started and preliminary indications of FCC, UL approval and various other requirements of engineering are looked into. Engineering works diligently in this part of the cycle to achieve the level of performance required by the design objectives. In the meantime, the finish and trim specs are fed in from industrial design and, after the 28th week, there is a tool release. At this time, there is a review with manufacturing to determine manufacturability of the receiver. There is also a service review to evaluate serviceability of the new design.

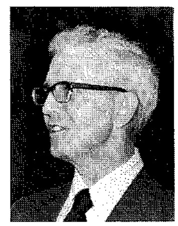
The final 28th to 76th week part of the cycle shown in Fig. 6 brings about field tests, a final tool release, and the refinement of the design and engineering sign-off. There is interaction with the purchasing department during this time. And, next, there is an engineering pilot run of a group of sets made by engineering (up to 15 or 25). At this time, there is a very stringent design review — there are radiation tests to meet the FCC specs, type tests, factory tests, safety analysis, reliability analysis, and life tests. Then the tooling cycle is completed.

Finally, the factory conducts a pilot run in which there are field reviews; the Quality and Reliability operation is very heavily involved in this stage. Really, quality, in a broad sense, is involved throughout the planning and design cycle. Quality is the essence of a product that makes the customer happy; and, in more specific terms, quality and reliability insure meeting the design specification. Reliability also means the product continues to function according to design specifications after it is in the customer's home. After the pilot run in the facotry, there is the pre-production run and finally a release by engineering, UL, FCC, and the Customer Acceptance Laboratory which is part of the Quality function, Production then begins at about the 76th week.

The next discussion by Thornley Jobe will go into more depth concerning the reliability program for Consumer Electronics.

## Reliability program for Consumer Electronic's product design engineering

**T. C. Jobe,** Mgr.
Product Analysis & Control
RCA Consumer Electronics
Indianapolis, Ind.



The Product Analysis and Control section was formed about 2-½ years ago to improve the reliability of our product. Our first problem was to determine the reliability of our television receivers. By reliability, I mean the long-term performance, extending out to one year. Our experience up to that time, except for some small pilot operations, had been associated with a 90-day warranty period.

### Need for data

We had information regarding what happened to television sets in the first 90 days. Except for information that we could obtain from the Service Company, we really didn't know accurately how reliable or how unreliable a television receiver really was. We didn't have a good input on service costs except, again, from the Service Company experience. Our warranty program includes letting any serviceman in the country service our television receivers (the customer is allowed to pick his own serviceman.) The first program was to find out the existing reliability so that we could attack the problem of improving it. We also knew we couldn't afford to spend a dollar to save 50 cents in warranty costs. That was the kind of constraint we faced.

At that time, in conjunction with the Quality Control section of CE, we began to develop systems for accumulating statistically valid field data. So, by brute force, thousands of invoices for the warranty program were manually perused and segregated to find out how long the set had been in service, when serviced, and what the cost and causes of service had been. At the same time, we had another group of people analyzing life test information.

### Need for design guide

To improve reliability, we concluded that the design engineers themselves should have a guideline to follow in choosing one transistor versus another, for example. We talk of "total cost" in our reliability program because what the division is actually paying for is the initial cost of the component plus the warranty cost of that component after it is out in the field. This is the cost we are trying to optimize in the "total cost" approach. We needed to provide some guidance to the design engineers so that they could optimize the design, utilizing the types of components we were buying, over the short-term. Reliability of the types of components we are buying must be improved also over the long-term.

At the same time that we aimed at developing a guideline, we set out to improve the reliability of our product and the individual components. Here again, the task was to find the real reliability of our components. We had to investigate infantile failures in the factory, as well as failures in the first 90 days. Beyond this point, life test information needed to be accumulated. We also needed to correlate the life test information with the number of hours in the field. We knew (within 10 percent) about many of these parameters, but that wasn't accurate enough. We determined how often a television set is turned off and on in a year, the length of time a television set is operated in the customer's home, and got some statistics on line voltage variations and temperature across the country. We also made some estimates of ambient temperatures of television sets in the customer's home. We compared measurements on all the various components in our sets under various conditions of line voltage, ambient temperature etc. with life test data. Each time we came a little bit closer. We received specifications for life test, thermal environmental tests, and humidity tests. The specifications for the components, and the standards books probably cover pretty well all of the various types of environments that components must suffer in a television receiver. Included are thousand-hour life tests, or five-hundred hour humidity tests. These tests are useful in qualifying components when a new supplier comes into the picture. We felt that these tests were not totally realistic since you don't have time in three days to run a thousand-hour life test or long-term humidity tests, or environmental cycling test. You can't really use these standard tests on a day-to-day basis to monitor the quality of compents.

### Component reliability

So we set out to find the cricical failure mechanisms of components we had been buying, and then develop short-term tests, and overstress tests that would give us some insight into the reliability of the components. We have, component-by-component, determined guidelines for transistors and other components. Some degree of confidence has been gained in the reliability of our own predictions to give this information to the design engineers.

We have had this reviewed by our engineering management and have reached the stage of preparing a complete booklet that will be distributed to every circuit design engineer. It gives the designer an opportunity to estimate the warranty cost of using whatever component he chooses. The major reason for developing the designers reliability guideline was to allow the engineers to aim at optimim cost. One of our purposes in making predictions, as a matter of fact, is to measure ourselves as far as the guidelines are concerned. In other words, we make a prediction (piece-by-piece) on the reliability of the receiver and factor in field information to measure ourselves against that prediction. Thus, the guidelines can be constantly improved and updated.

We also supply data to the Service Company and Parts and Accessories before a set goes into production to give them some idea of a ball-park figure for use in inventorying parts. We also review with the design engineers what we think the performance of the set is going to be and to highlight any areas of significant unreliability so that those can be corrected before the set goes into production.

The guidelines cover transistors, thyristors for deflection circuits, and thyristors used for other purposes. Integrated circuits are considered individually for the types used in television receivers (not integrated circuits in general). Diodes, vacuum tubes, capacitors, resistors, transformers and coils, kinescopes, pilot lamps, soldered connections and other types of connections are considered. The design engineer, we feel, has little control over infantile failures in his specification of components; therefore, the guideline is really not aimed at these failures. We are trying to remove the infantile failure by other means.

### Maximum stress limits

One segment of realibility in the guideline for circuit design engineers is a list of maximum stresses that should not be exceeded in the circuit application. To arrive at these numbers, data was accumulated by comparing field data and life-test data, particularly relating life-test data to our own measurements of the life-test stresses on the components. Matching the performances in our life tests against the measured stresses for various models has been done over a 2-year period. In some cases, failure models have been revised to fit the kinds of components available for consumer products. The maximum stress limits have been bassed on field experience including picture tube arcing transients and extreme conditions. It may not always be possible to adhere to a maximum stress limit that we recommend. If the design engineer just cannot follow this, he points out to his manager the reasons why he can't do so. If there is no over-riding reason for not being able to do this, the guidelines should be followed.

### Calculating failure rates

After getting the maximum stress problem out of the way, we've provided a simple means for calculating the failure rate; this includes only the random failure rate, but not infantile failures. The form of the equation is such that the number comes out in percent per thousand hours. Included also in the guide book is a list of average service call costs for various types of television receivers. There is also a listing of numbers of operating hours (in thousands of hours) that each type of television set will be likely to experience in the field. By knowing the percent failures per thousand hours, the cost of a service call, and the number of thousands of hours that a set is going to operate, an engineer can then calculate the warranty cost or estimate what the warranty cost will be.

So, we intend the design guideline to be a dynamic thing, something that reflects our continual monitoring of the factors that are included in this guideline. Emphasis in the guideline will be given to the biggest enemy of electronics components in television receivers...temperature and changes in temperature.

### Thermal tests

Thermal cycling tests will weed out a significant number of the infantile failures. We do intend to cycle both the temperature and the power on a one-percent sample of tuners and modules. The idea here is to get information on the longer-term reliability of these components to update the guidelines and reliability specifications.

### Conclusion

I'll summarize all this by saying that the composite of all of these programs will provide the design engineer the tools for designing a reliable product. Now Milt Pyle will tell you about the Quality Control functions to control the reliability because obviously it can't be done entirely by optimim design of the television receiver.

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## Consumer Electronics quality control programs

**M. O. Pyle,** Director
Quality and Reliability
RCA Consumer Electronics
Indianapolis, Ind.

Today I would like to talk about the Consumer Electronics communications program which is used to correct both technical and manufacturing problems. It is my contention that, if you can get the right people to sit down and review the facts, you can correct just about any problem. But before we get too far into my talk, let me set the stage by describing the complexities and mangitude of the RCA color television manufacturing program.

#### Four facilities

There are four manufacturing facilities supporting the production of a color television receiver - two foreign and two domestic. At Taiwan, we manufacture the color modules used in the XL100 color television models. At Juarez, we manufacture deflection yokes and high voltage transormers. The XL100 television chassis is also built at Juarez. Cabinets are assembled at Monticello, and picture tubes manufactured at Marion. All of these products are than shipped to Bloomington where the finished color television receiver is assembled. At Bloomington, material is consumed at the rate of approximately 1.5 million dollars per day, and in 1973 well over a million color television receivers will be built and shipped to RCA distriblutors.

#### Consumer acceptance testing

It is a big operation, and the quality system that controls this operation requires special measurement type programs to permit effective communications. For example, quality is measured by the Consumer Acceptance Laboratory (CAL) Bloomington. Finished TV receivers from each of the ten (10) production lines are sampled daily. The television receivers are measured against engineering and customer specifications. Defects are thoroughly analyzed, and cause of defect established. Corrective action with manufacturing personnel is accomplished in a timely fashion - within hours of actual production. Through this daily communication, changes in the manufacturing process have been made and quality limits tightened. A marked improvement in overall television instrument quality has been noted. When comparing CAL figures of January 1972 with our current CAL figures, you will find that the defect rate has been cut in half. At this time, the quality of the RCA color television receiver is superior to that of any other domestic color tv manufacturer.

#### Management reports

Another example of how we measure quality at Bloomington makes use of a computer. All defects found during the manufacturing process are inputted into the computer data bank. Hourly and daily reports are generated for the use of manufacturing personnel. I summarize an entire week's production in the Weekly Management Report. Defects are shown with the component failing at the highest rate listed first. Only 35 components are listed, but these few represent the majority of the defects noted during production. A typical listing of component failures for the CTC48 (XL100 chassis) would show Bloomington PMI results for modules built at Taiwan. Modules are normally shipped by boat from Taiwan, but before the shipment is accomplished, sample modules are air-shipped to Bloomington where PMI completes their critical inspection. If defects are found, instructions are then relayed back to Taiwan so that corrective action can be accomplished before the bulk boat-shipment is made. The report also shows defects occurring during the two major manufacturing phases — chassis and instrument. Surprisingly, though only 35 components are listed, 50 to 70% of all defects found during production are caused by these compoenents. Similar defect ratios are also noted during CAL and Life Test. The Weekly Management Report is an excellent communication vehicle — it identifies problems and permits concerned people to communicate in an intelligent manner.

Much of the data noted above, when supplemented with other detail, permits direct communications with the supplier of the problem component. The addition of circuit symbol, drawing number, supplier's name, and percent reject figure readily identifies the supplier who is causing manufacturing problems and identifies what needs corrective action.

#### Field data feedback

Field failure data is also used to measure product quality and manufacturing efficiency. Reports now available from the field show four (4) types of failure: Components, Modules, Adjust, and Workmanship. This type report provides useful information. First, it tells manufacturing where their skills must be improved. It also highlights the early life quality problems and, with time, identifies the equally important reliability problem. The report is new, but it clearly demonstrates how data can be used to improve communications and correct problems.

Other field data is obtained by detailed laboratory analysis of the failed component or sub-assembly. The Consumer Electronics Reliability Analysis Laboratory is located at Rockville, a suburb of Indianapolis. Defective integrated circuits, transistors, controls, modules, etc. are analyzed and exact cause of failure recorded. Knowing the cause of failure assures better communications with the supplier.

#### Corrective action

Once the data is obtained, it can be used in various ways to correct problems. One of the best techniques is to employ the Corrective Action Team. At Consumer Electronics, we have teams at each plant and at the Home Office. Team members include key representatives from Manufacturing, Material, Engineering and Quality. Meetings are scheduled each week. Problems are reviewed for validity and legitimate problems assigned for corrective action. Progress is reviewed each week and status reports provided to management for their information and occasional requested support. This technique has solved major problems and is recommended for any activity with a problem.

In conclusion, I would like to point out that a good quality organization, even an excellent organization, will not assure success. A successful program requires the support of everyone. In other words, Quality is YOUR business.

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## Quality control and reliability assurance at SSD

**R. M. Cohen**, Manager,
Quality and Reliability Assurance
Solid State Division
Somerville, N.J.

SSD's quality and reliability program has the objective of providing the best possible levels of quality and reliability on a technologically sound and economically practical basis. That says a mouthful. . . and means different things to different people, or it might be better to say, "It means different things to the different markets that we serve."

We have two principal markets. The *consumer market* includes not only entertainment products, but also automotive ignition, adaptive braking systems, heart pacemakers, and a number of other applications, such as electronic watches that have extremely challenging concepts with respect to reliability. We must realistically work toward obtaining failure rates in the order of 0.01% per thousand hours in the consumer market.

The *industrial, military, and aerospace market* involves ever-increasing system complexities, much larger numbers of components, and often highly critical applications; military demands have always been more severe because of the difficulty of repair in the field.

All types of applications (consumer, industrial, and military) place ever-increasing emphasis on reliability, but with vastly different economic and technical considerations. The problem is a very challenging one, and it is an absurdity to equate it to economics alone. Logistics play a major part in what you do in high-volume operations. A low-volume military application can specify several hundred hours of burn-in on each device. In a high-volume application, however, such a specification would require a prohibitive amount of test area and power consumption even if the very high cost of burn-in was offset by reduced field-failure costs.

#### Consumer market

Looking at the entire electronics market, consumer products present the greatest challenge because of the demand for ultimate reliability with greater cost effectiveness, all accomplished within the practical logistical limitations. We respond to this demand by taking a new and uniquely different approach from that of some of our competitors in the industry. As a result, some customers, who are concerned, for example, with the reliability of a new ignition system, are selecting RCA exclusively as a supplier. A similar decision was recently reached by a major car manufacturer in favor of RCA on a seal-belt warning system. It is obvious to all of us that customers are choosing suppliers based on the quality and reliability approach.

### Reliability through design

In new product areas, such as COS/MOS, business is also obtained by having a better state-of-the-art product than the competitors, and we have many products on the forefront of technology. On the other hand, you must keep the business once you've got it by meeting superior reliability and quality requirements and producing cost-effective products, taking field-failure costs into account. As the semiconductor industry matures, there is a changing balance between the pressure for new technological innovation and the pressure for a substantial and sound approach to quality and reliability achievement. A greater portion of our products have rapidly become well-established and "mature", available from many sources. Our management realizes that it's just as important to have a position of leadership in the reliability area as it is in the area of innovation, because this tangible evidence of better reliability through design and process control provides a competitive advantage of ever-increasing significance.

### Life testing

It has been traditional in the tube and semiconductor industry to evaluate the reliability of a product as it comes out of the factory by life-testing. However, life tests are inevitably after the fact and often provide too little information of the right kind too late to provide effective means for corrective action. Problems may occur in life-test samples from products already shipped, or may cause product to be held in escrow a month or more awaiting the results of life tests. If the life test fails and the quality group decides not to ship the product, it cannot be reworked. Huge losses occur for the producer, and the customer, deprived of product needed for his production line, is not well served by the unexpected delay. Thus, life-testing alone is not a viable approach, although it provides much useful information.

In our new approach, we try to develop, through a series of stress tests, current engineering "real-time" controls to supplement the life tests. Such stress tests appear at the earliest possible point in the manufacturing cycle and are applied on a daily basis (sometimes on an hourly basis) to determine whether or not the product is potentially reliable. After-the-fact life tests are continued to check up on our real-time controls and thus see how well we're doing.

### Step-stress testing

Step-stress testing, another very effective way to reveal potential reliability problems in a new design, is effectively applied to products in development. SSD's reliability-engineering laboratory performs the step-stress testing and develops the testing plan with the product design and application engineers. People in this group do the step-stress testing in a rather interesting way. At the time a product is in early development, we may have only 10, 20, or 30 samples available for reliability checks. The reliability lab (working with the application and design people) take the units which meet the contemplated rating (with its assigned safety factor) and continue to increase the stress. In a voltage-breakdown test, for example, voltage is increased in steps until each device fails, and the stress level at which failure occurs is noted. Current is limited to minimize destructive effects; thus, when a failure occurs, the device is not likely to be completely destroyed, and the unit can be used for failure analysis. We then analyze all failures.

Normally, out of 10 units, two may fail at a much lower stress level than the remaining eight. We try to find out specifically what made the two units fail, what made them look different from the other eight. When we find a solution (it may be in a design change), corrective action can be accomplished while the product is in early development.

If a particular stress test is effective as a real-time indicator, it is written into manufacturing test specifications and put in as a manufacturing test at the earliest possible point in the manufacturing cycle. With step-stress testing, the various kinds of failure mechanisms get to be well understood early, before a device is put into production, instead of being corrected as a result of a customer complaint after production. This is a very powerful approach. The SSD reliability-engineering lab is a unique function in the semiconductor industry and it has been every effective in enhancing RCA's image for product integrity.

### Manufacturing discipline

In the solid-state area, disciplined manufacturing through specification is extremely important. Our manufacturing people cannot make changes without the approval of engineering and quality and in some cases without submitting samples for customer approval, depending on the magnitude of the change. This manufacturing discipline is extremely important in our type of work. Field feedback, analysis, corrective actions and total involvement with the customer are all important to quality control and engineering on a continuing basis. It's really a team effort between the customer and the supplier, and you just can't be engaged in anything except complete cooperation and mutual trust—getting and responding to the facts in order to solve the problem, and then setting up corrective action so it will never occur again.

### Electrostatic problem

After everything has been done to make the device meet its reliability ratings, what happens in the actual application or equipment system? Do electrostatic potentials exist that are breaking down the MOS devices and even high-frequency bipolar devices? Everyone says "no", but an engineer may not recognize all the obscure sources of electrostatic energy. In tv receivers we're all acquainted with high voltage and the fact that stray electrostatic potentials can exist in the set. A more obscure source of electrostatic energy was encountered in an auto radio application where electrostatic potential was generated on a cold day when someone (maybe with rubber-soled shoes) touched the whip antenna. After some pretty careful detective work, the input circuit of the receiver was redesigned so that most of the electrostatic energy was not passed on to the transistor, and that particular problem was solved.

### Thermal fatigue

A great deal of good work has been done recently to design circuits that are more tolerant of changes in transistor parameters (leakage current values, etc). More mature circuit engineering is going to make circuits more dc degenerative. Failure mechanisms of a catastrophic nature to a great extent are mechanical. We have found that IC's can experience a differential expansion problem with temperature cycling and that temperature conditions literally caused IC's to behave as thermal switches under severe stressed conditions. An all-out engineering approach to analyze the cause of this problem revealed an intimate relationship with differential expansion effects where the different rates of expansion of plastic and metal parts of a device were such that the device was being torn apart. A very effective program was developed to solve this. Real-time indicators were placed in the factory to improve the situation. Two orders of magnitude of improvement occurred for this thermal-switch effects with failure reduced from about 1% to 0.01% or better.[1]

RCA was the first company in the semiconductor industry to describe thermal fatigue, provide ratings and real-time indicators for it and to tell everybody what it is. In power transistors, the constant expansion and contraction as a function of temperature cycling when you turn the device *on* or *off* results in flexing of the internal connectors. And eventually they break. It's a wear-out mechanism. The power ratings on our power transistors and SCR's for thermal fatigue have been so extended that now our units have a service-life rating that exceeds many of our competitors by an order of magnitude. To date, we're the only company that has ratings on thermal fatigue, the ratings being a function of dissipation, ambient temperature, and number of times you turn the transistor *on* and *off*). This too is a contribution to reliability that has earned RCA another plus as a conscientious and competent supplier.

### Reliability follow-up

The solutions of the other elusive problems, such as insulation (oxide) deterioration; metal deterioration, and thermal regeneration, have been important contributions to the reliability program for power transistors. At this point in time, we think that RCA IC's have reached the high level of reliability that we have had with discrete devices. Products all go through a "learning curve", and now IC's despite their infinite complexity (compared with simple bipolar transistors), show line failure rates, field failure rates, and life-test failures that are about comparable with the best of the discrete transistors. Consumer Electronics engineers have their consumer-acceptance-lab tests, and we work closely with them We also follow results from Service Company and from the quality index dealers. The failures are always analyzed, and we try to get as much information as we can as to the circumstances relating to the failure so that we can take specific action.

### Military and aerospace markets

Military and aerospace markets require really different approaches, although there are beneficial spillovers. The step-stress testing and real-time indicators for consumer products have increased the reliability of our products. In particular, for high-volume consumer products, we need a better means of evaluating and justifying to the user a higher initial cost to effect greater increases in reliability; the small cost increases to our customer will be more than offset by their savings in reducing warranty costs.

### Conclusion

The Solid State Division fully recognizes that industry pressure is changing in emphasis somewhat. Product innovation and novelty are still important, but product reliability is considered now to be at least of equal significance, and in some respects more significant. We believe the heavy investment SSD is making in this area is the most responsive thing we can do to support this increasing industry concern for product reliability.

### Reference


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# Product Innovations

Session five was devoted to descriptions of three major product innovations involving engineering-marketing team planning, individual entrepeneurship, and the development and design of advanced color tubes for mass markets.

## The precision in-line color tube system
## Part I: Historical system evolution


**C. W. Thierfelder,** Divison Vice President
Color Picture Tube Manufacturing
Electronic Components
Harrison, New Jersey


The RCA Precision In-line (PI) Color Tube System is a novel high performance, simplified system intended to stimulate lower cost, and a more profitable growth of the expanding solid-state portable television market. We believe the system represents one of the most significant color tube technical advancements since RCA pioneered the shadow-mask color tube. RCA has maintained and reaffirmed its technical leadership with the advent of the precision static toroid (PST) 110° and precision in-line systems.

### A good reception

The RCA precision in-line system has been very favorably received by our domestic and foreign customers. Our joint United Kingdom venture, Thorn Color Tubes Ltd., created quite a stir in their British markets with similar PI demonstrations. It offers Thorns' customers the opportunity to make high-performance low-cost, solid-state, small-size receivers to compete with imports.

The Japanese seem inclined to reconsider their small-tube 110° matrix thrust and adopt the RCA basic PI system. It appears that RCA's PI development is timed right to fill the worldwide market needs and to enhance our business position. We have already had several months experience going up the production learning curves with the 15-inch non-matrix and 17-inch matrix tubes in our Marion plants, and are currently involved with 19-inch precision in-line matrix production.

### Trends and objectives

In 1961-63 nearly all the color tv receivers made and sold were consoles. The compact 19-inch through 13-inch table or portable model sales grew substantially with the advent of commercial color to account for a 50% business level by 1970. This trend is expected to continue. By 1976, marketing forecasts show that about 75% of all the color sets sold domestically will be 19-inch or small sizes. Less material is used to make a small tube but generally it takes the same equipment and the same labor.

In line with early marketing forecasts, objectives were established to guide the creation of a simplified low-cost system that was uniquely applicable to the 19-inch V and smaller portables. We set out to find the system that offered potential manufacturing cost savings, with the idea that the new system must provide equal or superior performance and quality characteristics when compared with all other systems. The system would have to provide styling features suitable to package attractive compact portables, and be reliable and serviceable.

### Early research and engineering

During the early 1950's and again in the 1960's, the RCA Laboratories in Princeton undertook an extensive research program on two non-shadow-mask color tube systems to assure RCA's success in the new color television business venture. We explored several variations of these systems in an effort to find an optimum system. The beam-indexing system was evaluated as one of the alternative systems. However, the beam indexing system failed to meet the cost-performance criteria required to obsolete the shadow mask system; thus, the basic labor cost of large-and small-size systems once again proved to be about the same.

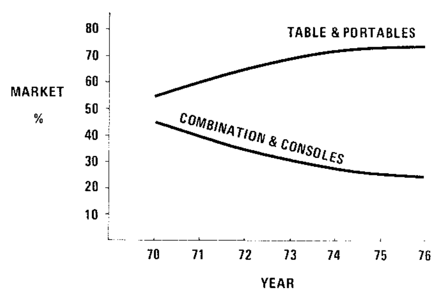


**Fig. 1 — Color tv sales mix.**

Next, two variations of the penetraiton system were explored. This system was potentially attractive for portables because RCA Laboratories had invented an onion-type phosphor cell which could be settled like a typical monchrome black-and-white tube to provide a non-textured type of screen. This system produces the colors by having different energy "dumps" in different layers of the phosphor crystal.

Every color in the rainbow can be made by properly varying the high-voltage beam energy. This system also failed to meet the cost-performance criteria required to obsolete the shadow-mask system, and furthermore the costs of the small-size tube set systems were not significantly more attractive than the large-size tube.

We returned to the early work of RCA Laboratories on the in-line gun system performed in the early 1950's. In 1968, GE entered the market with a small portable in-line system; the system was lower in cost but provided marginal quality and performance and consequently was not adopted by the industry. Sony introduced the Trinitron in about 1969 which provided an excellent focus gun but proved to be expensive because of the cylindrical envelope, the heavy, costly cylindrical tension-line shadow-mask assembly, and a complex electron gun requiring electrostatic convergence with related high-voltage insulation problems. The Trinitron fits Sony's needs but has not been adopted by the rest of the industry because of cost and complexity problems. RCA also explored narrower and wider-angle shadow-mask systems in the 1969 to 1970 period but found no solution to the basic cost dilemma.

### PI breakthrough

After all of this effort and numerous unsuccessful explorations, Messrs, Barkow, Gross, Morrell, Barbin and Hughes came up with individual and collective revelations that could be consolidated into the RCA precision in-line system during 1970. We used constructional concepts of the precision static toroid or PST deflection yoke proven in our RCA European 110° program to provide a unique electron optical approach for the in-line gun system. This allowed us to capitalize on the simplified, low-material cost structure of the PST yoke with its excellent yoke-to-yoke product uniformity characteristics, superior eletron optical performance, and lower impedance characteristics. This combination resulted in automatic self-convergence, and produced quality color pictures without the cost and complexity of dynamic convergence. The small neck 90° system also reduced the required deflection power and added to the circuit cost savings that made the system attractive to all equipment manufacturers. These design features could not be achieved without considering the inherent design tradeoffs of the shadow mask system. Close beam spacing theoretically requires a reduction in brightness for equivalent tolerance or quality of color. This limitation was overcome by using the slit-mask, line-screen structure. As a by-product of the small precision gun and PST yoke, it was possible to shorten the neck length by 1.8" and thereby offer a styling advantage over competitive 90° systems. This overall self-converging PI system is now applied to 19-inch and small sizes: larger 90° types are not now competitive for focus and convergence. This system uniquely satisfied the design objective and provides an excellent overall performance system for solid state portables.

### PI versus other systems

Now, let's take a look at the competitive building blocks for various in-line systems that are in the commercial arena. The Trinitron electron gun is a single-barrel, triple-beam structure in which three separate cathodes are positioned. Beams are produced and pass through the center of a lens to be converged on the top end of the gun by electrostatic deflection plates. This system requires a dynamic convergence signal be fed into the plate which operates at a few hundred volts lower than the anode potential: hence, a dual anode button must be used to bring the high voltage down to the top end of the gun and separate it from the next element below the top superstructure of the deflection plates. A signal has to be developed by a little circuit board which also runs at the high voltage. If one could achieve the excellent focus characteristics of the Trinitron gun without the disadvantage of the design tradeoff of the electrostatic convergence, we'd all be using this type of system.

The new GE in-line gun that GE has been talking about commercializing in the near future has three separate electron barrels that produce three in-line beams. The relative alignment of the three beams is determined mostly by manufacturing assembly tolerances; the problem with this basic system is that as the beams fall out of the plane because of manufacturing assembly variations, there is no correction for the resulting convergence error that occurs on the horizontal lines. This system entails the use of vertical-convergence dynamic waveforms fed in at frame rate to correct vertical convergence errors.

Relating to deflection yokes, the hybrid Trinitron yoke uses a saddle coil to produce the horizontal fiefd; behind this, a toroid is random wound on the core. This type of yoke tends to have the centers of deflection for the horizontal and vertical fields in different locations, tends to have great variance yoke-to-yoke due to manufacturing, and uses much more material than the PST precision in-line yoke. The GE Quadraline yoke uses mulitple windings to produce the horizontal and vertical fields. A quadrapole is used to compensate and produce convergence on axis; this system also requires dynamic vertical convergence.

There are major differences in complexity between the RCA precision in-line mask-frame assembly and the Trinitron mask-frame assembly. The RCA frame consists of four simple stamped-out pieces which are welded toegether to support the spherically formed slit-mask aperture assembly. By contrast, the Trinitron assembly uses a cyclindrical-shaped mask held in very tight tension to precisely maintain the spacing between the narrow continuous vertical slits that separate the metal strips. The assembly requires a massive strong frame to support the forces required to maintain the cylindrical shape under the conditions of electron beam heating during tube operation.

The RCA system has phosphor lines that run continuously from the top to the bottom of the screen. We do not print the mask tie bars so that beam misregister (up and down the phosphor line) will not cause loss of tolerance under certain magnetic field effects.

### PI — a versatile system

The PI system maintains near perfect convergence even when scanning systems are changed from the US NTSC 525, the West German PAL 625, the French SECAM 819 or the old UK 405 line methods. The high voltage has little effect on convergences and can be varied over wide ranges of scan size. The operating conditions for the tube can be varied over wide ranges without affecting convergence. In the PI system, convergence and purity are independent of the driving circuits; so, it becomes feasible to set up and permanently attach, the yoke and the neck components to the tube at the manufacturers plant. Such an integral tube and component assembly is shown in Fig. 2. We have the opportunity then to find a low cost way of making this assembly using automated instrumentation, and resulting in better performance than convenional systems; the latter are assembled by equipment manufacturers who load the tube, the deflection yoke, and all the neck components separately. The permanent arrangement greatly simplifies the installation of the tube for the set manufacturer and the serviceman.

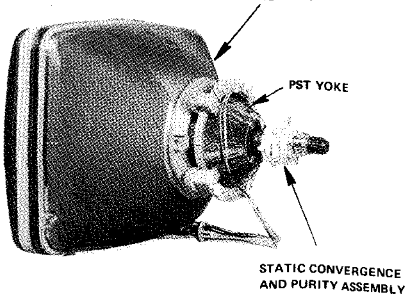


**Fig. 2 — RCA's precision in-line assembly.**

## The precision in-line color tube system Part II: Development philosophy


**D. D. VanOrmer, Manager**
Picture Tube Development Engineering
Entertainment Tube Division
Electronic Components, Lancaster, Pa.


Background on the PI system and the interrelationship of this system with its market need has been described by Chuck Thierfelder. This discussion will deal with the specific elements of the system developed, their interrelationships with each other, and the philosophies of design.

### Cost reduction objectives

The objective of the development was to achieve a significant cost reduction in the overall system, particularly for portable sizes. It was the further objective to achieve this without sacrificing picture performance, and to achieve simplification of the system.

The rapid change tosolid-state color receiver circuitry has made possible the optimum integration of two of the major components of the system; the low impedance PST yoke and the PI unitized electron gun requiring RGB drive circuitry. These, in combination with the slit mask line screen and the integral tube component system, have been combined to form a unique new shadow mask display system.

The major contributor to cost reduction and simplification is the self convergence feature achieved through the use of close spaced in-line beams in combination with the PST line focus yoke without the help of any auxiliary neck components, special yoke coils or extra circuit wave forms. The three beams are deflected by conventional waveforms, and remain converged over the entire face of the tube.

### PI electron-gun structure

The electron gun construction differs radically from thje standard delta gun in that the emphasis has been placed on simplicity of structure in order to achieve precision, alignment and uniformity. Without the need for dynamic convergence, there is no need for magnetic pole pieces within the tube.

The focus system is the standard bi-potential lens type as used on the large screen delta tube. The neck is 29mm in diameter as used on the 110° tubes. All gun elements are electrically common to the three beams except for individual cathodes.

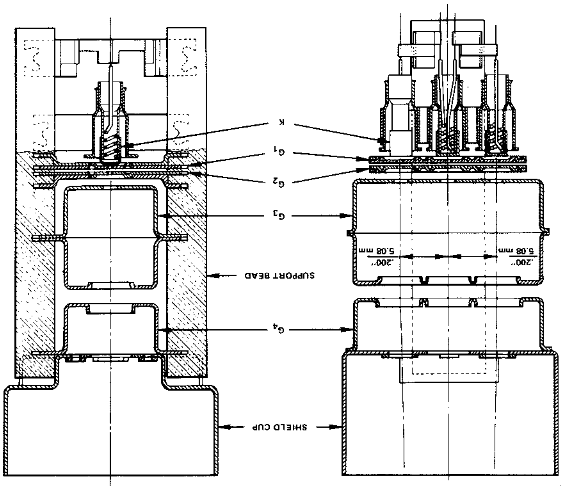


Fig. 1 — Cross-section of the RCA precision in-line electron gun.

Before describing the gun structure, let me state that the gun-yoke interrelationship in an important part of the self-convergence characteristics: it is the focusin characteristic of a special yoke design that is used with the PI system to achieve self convergence. The yoke is designed to that the three beams are maintained in substantial convergence over the face of the screen as shown in the illustration. With the superior electron optical characteristics of the PI gun, yoke and the precision of the PST winding method (where each wire has its own private groove in a plastic end piece), typical convergence over the face of the screen is achieved in production that is equal to or better than that "specified" for the standard delta-dynamic-convergence system.

### Unitized gun construction and alignment features

The main feature of the PI gun is its unitized construction. The apertures for the three beams are accurately formed with respect to each other into the gun elements that are common to the three beams. This permits very accurate alignment of the electron lens elements for each individual beam, as well as accurate alignment of the beams with respect to each other. In a manufacturing environment, the alignment achieved in the PI system is more accurate by a factor of ten than that typically achieved with the conventional individual lens element type construction.

Accurate alignment of the beams within their focusing lenses is the primary reason for the excellent focus performance of the PI gun. However, there are additional features of the system that preserve the good beam alignment and focusing characteristics in the operating receiver: 1) Dynamic convergence and blue lateral magnetic correction fields are eliminated; 2) Centering the yoke on the beams adjusts edge convergence (minimizes the range of purity correction required)' 3) Static convergence correction is very small, and a unique neck component has been developed to move only the outer beams, converging them on the center beam using non-interacting magnetic fields; and 4) The line screen geometry only requires purity adjustment in the horizontal direction. Thus the major causes of beam distortion have been eliminated or minimized. Therefore, even in the face of theoretically poorer, small lens electron optics, the practical execution of the PI system provides focus performance equivalent to the large lens bi-potential 90° delta system, and is superior to the unipotential focus lens gun. Another unique feature of the PI gun is the magnetic shunt system mounted on top of the gun. These small rings of magnetic material are concentric with the outer green and blue beams, and are place dabove and below the central red beam. They provide second-order magnitude fine tuning of the self convergence feature by equalizing the size of each of the three scanned rasters.

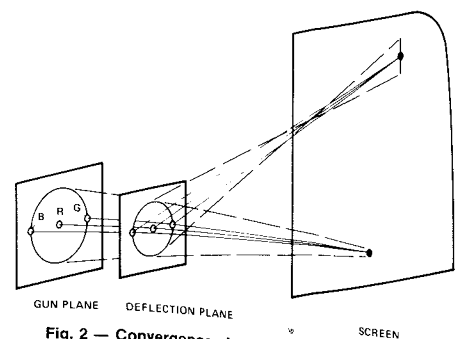


Fig. 2 — Convergence characteristic of line focus.

The PI gun used in conjunction with the special yoke gives equivalent or better performance in the 19V size and smaller. However, further development is needed to extend this simplification to larger screens sizes and wider deflection angles.

### Slit-mask approach

The slit-mask line-screen is used in the PI system to its fullest advantage. The PI screen structure consists of continuous vertical matrix lines separating continuous vertical phosphor lines. The screen is made using application processes that are essentially the same as used with the dot screen with the exception of those factors related specifically to line geometry. A method was developed which permits printing continuous screen lines using the slit mask array.

The slit-mask approach was chosen to provide mechanical strength in the horizontal direction so that standard mask-forming methods and support structure could be used in the standard spherical-face envelope. The mask support assembly was designed with a low-cost, four-piece frame to permit frame-to-mask assembly with better conformance to the skirt of the mask and thus achieve better contour control.

The line screen offers additional advantages in both design and performance. The phosphor lines and beams can be fully nested to give essentially 100% utilization of the screen area compared with only a 91% utilization in the dot-screen geometry. Although in close spaced beam geometry we inherently face a disadvantage from lower mask transmission, the combination of the line screen and its better utilization of phosphor area has permitted us to regain mask transmission so that an equivalent level of brightness can be achieved in the PI system. An

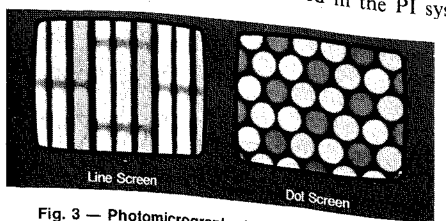


Fig. 3 — Photomicrograph of RCA matrix screens.

additional advantage is that geometric trio distortion can be eliminated. In the delta curved system, we suffer register limitations due to deflection distortion of the electron trio in the corners.

Lighthouse lens parameters are optimized for horizontal register correction. In the PI system, the earth's magnetic field effects are reduced because only the component producing horizontal beam motion affects register. Chassis components having stray magnetic fields can be oriented to minimize the horizontal register effect. We take full advantage of the fact that register in the vertical direction does not affect color purity. All tolerances can be then optimized to give the best horizontal register.

An added bonus of the line screen is its apparent increased picture sharpness over the dot structure of the delta system. This gain is attributed to the lack of dot interlace of the screen structure or the square-wave filter effect of the line structure.

### Summary

The PI system is being made with both matrix and non-matrix configurations. The PI system has been designed to take maximum advantage of the tube yoke interrelationships by assembling yoke and neck components to the tube at the factory, and shipping to the customer as a module.

The PI system development succeeded in a reasonably short time because the program benefited from the full spectrum of product experience feedback, from customer reaction, and the manufacturing experience built up over the years on the shadow-mask system.

## The precision in-line color tube system Part III: The Customer application interface

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The integral tube-components system comprising the precision in line color picture tube and the specially designed factory adjusted components associated with it, provides the tv receiver manufacturer a new unique building block. Until the development of the new PI system, the receiver manufacturer would bring together for the first time a unique television chassis, a unique color tube, and a unique set of neck components that must all go together successfully. If successful assembly does not occur, determining the responsibility for performance problems is not always an easy task. The problems could be caused by the tube, the yoke, or the chassis. However, by delivering a complete factory-preadjusted color tube and neck component system, the color tube maker assumes a major systems-performance responsibility and thereby provides a unique advantage to the industry in the form of improved performance and, ultimately, cost reductions.

The color tube and receiver adjustments made in present-day tv receivers are well-known. A purity yoke-positioning adjustment is followed by a center static convergence adjustment, then 12 adjustments for achieveing dynamic convergence performance ... and finally, a black-and-white picture tracking operation. The preadjusted precision in-line system eliminates all of the previous adjustment needs at the user's factory with the exception of black-and-white tracking.

One of the elements contributing to the PI system capability is the purity magnet which is very much the same as that used for the delta product. The adjustment, however, is handled differently since we are not concerned with vertical register problems, but only left and right register because of the line-screen configuration.

### Convergence features

Static convergence is achieved by the development of a new device (Fig. 1) which uses barium ferrite permanent magnets to achieve coincidence of the beams in the center of the raster. There are no internal pole pieces within the tube to direct the motion of the beams. The design elements of the gun require that we strive to maintain the basic integrity of the beam performance by moving these beams an absolute minimum. To achieve this, the tube neck component has a four-pole configuration with a zero field in the center so that the red beam (the center gun) in the system does not move with increases or decreases of the magnetic field strength external to the tube and rotating this magnet structure changes the direction of motion for the outer beams. The outer beams move in opposite directions so that they can be made to approach each other and thereby converge the blue and green beams. A second adjustment is made with a six-pole device and again the red beam sits in a zero field and is never moved; the outer two beams which were previously superimposed on themselves are now moved in the same direction; by adjustment of direction and strength, the outer beams can be made to coincide with the red center beam.

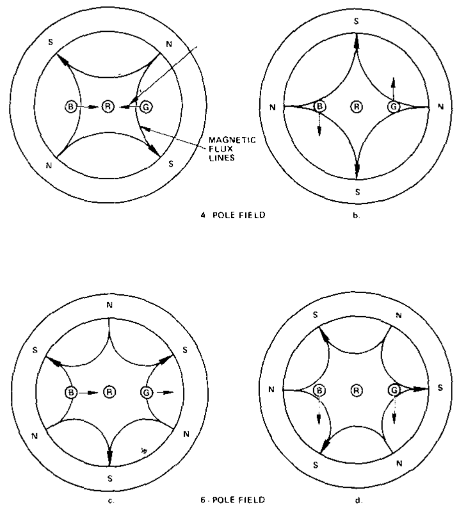
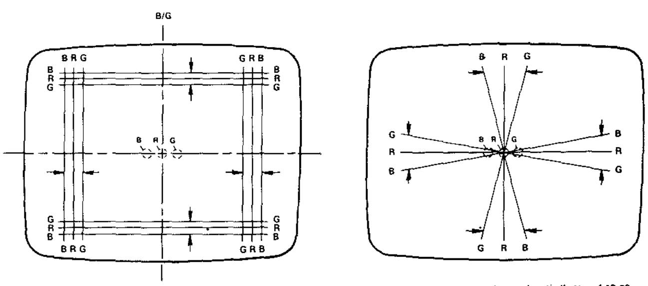



**Fig. 1 — Beam motion produced by the convergence magnets (a) and (b) ... four-pole field; (c) and (d) ... six-pole field.**

The final edge-convergence adjustment is paramount to achieving dynamic convergence without the 12 adjustment controls previously needed in the delta system. In the PI arrangement, we exacly position the center of the magnetic deflecting yoke to the beams; we do not wish to move the beams to the yoke. Attempts are made to put the beams in the physical center of the neck, but mechanical tolerances of neck alignment and gun alignment do not fully achieve this. Exact beam centering in the deflection field is readily detectable (Fig. 2) by observing the convergence performance of the raster. A horizontal motion of the yoke will have a net effect of changing the raster size of the outer two beams relative to the red raster. So, by looking at the vertical left and right lines and the horizontal top and bottom lines, the yoke may be adjusted to the left and right to make the lines coincident, thus defining the proper *X*-axis position of the yoke. By looking for coincidence of horizontal and vertical center lines, one can superimpose the blue nad green rasters on the red raster by finding the proper *Y* positioning of the yoke.




Convergence effect as the Yoke is moved horizontally toward 9:00 — Convergence effect as the yoke is moved vertically toward 12:00

**Fig. 2 — Convergence effect of yoke x-y adjustment.**

### Yoke application machine

We are optimistic about the PI system because a number of new opportunities are offered to the industry, and we can now design specialized equipment which will be aimed at specific functions such as yoke positioning, purity adjustment, etc. As a result, we have developed in Electronic Components a yoke application machine (YAM) which provides all of the conveniences which normally are not present in doing these adjustments in a receiver factory. This machine provides all the convenient "handles-' for adjusting yoke positioning: purity, $X$ and $Y$ yoke positioning, and finally for hot-melt glueing of the yoke in the unique final position that we have strived to find. Not only does this provide convenient and easy adjustment, but it also provides a standardized and narrowed enviornment to avoid receiver problems in the customer's factory. In addition, the stable environment allows an opportunity to manipulate this environment so that the tube "thinks" it is in a specific television receiver or in whatever product the tube will ultimately be used. The YAM equipment is designed so that the front and rear have handles that can be operated from either side. The PI system gives us further opportunity to develop specialized equipment for setting tubes up for purity and convergence on a fully automated basis which will provide a higher degree of performance and product uniformity. Such a machine will require a minimum of operators. The operators will be specialists in doing a particular operation...with a final retest position to establish a quality check to assure that all operations have been properly performed. Rejectable tubes are unloaded, or if troubleshooting can further improve a tube, it may go around a second time. The PI system has greatly reduced the manpower required in the receiver plant; such reductions have offset the additional labor requirements in the tube manufacture. Thus, we are very optimistic that substantial economies can be effected and improvement in general tube quality and performance achieved.

### Simulates user performance

To optimize our yields, we simulate within the YAM equipment the receiver environment in which the tube will ultimately be used. There are a number of elements which require precise simulation; one is the magnetic shield. Not every receiver manufacturer uses the same magnetic shield component; thus, the YAM equipment must have a magnetic shield in which we can perform tests that replicate exact performance experienced with the user's magnetic shield. In addition to magnetic shield considerations, there are interactions between chassis and the yoke external fields which, in effect, produce a beam-to-phosphor register problem. We have the further task of simulating this registration effect of the user's chassis. Small pieces of magnetic material within the machine's environment are used to simulate the effects of the i.f. shield and other metal parts. Any magnetic interfering chassis component or the chassis itself must be simulated with respect to its effect on the yoke field in the user's chasses.

### Stability achieved

After the neck components have been precisely adjusted and locked in position so they are not easily disturbed, the tube and the neck components are wrapped in a package (Fig. 3) which covers the neck and thereby protects the integrity of the adjustments.

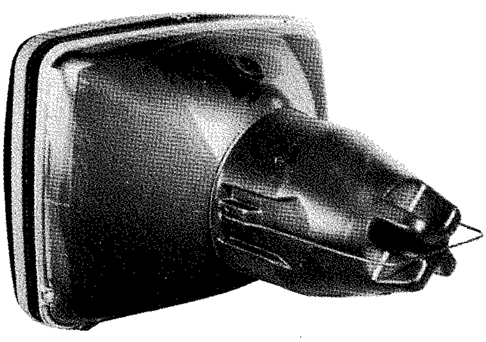
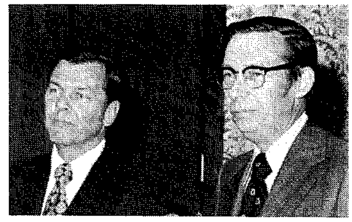


**Fig. 3 — Precision in-line protective cover and handle.**

## TCR-100 video cartridge recorder — engineering and marketing teamwork

**H. H. Klerx,** Manager, Broadcast Planning
**A. C. Luther,** Chief Eng'r, Broadcast Systems, CSD, Camden, N.J.



We selected the TCR-100 project to talk about becasue it was successful and also involved close engineering/marketing teamwork. Moreover, it is an opportunity to portray a market need in search of a product, as opposed to the situation where the product is looking for a market.

The teamwork actually started back in the mid 1960's when there was quite a bit of discussion between engineering and marketing about trying to find a way to meet this recording need of the broadcast marketplace. During those early years, the back-and forth conversation and the willingness of engineering to listen to seemingly impossible requests from marketing were key factors that led to the TCR-100. To understand the market need and how we responded, one must appreciate that in the broadcast business *time* is the commodity they sell.

Time is a very critical inventory; when the time goes by, you can't recover it, it is gone. Broadcasters can and do transmit up to 20% of the programming content as commercial material. This is representative of what is actually transmitted to the home viewer, and it is what pays for the programs. The problem would be simple if the commercial programming took place in one-fifth of the hour. Actually, it is a scattered arrangement wherein there are as many as fifty to sixty short commercial program segments during a program hour, ranging from two seconds up to a minute or more. The commercials are on various types of media such as 16 mm film, 35mm slides, tape, live announcements, and some are canned-audio "spots." All must be coordinated and scheduled by the station staff. There are many opportunities for mistakes and malfunctions either by the operator or equipment.

To present three 30-second "spots" consecutively ties up three $100,000 devices — or $300,000 worth of equipment to put 90 seconds of programming on the air. An early dream was to put all of that on one machine and make it program automatically. This could be substituted for the three machines. The station manager could then do more with his other station equipment, and could schedule his manpower differently. We saw the need, but weren't really sure how we could respond to it.

It is hard to put into context because today you are all familiar with thousand-dollar video-cassette recorders, etc. But, back in 1965 they didn't exist. In fact, videotape itself was just beginning to satisfy the needs of the professional industry. There were no cassette video recorders. RCA was the first to introduce a cartridge recorder, before Sony or anyone else demonstrated their first working models. We had our first unit on display in 1968.

Before the TCR-100 video cartridge recorder, film had to be threaded on an individual projector for every 10-second or 30-second spot. The same ritual was repeated with rows and rows of television tape equipment (each one costing about $100,000). Typically, a station has three to five such facilities plus the television film equipment. The station log is the bible that is used to coordinate all the schedules; without this, there would be total confusion.

The station makes all its money every time it airs a commercial sequence, and if anything goes wrong that is where they lose the profits. The station operator uses the station log to know what commercial to load on what machines. One 30-second commercial, depending on the size of the station, can represent revenue anywhere from $25 to $1,000. Mistakes can become very costly.

### TCR-100 concept development

The idea of developing an equipment with the capability of playing many short messages pushed us into the development of the other concepts that would ultimately be in the TCR-100. For example, restriction to a playing time of three minutes made possible the reduction of the tape-reel hub to a diameter of only one inch instead of the 4-½ inches used for standard large reels. This contributed greatly to the reduction in size to the videotape cartridge. Another key concept was the early recognition that a single machine should include the capability of continuously playing one cartridge after the other ... this could be achieved by using more than one tape transport playing through a single electronic system which would do all control and switching of signals. This was a significant cost consideration since the electronic system for playback represents about 50% of the cost of a single videotape recorder. Further concepts developed included automatic threading mechanisms, allowing the tape to be threaded into the tape path without any attention on the part of the operator, and a cartridge-changing magazine which allowed a multiplicity of cartridges to be automatically sequenced through the machines.

During this conceptual stage, we involved our customer and covered the gamut of large network operations to small stations. Following this, we found that we had a better understanding of what was required than the station engineer. We knew what was going on in the back room, and could ask many probing questions.

This brought us to a presentation to management in 1968 to sell them on our concepts. As we got further and further into the program, we realized that there was a very close relationship to other products and that we could spread our engineering investment across a broader base. We needed new products to upgrade our present professional broadcast line. So, we put together a business plan that showed a family of products. This took us to the next step: which do you do first? The video cartridge recorder was without question a highly innovative product and became our choice. We embarked on the program in September 1968.

### First video cartridge recorder

Our target was to have equipment for demonstration at the National Association of Broadcaster's Convention in March 1969. This way we would get a quick market response to this new concept. Our problem now was to carry out the product development program successfully shown to management. This would appear to be a simple task but the program schedule called for a complete working system model to be shown at 1969 NAB, barely six months away, and the design was not yet complete — even on paper. But our engineers were armed with enthusiasm and the drive which comes from pursuing a revolutionary new course.

After resorting to much after-hour effort, we succeeded in getting to the 1969 NAB with a new video cartridge tape recorder product. As expected, it generated a great deal of customer interest. Our exhibit at most times had wall-towall people. However, the short-term engineering effort had not yet produced anything like the reliable system desired. To test the international market response, we demonstrated the first machine at a television conference in Montreux, Switzerland in May of '69. At Montreux we determined that there was potential overseas interest, enough to merit a machine meeting their special tv standards.

### TCR-100 field trial

Following NAB and Montreux we went into the product design phase, and simplified the modular structure; instead of using individual subsystem drawers, we packaged the electronics in a single drawer. This effort continued and in 1970 we built two new prototype models of the final design. One went to NAB in 1970. This time we were on firmer ground with a reliable design and it was displayed in a theatre configuration designed to handle the expected crowd. This was completely successful and the TCR-100 was again the "hit of the show."

Following the '70 showing, we decided to take the model and send it to a field test site. We picked a small uhf station because they had no network affiliation and had to rely very heavily on local program facilities. This happened to be a station where both the chief engineer and several engineers on the staff showed a high degree of interest and capability. They knew they had a real need for the TCR-100 and it was a challenge for them. Nearby Washington, D.C. was the location of the field test site we had chosen. With the successful completion of this field test, we began releasing parts of the system to production.

### Production

The complex job of setting up production began. The first unit was completed by production in time to be on display at the 1971 NAB with subsequent shipment of eight machines to customers in April. On these first shipments we set up a comprehensive program to monitor the performance of the units as they went into the field. After shipping eight units, it was becoming clear we were not getting the desired reliability. We then decided to stop production and re-direct the engineering/marketing team efforts to a reliability program.

### Reliability program

The goal for the reliability established earlier called for a system failure rate of less than one on-air program fault in a thousand plays, representing a program week. In the case of the TCR-100, we classify a failure as any event that causes an on-air disturbance, even if corrected immediately. The customer needs this reliability for the TCR-100 to be giving him the cost effectiveness which we claimed that it would have. We established a program to get data on every failure by reporting every detail about the operation of the eight machines we had in the field. A field man was assigned to every installtion. In a similar manner we set up four more machines in the plant on a life-test mode continuously operated at even higher rates than at the stations. A failure analysis activity was established in engineering to collect the feedback material and identify specific problems that could be addressed by the appropriate engineers for correction. Very soon we had an action list of more than 100 items moving along. We began to find answeres to the problems and fed those corrections back into the life-test machines.

By the end of 1971, six months after starting this mode of operation, the failure rate of the life test machines had passed the goal. We took steps then to re-start production with all of the changes incorporated. During the life testing and operation of the machines, the production peop;le became well trained in the functioning and use of the machines. As production started, we continued to analyze field data and confirmed that the new units would be acceptable.

### Sales record

The highlight of the whole program can be best reflected in sales. We are in our second year of production of the TCR-100. Over 100 recorders have been shipped and we are leading our competition by a factor of almost 3 to 1. We have already passed $20 million in sales and expect that throughout the life cycle sales will exceed $100 million.

### Conclusions

Looking back we have learned some things for the future. In a new program, we would look much more carefully at the choice of technology in making sure we aren't being too conservative. In the product cost area, our original estimates made early in the program were low. That is not too unusual, but looking back we probably knew more about product cost at the time than we thought. As a result, the price of the product at introduction was about half of what it is today.

Similarly, the reliability effort took place in a way that wasn't planned. With such demanding reliability requirements, we should have pre-planned the program before going into production.

A plan for continued product growth and supporting accessories is an area that can be easily overlooked. Our plan was not complete in its early phases but we eventually came up with a program to bring a new product to the marketplace together with the many supporting products that would ultimately be required with the TCR-100. The resulting sales from those supporting products will be in the order of millions of dollars annually. And last, the selling techniques deserved more attention when we first embarked on this program. We were able to convince the engineering community that this was a great thing to do but we had a credibility gap when we tried to sell management.

Looking back, we can see the reasons for many of our problems and put them into perspective. However, we also see the results of a very successful program brought about through a close relationship between engineering and marketing — throughout the formulative stages of the design, manufacture and marketing programs. The TCR-100 is one of the most successful products we have had in broadcast.

# Technology to product to profits

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Although the subject of this paper is complementary-symmetry MOS (COS/MOS) integrated logic circuits, some of the areas covered will illustrate the type of problems one may encounter in any product development. The problems, the decisions one has to make, and the work one has to do in the development of any product are very similar. We will discuss where we are in the marketplace, how we got started, what the problems are, and the decisions we had to make. We'll also describe the problems and decisions we face today, and have to make today. We will discuss some suggestions on how to improve the probability of success in the choice of new-product development.

COS/MOS has been in production for about 3 to 4 years. The origin of this product, as is true of many of our other products, was RCA's Princeton Labs. Complementary MOS is a logic form based on three major types of building blocks: a p-channel/n-channel inverter, single-channel transistors, and a transmission gate. The basic electronic concepts have been known for a long time; it was the introduction of MOS technology that made it possible to develop a practical integrated circuit.

| COMPANY | MARKET POSITION | | |
|---|---|---|---|
| | 1972 | 1973 | 1977 |
| RCA | 1 | 1 | 1 |
| SOLID STATE SCIENTIFIC | 2 | 2 | 5 |
| MOTOROLA | 3 | 3 | 3 |
| SOLITRON | 4 | 5 | 6 |
| NATIONAL | 5 | 4 | 4 |
| TEXAS INSTRUMENTS | 6 | 6 | 2 |

**Fig. 1 — COS/MOS manufacturers.**

Fig. 1 shows RCA's position in the market place. Our 1973 sales are a two-fold increase over 1972, so it can be seen what a rapid, dynamic business we are in. In 1977 the total industry-wide sales will probably be over $225 million, and we anticipate maintaining a leading share of the marketplace at that time.

## Fundamental product decisions

Early in the game of product development, we are often faced with having to make fundamental decisions. The future success of the product is often rooted in those decisions. The proper blend of both technical and commercial thinking must be involved in the decision-making process.

Some of the decisions we had to make for the complementary-symmetry device are shown in Fig. 2. We placed sufficient emphasis on standard circuits so that today we have over sixty standard logic types either commercially or developmentally announced. Our rapidly expanding family of circuits gives us credentials in the marketplace. We chose to emphasize logic *vs* memories because we felt that it was important for us to get a foothold in the general-purpose logic market. We did not feel we had the resources at that time to do a good job in both areas. We are happy to say we are now announcing our first complementary-MOS memories in the form of a 256-bit memory and we will be announcing larger memories in the future. A very important decision was to develop a low-cost plastic package. Today it appers to be an obvious thing to do, but at the time it was deemed to be taboo to have MOS in a plastic package. However, we recognized that one of the product areas we wanted to make a niche in was in some of the TTL logic applications where speed was not a major factor. We had to have a low-cost type of device and we adopted the plastic technology that was currently being used in the linear line with some modification and made it work for MOS. Our sales have undergone a change over a three-year period from about 90% ceramic to 90% plastic. So you can see that it is a highly accepted product.

– DEVELOP STANDARD LINE

– EMPHASIZE LOGIC VS MEMORIES

– DEVELOP LOW-COST PLASTIC PACKAGE

– DEVELOP TTL COMPATIBLE LINE (3 V – 15 V)

– DEVELOP LOW $V_T$ PROCESS (1.5 V POWER SUPPLY)

– QUALIFY FOR HI-REL SPECS
MIL-STD 883
MIL-M - 38510

– EMPHASIZE HIGH-VOLUME CUSTOM CIRCUITS

**Fig. 2 — Fundamental product decisions.**

Developing a TTL-compatible line by refining technology to extend the operating voltage down to 3 V was important to gain acceptance by the present users of bipolar logic. It was important to develop a low-threshold process to take advantage of those applications where only a single-cell battery is available.

Our early efforts to qualify our product for MIL-STD-883 and MIL-M-38510 specifications to participate in the military market have paid off in incremental sales and improved reliability. The development of high-volume custom circuits, such as for the watch, clock, and automotive applications, as well as communications, has generated significant sales.

## Second sourcing

A very important problem we faced in the early days was credibility. RCA was hardly a giant in the digital-IC world. Although many potential users were anxious to use this new logic form, they were concerned about on-going suppliers. What if RCA had a problem?

Where was their second source? So the establishment of a second source became important. Hughes, as an early producer of COS/MOS, helped. When Motorola came on board in 1971, we received a real shot in the arm, since they had credentials and acceptance in the marketplace.

## Education

We recognized that in order to increase the sales of our products and establish complementary MOS as a standard logic form it was necessary to undertake an extensive educational process, and we invested a substantial part of our engineering resources during 1970, 1971, and 1972 for this purpose. We issued a design manual. We instituted seminars which were attended by auidences as high as 200 people. These were two-day seminars and they were quite extensive and thorough and, We think, worthwhile. These were followed by shorter seminars.

We had technical and design information recorded on videotape with the help of the RCA Educational Services Group. We even recorded a number of audio tapes so that we could distribute them to our sales people and have them play them while they were driving. These were very effective. We are currently working on a programmed learning manual.

The importance of customer education in a complicated new product area can't be overemphasized. Without this we don't think our product would be moving as fast as it is today.

## Present marketing strategies

Our present marketing approach is summarized in Fig. 3.

| MARKET | STRATEGIES |
|---|---|
| AUTOMOTIVE | • WORK WITH MAJOR MANUFACTURERS<br>• INVOLVE POWER CIRCUIT FUNCTIONS GROUP |
| CONSUMER | • CONCENTRATE ON MAJOR WATCH COMPANIES<br>• DEVELOP STANDARD CIRCUITS AND MODULES<br>• DEFINE TV APPLICATION NEEDS |
| INDUSTRIAL | • PENETRATE MAJOR NON-COS/MOS USERS<br>• INTRODUCE FRIT-SEAL CERAMIC<br>• DEVELOP BROAD RANGE OF STD CIRCUITS<br>• DEVELOP FAMILIARITY WITH INDUSTRIAL DIGITAL MARKETPLACE |
| GOVERNMENT | • PROMOTE MIL-M-38510 CAPABILITY<br>• MAINTAIN COMPETITIVE HI-REL PRICING |

**Fig. 3 — Present market strategies.**

## Current product decisions

What are some of the current product decisions we are facing? In spite of the fact that we have made a decision to emphasize standard and selective custom circuits, we are constantly bombarded with pressures to increase our participation in the custom market. What is the right balance between custom and standard circuits?

What is the role of beam leads in this technology? We have the technology for making beam-lead complementary-MOS devices. We believe we are the only manufacturer that has this capability. The question is: what is the right timing to introduce a beamlead product line. Introducing it too early could dissipate engineering effort without the proper payoff in the sales of devices. Introducing it too late will casue us to miss the marketplace.

What is the role that complementary MOS on sapphire will play in the marketplace? This is a question we are facing now. Our first product will probably be a watch circuit which will be able to function at 2 to 4 MHz with a power dissipation of about 10 microwatts, and that is no small accomplishment. There is no other way to do this as far as we can see. This will be followed by other logic circuits as well as memory devices.

We are constantly searching for ways to improve circuit density. We are developing a set of design rules that will allow us to improve our density for a factor of 2. This is an important improvement, and we will be coming out with MSI and LSI circuits that reflect the economics of this move.

We are inititating the development of standard system chips that go beyond simple logic, such as micro-processes on a single chip, calculator chips, and memories. These are some of the basic product decisions we are making and attempting to resolve today.

## Cost reduction

Fig. 4 shows some of the cost-reduction opportunities we are pursuing.

– FRIT-SEAL PACKAGE

– 3-INCH WAFERS

– IMPROVED GUARD BANDS – YIELD IMPROVEMENT

– OPTIMIZED TEST PROGRAMS

– LASER SCRIBING

– PROCESS CONTROLS

**Fig. 4 — Cost reduction opportunities.**

## Organization

In a growth business, "organization dynamics" or modifying the organization in anticipation of need becomes important. We will focus on the engineering organizaiton, although the same things can be said for marketing and manufacturing.

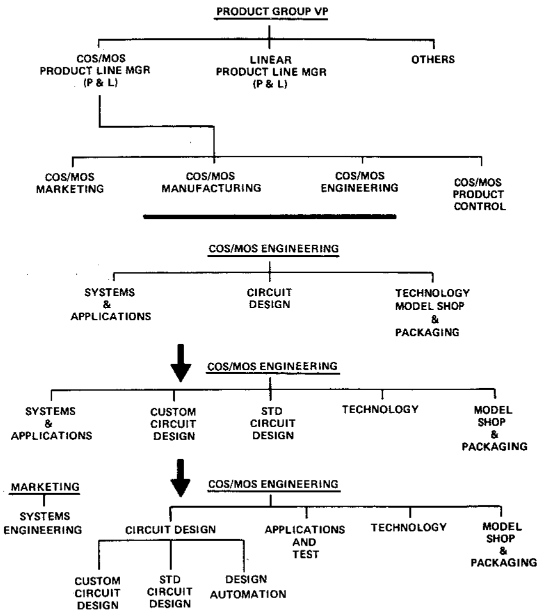



**Fig. 5 — Organization dynamics.**

The organization must be modulated and changed with the requirements of the time. The organization that was established initially is rarely good in the current time frame. Fig. 5 illustrates some of the changes we have instituted to cope with our growing business.

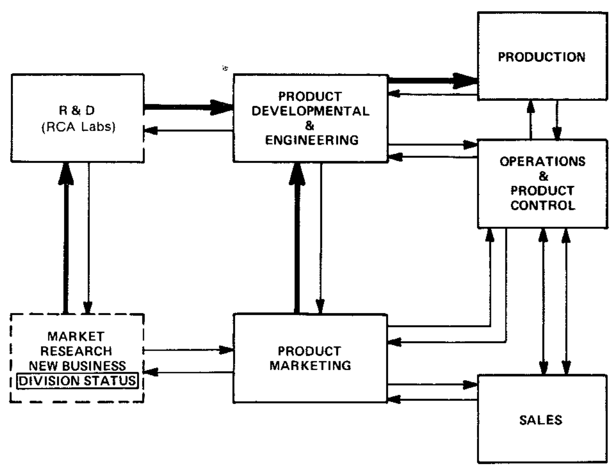



**Fig. 6 — Product-profit machine.**

Fig. 6 illustrates some of the interaction that takes place in the development of a new product. The arrows illustrate the patterns of information flow. The heavier lines indicate the dominant pattern of information movement. It is suggested that the creation of a new-business group on a divisional status (dotted box) could catalyze and enhance the timely choice for new produce developments and, perhaps, increase their probability for success.

# Books by RCA authors

**Presented here are brief descriptions of recent technical books that have been authored, in whole or in part, by RCA scientists and engineers. Readers interested in any of these texts should contact their RCA Technical Library or their usual book supplier. RCA authors who have recently published books and who were not cited in these listings should contact the editors, Bldg. 204-2, Cherry Hill, Ext. PY4256.**

## Handbook of wiring, cabling, and interconnecting for electronics

**B. R. Schwartz**
(contributor)
Technical Assurance
Missile and Surface
Radar Division
Moorestown, N.J.

The *Handbook of Wiring, Cabling, and Interconnecting for Electronics* covers all important types of flat and round wires and cables, together with rigid and flexible etched circuitry, and discusses various types of connectors and terminations for all applications from power systems through low signal systems, high-frequency systems, and microelectronics.

The chapter on "Basic Selection of Connector Systems" was co-authored by Mr. Schwartz and Gustave R. Gaschning (formerly with RCA). This Chapter provides a rational connector-system selection technique which defines packaging interconnection levels, describes the variety of connectors available and discusses the applicable advantages and disadvantages of each. In this manner, the reader is literally led through a series of decisions that must be resolved, and then is given sequencing to other levels to provide the best possible connector-system selection. (McGraw-Hill Book Co.; New York, N.Y.; Charles A. Harper, Editor-in-Chief; 1972; *price* $29.50).

**Bernard R. Schwartz** received the BEE from City University of New York in 1949, the MSEE from Newark College of Engineering in 1953, and the MBA from Drexel University in 1968. His current assignment at MSRD involves three major activities associated with AEGIS: 1) reliability, maintainability assurance; 2) parts, materials and processes application and standardization; and 3) integrated logistics engineering. Prior to 1970 he had been Group Leader for RCA Spectra 70 computer product line in engineering reliability tasks, and with RCA Defense Electronic Products Central Engineering (1955-1968), as Group Leader of electronic, electromechanical and mechanical parts application and standardization. Prior to RCA, Mr. Schwartz was involved in the test and evaluation of resistive and connector components at the Signal Corps Engineering Laboratories (1950-1955).

## Modern sound reproduction

**Dr. Harry F. Olson**
Staff V.P. (retired)
Acoustical and
Electromechanical
Research
RCA Laboratories
Princeton, N.J.

This book describes today's newest and most important elements, systems, and accessories used in high quality sound reproducing equipment, along with methods and applications that help achieve high levels of excellence and performance in sound reproduction. It highlights such aspects of the field as effects of electrical and acoustical noise; quadraphonic sound reproduction in magnetic tape and disk record reproduction; theory, action, and performance of transistor and integrated circuit audio amplifiers; electronic modifications used to heighten the emotional impact and artistic embellishment of recorded sound. In summary, the book is a detailed technical exposition of significant and essential elements, systems, principles and techniques in modern sound reproduction. (Van Nostrand Reinhold Co.; New York, N.Y.; 1972; 336+ xiii pp.; 250 figs., *price* -$27.50.

**Harry F. Olson** received the BE in 1924, the MS in 1925, the PhD in 1928, and the professional degree of Electrical Engineer in 1932 — all from the University of Iowa. He received the honorary DSc from Iowa Wesleyan in 1959. In 1928, he joined RCA as a member of the Research Department. In 1934, he was placed in charge of acoustical research and, throughout his career at RCA, continued to head research activities in this field. He retired as Staff Vice President Acoustical and Electromechanical Research, RCA Laboratories, on January 1, 1967. He continued as an Advisor to RCA Laboratories to January 1, 1972. One of Dr. Olson's early contributions during his career was the velocity microphone which became standard for broadcasting use. Subsequently he developed several other types, including the uni-directional now used, or coming into standard use, in television broadcasting and sound motion picture filming. He also has made pioneering contributions to loudspeaker development.

## Computer control of modern radars

**R. A. Baugh**
Leader, System Design
AEGIS Program
Missile and Surface
Radar Division
Moorestown, N.J.

The objectives of this book are to show the influence of the computer on radar system design and integration and to present the most commonly encountered control problems. It was written to reach the radar engineer and, as such, assumes no knowledge of computer programming. At the same time, however, the radar material is basic and could serve as a primer for the computer programmer faced with the problem of radar control design. To a large extent, the experience gained in the development of the overall architecture and specific control programs for the Navy's AEGIS AN/SPY-1 radar system provided the foundation for the book. However, to encourage general applicability, most topics are treated from a somewhat broader point of view. Where necessary, general principles are illustrated with specific examples. In these cases, care was taken not to employ AEGIS as a model due to the classified nature of the project. (Printed and distributed by RCA.)

**Richard A. Baugh** received the BSEE from VMI in 1955 and the MSEE from Drexel Institute of Technology, in 1962. Since joining RCA in 1955, Mr. Baugh contributed to various projects in capacities ranging from circuit design to system engineering and concept studies. His early work included studies to determine the reliability and task analysis for automatic checkout of surveillance satellites using on-board computers; the development of the optimum characteristics of a data processor to control automatic test equipment; and research in number theory, where he holds a patent on an application of residue number theory to digital computers. His recent work has been devoted to the application of digital computers to the control of radars ranging from radio telescopes to modern strategic and tactical phased array systems. Mr. Baugh is presently an engineering leader in system design, assigned to the Navy's AEGIS AN/SPY-1 radar program.

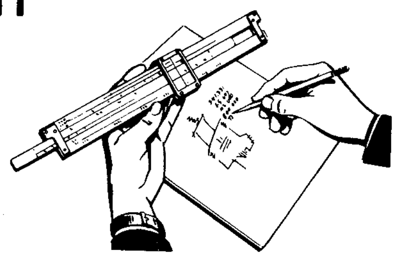
## Semiconductor device modeling for computer-aided design

**Robert G. Harrison**
(contributing author)
RCA Limited
Montreal, Canada

In *Semiconductor Device Modeling for Computer-Aided Design*, edited by G.J. Hershkowitz and R.B. Schilling, Dr. Harrison has contributed Chapter 3, "Large-signal microwave frequency transistor modeling". This chapter describes how an established large-signal transistor model, known to give satisfactory results at lower frequencies, was used to simulate a 2-GHz, 1-watt device. The great importance of characterizing the parasitics accurately is emphasized. Also described is the computer-aided analysis of the model's performance in a amplifier enviornment. Included is a detailed study of the approximations involved in proceeding from the equations of semiconductor physics to the actual device model employed (McGraw-Hill, Inc.; New York, NY; 1972; 360 pp.; *price* $16.50).

**Robert G. Harrison** received the BS and MS from the University of Cambridge in 1956 and 1960 respectively. He was awarded the PhD by London university and the D.I.C. by Imperial College in 1964 for research work on steady-state and transient phenomena in parametric subharmonic oscillators. From 1956 to 1957 he was the Computing Devices of Canada Ltd., Ottawa, specializing in semiconductor circuit design. In 1957 he joined the Canadian Defense Research Board where he worked on 12 Megabit/sec logic systems. In 1960 he was a consultant on color tv equipment to Central Dynamics Ltd., Montreal. Dr. Harrison joined the Research Laboratories of RCA Limited in 1964 and was involved in the design of the PCM encoding system used in the ISIS series of research satellites. Subsequently he was engaged in studies of the behaviour of power transistors at large signal levels. This work led to a detailed report on large-signal (class C) microwave transistor modelling for computer-aided design (CAD) and to the development of a computer system for nonlinear ac analysis of microwave transistor circuits. Currently he divides his time between the recently-established CAD and Graphics Facility and doing research on communications aspects of microwave power devices.

# Engineering and Research Notes



## Initializing COS/MOS storage elements


**O. Bismarck**
Solid State Division
Somerville, N.J.


It is sometimes desirable to initialize the storage elements (flip-flops, registers, counters) of a COS/MOS system to the all 1's or all 0's state when the power supply is turned *on*. COS/MOS IC's lend themselves to initialization more than any other technology because of their negligible input current. Fig. 1 shows that all that is needed is a 1/8-W resistor and a small capacitor for initialization to either state.

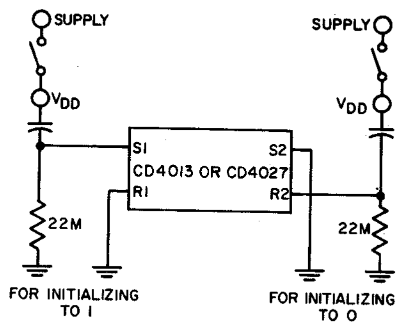



**Fig. 1 — Initialization circuit.**

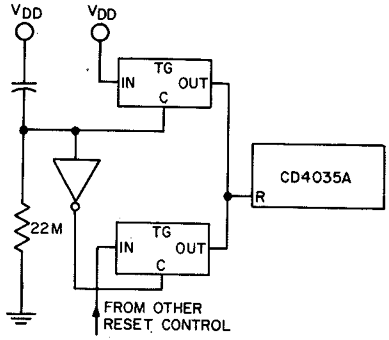



**Fig. 2 — Set/reset function.**

Experiments have shown that for most COS/MOS storage elements, a 30-pF capacitor is sufficient to ensure setting or resetting when $V_{DD}$ is turned *on* via a switch. (A bounce-free *switch* is *not* needed). If the power supply is turned *on* while the $V_{DD}$ line is directly connected, a capacitor of the order of 1000 to 1500 pF is needed.

If the set or reset function is to be used after initialization, a pair of CD4016A or CD4066A transmission gates should be used as shown in Fig. 2. In this arrangement, the set or reset is tied to 'high' initially, while the regular reset signal line is open-circuited. Once the capacitor is charged, the transmission gate connecting set or reset to $V_{DD}$ becomes an open circuit. The capacitance seen by the regular reset control is 15 to 20 pF. In this arrangement, a capacitor of the order of 0.001 $\mu$F will be needed if the $V_{DD}$ line has a switch; about 0.005 to 0.01$\mu$F is needed if the power supply is directly connected to the COS/MOS circuit.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## Circuit-board clamp


**Edward P. Cecelski**
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The circuit board clamp described is a convenient work positioner which securely clamps and positions a circuit board or like product in several work orientations and which holds and dispenses solder. The novel features of the clamp are shown in Fig. 1 and 2. The circuit board clamp includes a base member formed from brass or other suitable heavy material having a planar upper surface (12) and planar spaced side surfaces (14). Planar intersecting surfaces (16 through 20) together form a portion of a regular polygon or may be arranged, as convenient, at suitable angles with respect to each other to form the base support surfaces when the base is on a work table. Securely attached to the side surfaces (14) are a pair of U-shaped clamp assemblies (24 and 26) formed of stiff resilient wire. These clamps are commercially available and may be purchased from the Wedgelock Corporation of California.

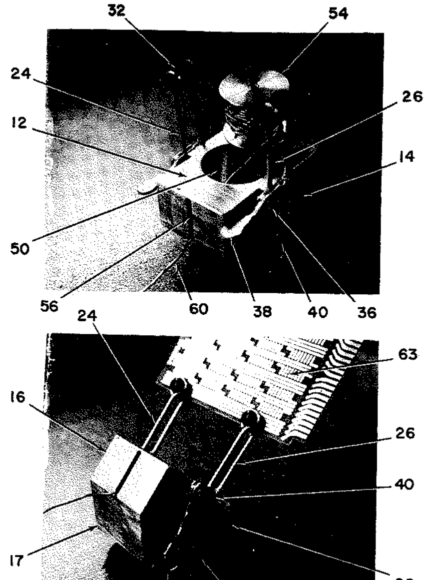


**Fig. 1 (top) — Circuit board clamp with solder holder. Fig. 2 (bottom) — Printed circuit board secured.**

At the upper open clamping end of each of the U-shaped assemblies are a pair of rubber clamping pads (32). The clamp assemblies (24 and 26) are secured at the midsection by a frame (36) including a pivotally mounted cam and level (38) which serves to open and close pads (32) by way of camming the legs of the member toward each other. Clamp assemblies (24 and 26) are secured to the respective sides (14) by suitable screws (40).

A circuit board (63) to be secured by clamps (24 and 26) is placed between the pads (32). Lever (38) is then actuated to cam the pads into a closed position securely clamping the circuit board without marring the surface finish of the board. The inner surface of the circuit board may then be oriented at any angle with respect to the support surfaces (16 through 20), the weight of the base providing sturdy support for the circuit board during a soldering or assembly operation.

As a further convenience, a cylindrical hole (50) adapted to receive a spool of solder (54) is formed within surface (12). A transverse slot (56) is formed in surface (16) and hole (50) to permit a strand of solder (60) to be removed from spool (54). The spool is formed so as to closely fit into hole (50) and arranged to receive solder in wire form as shown.

While five support surfaces (16 through 20) have been illustrated, any number and orientation of support surfaces may be provided in accordance with a particular desired application.

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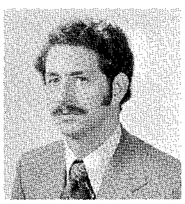
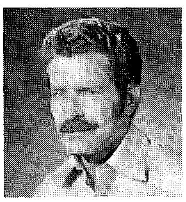
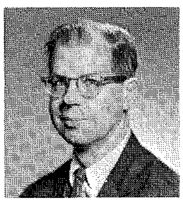
## Inexpensive laser mirrors

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Precise, highly sophisticated devices, such as monolithic integrated circuits, are made by modern mass-production techniques. Equally modern techniques are used to fabricate more mundane products, such as window glass; these products are also often correspondingly precise and "sophisticated". This note points out that various common commercial glasses are interferometrically flat enough to be used as laser cavity mirrors. These window glasses are inexpensive, readily available mirror substrates that can be used in laser experimentation, as well as in research laser construction. We describe several preliminary tests that can be made to determine the suitability of particular window glasses, as well as our experiences in their actual use in *HeNe* lasers.

### Interferometric testing

For testing the flatness of large areas, the cleaned glass substrate is pressed firmly against a glass optical flat to establish good contact, and the interference fringes under monochromatic illumination are observed. The spacing of the fringes indicates the large-area flatness of the substrate. For example, if there are four fringes per inch, then the substrate is said to be flat to two wavelengths over an inch. A test for large-area flatness is meaningful when the substrate is to be used with a beam that is comparably large *and* when smaller surface variations are below the optical resolution of the final application. Often a substrate is flat over large areas, but has a fine shallow surface ripple. Such a substrate might make an excellent cosmetic mirror but be unsuitable as a laser mirror. For example, polished plate glasses are often flat to one wave/inch over large areas, yet show an orange-peel surface characterisitc of the mechanical polishing processes.

To determine the small-area flatness of a substrate, we used a 10X Watson interferometric microscope objective. With this device, the substrate under test forms one of the mirrors of a Michaelson interferometer, while this substrate surface is simultaneously magnified by the microscope optics. The interfereometric flatness of a region of the substrate approximately 1 mm in diameter can be readily determined using this device.

We have examined several different glass types and found that a number of them are sufficiently flat to be useful as laser mirrors substrates. Table I lists three such glasses and summarizes their large-and small-scale flatnesses. All of these glasses are adequate mirror substrates for reflecting small-area beams, such as unexpanded laser beams. Indeed, the results in the table indicate that such glasses could even be used as substrates for a flat mirror in *HeNe* laser cavities.

### Laser application

The laser cavity of typical commercial lasers consists of a curved output mirror and a totally reflecting flat mirrow. In this cavity the smallest beam diameter or beam waist of the $TEM_{oo}$ mode is at the flat mirror. The radius of the beam waist, $w_o$, is given by[1]

$$w_o = (b/k)^{1/2}$$

where $b=2[d(R-d)]^{1/2}$, $k=2\pi/\lambda$ is the optical wave vector, $d$ is the mirror separation, and $R$ is the radius of curvature of the curved mirror. The cavity parameters of a typical small 633-nm *HeNe* laser are $d=27$ cm and $R=30$ cm. Thus the beam radius at the flat mirror is 135 $\mu$m. Over such a small region all of the glasses in Table I ought to be suitable flat mirror substrates.

To verify this, 2- and 3-inch square samples of window glass and float glass were coated with 633-nm high-reflectivity dielectric coatings. They were tested in a *HeNe* laser cavity with $R=67.5$ cm. The flat, coated-glass mirrors were placed at variable distances from the curved mirrors, and aligned perpendicular to the axis of the laser. Lasing was then observed, and the structure continued to lase, without further adjustment, when the flat mirror surface was translated sideways so that the flat-end mirror spot was effectively scanned across the entire 2 to 3-inch face of this mirror. Laser cavity lengths as short as 49.7 cm were successfully used; this figure corresponds to a beam radius at the flat mirror of 245 $\mu$m. The laser output powers observed with these large glass sheet mirrors were identical to those seen under comparable geometries with commercial laser mirrors in the same cavity. Thus the surface quality of these substrates is adequate for their use as flat *HeNe* resonator mirrors as well as beam-directing mirrors.

**Table I — Properties of commercial glass types.**

| *Type* | *Thickness (in.)* | *Large-area flatness (waves/inch)* | *Small-area flatness* |
|---|---|---|---|
| Microscope slide | 0.06 | 6 | No discernible fringe curvature over 500 $\mu$m |
| PPG double-strength window glass | 0.13 | 4 | " |
| PPG float* glass | 0.25 | 2 to 3 | " |

*It should be noted that often the terms *float* and *plate glass* are confused and used synonymously by glass suppliers. Float glass is produced by floating the soft glass on molten tin, so that one glass surface contacts only air and the other only liquid tin. A simple test to identify float glass is to observe its fluorescence under uv radiation; the tin side of float glass fluoresces strongly.

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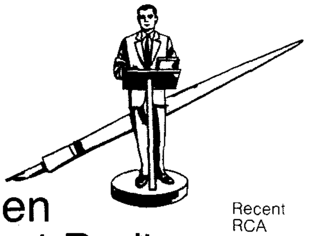

# Pen and Podium

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**ION SCATTERING SPECTROMETRY Below 10 keV** — R.E. Honig, W.L. Harrington ((Labs, Pr) Intl. Conf. on Ion Beam Surface Layer Analysis, IBM Research Center, Yorktown Heights, N.Y.; 6/20/73

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## 170 Manufacturing and Fabrication

production techniques for materials, devices and equipment.

**ELECTROLESS PLATING PROCESSES, Polarization Studies in** — N. Feldstein (Labs, Pr) The Electrochemical Soc., Philadelphia Section, Drexel Univ.; 6/5/73

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value analysis, reliability analysis, standards for design and production.

**PRODUCT INTEGRITY Through Design** — A.C. Spear (ASD, Burl) ASQC Conf., Cleveland; 5/23/73

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**INTEGRITY OF PRODUCTS, Feedback Systems for Improving the** — G.F. Fairhurst (EASD, Van Nuys) ASQC 27th Annual Conf., Cleveland, OH; 5/21-23/73

**PROJECT Management - Future Developments** — M.W. Buckley (MSRD, Mrstn) Meeting Chairman and Lecturer at AMA Seminar in New York City; 4/30-5/3/73

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## 220 Energy and Power Sources

batteries, solar cells, generators, reactors, power supplies.

**SOLAR CELLS, Temperature Dependence of Damage Coefficient in Electron Irradiated** — T. Faith (AED, Pr) IEEE Conf. on Nuclear and Space Radiation Effects, Logan, Utah; 7/23-26/73

## 225 Antennas and Propagation

antenna design and performance; feeds and couplers, phased arrays; randomes and antenna structures; electromagnetic wave propagation, scatter, effects of noise.

**ELECTRO-MAGNETIC COMPATIBILITY, AEGIS Design and Evaluation for** — M. Kant (MSRD, Mrstn) 1973 IEEE Intl Symp. on Electromagnetic Compatibility, New York Hilton, N.Y.; 6/20/73

**PHASE SHIFTER, Low Drain** — A. Schwartzmann (MSRD, Mrstn) IEEE Microwave Components for Phase Arrays Systems, Boulder, Colorado; 6/7/73

**PHASE SHIFTERS for Shipboard Use, S-band Ferrite** — N.R. Landry (MSRD, Mrstn) IEEE Microwave Components for Phased Array Systems (Workshop) 6/7/73

## 240 Lasers, Electro-Optical and Optical Devices

design and characteristics of lasers, components used with lasers, electro-optical systems, lenses, etc. (excludes: masers).

**ACOUSTIC IMAGING with Thin Annular Apertures —** D. Vilkomerson (Labs, P) 5th Intl. Symp. on Acoustical Holography, Palo Alto, Calif.; 7/18-20/73

**ACOUSTO-OPTIC DEFLECTORS, New Results on Broadband —** G.A. Alphonse (Labs, Pr) P.S.G. College of Technology, Phys. Dept. Coinbatore, India,; 7/12/73

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**IMAGE TUBE in Ultra High-Speed Frame and Streak Photography —** R.W. Engstrom, R.W. Fitts (EC, Har) SPIE 17th Annual Technica Mtg. and Equipment Display, San Diego, Calif.; 8/27-29/73

**INFORMATION STORAGE, The Laser, Holography and —** G.A. Alphonse (Labs, Pr) Inst. of Engineers, Hyderabad, India; 7/4/73 and India Intl. Cntr., New Delhi,; 7/9/73

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**LASERS, Modes of Wide Injection —** H.S. Sommers, Jr. (Labs, Pr) 1973 Device Research Conf., Boulder, Co.; 6/26-28/73

**NEGATIVE ELECTRON AFFINITY EMITTERS, Pickup Tubes and Display Devices with —** E.S. Kohn (EC, Har) Meeting of New England Chapter, Society for Information Display and Soc. for Photographic Scientists and Engineers, Boston, Mass.; 5/16/73

**OPTICAL WAVEGUIDE Modulation Using Nematic Liquid Crystal —** D.J. Channin (Labs, Pr) Appl. Phys. Lett., Vol. 22, No. 8, pp. 365-366; 4/15/73

**PbO VIDICON, An Approximate Model of the Beam Blocking Contact in a —** A.M. Goodman (Labs, Pr) IEEE Device Research Conf., Boulder, Co.; 6/26-28/73

**PHOTOEMITTERS, Conventional and Negative Electron Affinity —** A.H. Sommer (EC, Har) *Congres due Centenaire de la Societe Francaise de Physique*, Vittel, France; 5/28-6/2/73

**PHOTOMULTIPLIERS for Liquid Scintillation Counting, Recent Developments in —** D.E. Persyk, T.T. Lewis (EC, Har) Symp. on Liquid Scintillation Counting, Brighton, England; 9/3-6/73

**SEMICONDUCTOR LASERS Pumped by a Pulsed Electric Discharge in Vacuum —** F.H. Nicoll (Labs, Pr) *Appl. Phys. Lett.*, Vol. 22, No. 8, 363-364; 4/15/73

## 245 Displays

equipment for the display of graphic, alphanumeric, and other data in communications, computer, military, and other systems, CRT devices, solid state displays, holographic displays, etc.

**MAGNETOELECTRIC PRINTING —** E.C. Giaimo, Jr. (Labs, Pr) *RCA Review*, Vol. 34, No. 1, pp. 112-1120; 3/73

**PAGE COMPOSER, A Membrane —** L.S. Cosentino, W.C. Stewart (Labs, Pr) *RCA Review*, Vol. 34, No. 1, pp. 45-79; 3/73

## 250 Recording Components and Equipment

disk, drum, tape, film, holographic and other assemblies for audio, image, and data systems.

**HOLOTAPE, Holographic Motion Pictures for TV Playback —** R.A. Bartolini (Labs, Pr) IEEE/OSA Conf. on Laser Engineering and Applications, Washington, D.C.; 6/73

**VIDEO RECORDING Standard, A New Compatible —** A.C. Luther (CSD, Cam) Wireless World, London; or TV Mail in London

## 280 Thermal Components and Equipment

heating and cooling components and equipment, thermal measurement devices, heat sinks.

**FOIL INSULATED SiGe CONVERTERS, Thermal Performance of —** R.R. Lorentzen (EC, Har) IECEC Mtg., Philadelphia, Pa.; 8/12-17/73

**FOIL INSULATED SiGe Thermoelectric Devices, Dynamic Performance of —** R.D. McLaughlin (EC, Har) IECEC Mtg., Philadelphia, Pa.; 8/12-17/73

**MHW CONVERTER, Performance Models for the —** R.R. Lorentzen (EC, Har) IECEC Mtg., Philadelphia, Pa.; 8/12-17/73

**SiGe THERMOELECTRIC Properties, Updated —** A. Amith (EC, Har) IECEC Mtg., Philadelphia, Pa.; 8/12-17/73

## 305 Aircraft and Ground Support

airborne instruments, flight control systems, air traffic control, etc.

**RADAR Processing, Digital Step Transform Approach to Airborne —** R.P. Perry, H.W. Kaiser (MSRD, Mrstn) NAECON 1973, Dayton, Ohio; 6/14-16/73

## 310 Spacecraft and Ground Support

spacecraft and satellite design, launch vehicles, payloads, space missions, space navigation.

**ATMOSPHERE EXPLORER Spacecraft, Dynamic Analysis of the —** W.W. Metzger, R.A. Kenny (AED, Pr) I.C.E.S. User's Group Conf., St. Louis, Mo.; 6/15/73

## 312 Land and Water Transportation

navigation systems, automotive electronics, etc.

**AUTOMATIC BRAKING that is Immune to Blinding and Clutter, A Radar Sensor for —** H. Staras, J. Shefer, R.J. Klensch, H.C. Johnson (Labs, Pr) Brighton Microwave Conf., Brighton, England; 6/19/73

**AUTOMOTIVE COMPUTER (Panel Discussion) —** G.B. Herzog (Labs, Pr) Natl. Computer Conf. & Expo.; New York City; 6/7/73

**ELECTRONICS, Driving Under the Influence —** A.S. Clorfeine (Labs, Pr) *IEEE Spectrum*, Vol. 10, No. 5, pp. 32-37; 5/73

**HARMONIC RADAR Helps Autos Avoid Collisions —** J. Shefer, R.J. Klensch (Labs, Pr) *IEEE Spectrum*, Vol. 10, No. 5, pp. 38-45; 5/73

**SATELLITE SYSTEMS for Civilian Vehicle Traffic Control —** B.P. Miller (AED, Pr) AIAA/ASME/SAE Joint Mission Planning and Execution Mtg., Denver, Colo; 7/10-12/73

## 315 Military Weapons and Logistics

missiles, command and control.

**INDUSTRIAL LOGISTICS Management —** J.W. Hurley (MSRD, Mrstn) Joint Penn State College, Phila. Chapter Soc. of Logistics Engineers, One-day Seminar; 6/7/73

## 320 Radar, Sonar, and Tracking

microwave, optical, and other systems for detection, acquisition, tracking, and position indication.

**DOPPLER SENSOR, Solid State Null Tracking —** J.W. Cruetz, Dr. L. Weinberg (MSRD, Mrstn) National Aerospace Electronics Conf., Dayton, Ohio; 5/14-16/73

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## 325 Checkout, Maintenance, and User Support

automatic test equipment, (ATE), maintenance and repair methods.

**DIAGNOSTIC Instrumentation for Military Vehicles —** N.A. Teixeira (ASD, Burl) SAE Meeting, Chicago; 6/18-22/73; *Proceedings*

## 340 Communications

industrial, military, commercial systems, telephony, telegraphy and telemetry, (excludes: television, and broadcast radio).

**COMMERCIAL RECEIVERS, Necessary Bandwidth and Receiver Characteristics of —** E.M. Leyton (Labs, Pr) Intl. Telecommunications Union Seminar, Sao Paulo, Brazil; 6/73

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**QUADRIPHASE MODEM, A Variable Data Rate Multimode —** R.W. Allen, B.H. Batson (CSD, Cam) Int'l Conf. on Communications, Seattle, Washington, Proc., Vol. 2, Pages 3718-25; 6/11-13/73

**TDMA SYSTEM DESIGN for Small Satellite Terminals —** J.R. Allen (CSD, Cam') Intl. Conf. on Communications, Seattle, Washington; Proc. Vol. 2, p. 4912/11-13/73

## 345 Television and Broadcast

television and radio broadcasting, receivers, transmitters, and systems, television cameras, recorders, studio equipment.

**COLOR TELECINE CAMERAS, New Developments in —** J.J. Clarke, L.J. Bazin (CSD, Camden) 1973 Intl. TV Symp. & Tech. Exhib., Montreux, Switzerland; 5/18-24/73

**LIGHT CONTROL System, The TK-28 Telecine Camera —** H.G. Seer, Jr., L.J. Bazin (CSD, Camden) SMPTE 113th Tech. Conf. and Equipment Exhibit, Chicago, Illinois; 4/10/73

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## 355 Business and Industrial Systems

point of sale systems, test equipment, (etc).

**A STORE that has been using Electronic Product Information Since July 1972 (Case Study) —** T.A. Beshaw (ASD, Burl) AMA National Packaging Conf., Chicago; 5/9/73

## 360 Computer Equipment

processors, memories, and peripherals.

**CACHE-Based Computer Systems —** K.R. Kaplan, R.O. Winder (Labs, Pr) *Computer Mag.*, pp. 30-36, Vol. 6, No. 3; 3/73

**DATA STORAGE AND RETRIEVAL Device for Aircraft —** P.L. Nelson, R.H. Norwalt (EASD, Van Nuys) sid Intl. Symp., New York, NY; 5/15-17/73

**HOLOGRAPHIC MEMORY, An Experimental Read-Write —** W.C. Stewart, R.S. Mezrich, L.S. Cosentino, E.M. Nagle, F.S. Wendt, R.D. Lohman (Labs, Pr) *RCA Review*, Vol. 34, No. 1, pp. 3-44; 3/73

**MEMORY HIERARCHIES, Asymmetric —** J.G. Williams (Labs, Pr) *Communications of the ACM*, Vol. 16, No. 4, pp. 213-222; 4/73

**MICRO-CPU Project —** R.O. Winder (Labs, Pr) IEEE Computer Devices Subcommittee Workshop on Microprocessor, Vail, Co.; 6/25-28/73

**PROCESSOR, A Partitioned Ring Structure —** L.J. French (Labs, Pr) Design Automation Workshop, Portland, Oregon; 6/73

## 365 Computer Programming and Applications

languages, software systems, and general applications (excluding: specific programs for scientific use).

**TACTICAL EXECUTIVE PROGRAMS?, What's Different About —** W.G. Phillips, Jr. (MSRD, Mrstn) National Computer Conf. and Exposition, New York, NY; 6/8/73

## 380 Graphic Arts and Documentation

printing, photography, and typesetting; writing, editing, and publishing; information storage, retrieval, and library science.

**GRAPHICS in Relation to College Training —** A.T. Farrell (ASD, Burl) American Institute of Designers and Draftsmen, Philadelphia; 4/19/73

**TECHNICAL REPORT, Preparing the —** D.R. Higgs (MSRD, Mrstn) RPI Technical Writers' Institute, Troy, New York; 6/12/73

**WORD PROCESSING, Making it Work for You —** B. Piscopo (ASD, Burl) *Reproductions - Review and Methods'* 6/73

## Author Index

Subject listed opposite each author's name indicates where complete citation to his paper may be found in the subject index. An author may have more than one paper for each subject category.

### Astro Electronics Division



### Aerospace Systems Division



### Communications Systems Division



### Electromagnetic and Aviation Systems Division



### Electronic Components



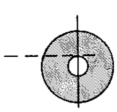
### Missile and Surface Radar Division



### Laboratories



# Patents Granted



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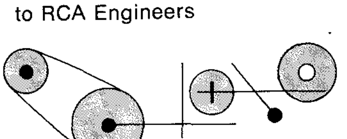

As reported by RCA Domestic Patents, Princeton

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### Astro-Electronics Division

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**Anti-Condensation Device for Infra-Red Detector —** R. J. Williams (AED, Hghtsn.) U.S. Pat. 3746873, July 17, 1973

### Aerospace Systems Division

**Spatial Discrimination System for Use with Pulsed Optical Energy and Television Pick-up Tubes —** M. J. Cantella and M. W. Stewich (ASD, Burl.) U.S. Pat. 3731892, May 8, 1973; Assigned to U.S. Government

**Vibrating Web Transport Apparatus —** P. Debruyne (ASD, Burl.) U.S. Pat. 3731317, May 1, 1973

### Missile & Surface Radar Division

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**Bus Bar with Integral Terminal —** J. T. Gorman (MSRD, Mrstn.) U.S. Pat. 3740693, June 19, 1973

### Electromagnetic and Aviation Systems Division

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### Government Engineering

**Two Phase Logic Circuit —** W. F. Gehweiler (ATL, Cam.) U.S. Pat. 3731114, May 1, 1973

**Maser Incorporating Crystal Having F-Centers —** C. H. Anderson, B. R. Feingold, E. S. Sabisky (ATL, Cam.) U.S. Pat. 3736518, May 29, 1973

**Self Loaded Uneven Power Divider —** A. Schwarzmann (MSRD, Mrstn.) U.S. Pat. 3742392, June 26, 1973

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**M-Ary FSK Digital Modulator —** L. P. Nahay (CSD, Cam.) U.S. Pat. 3740669, June 19, 1973

### Palm Beach Division

**Document Picker —** J. P. Watson (Palm Beach Div., PBG) U.S. Pat. 3735976, May 29, 1973

**Wire Stripping Apparatus and Method** — R. V. Tompkins (Palm Beach Div., PBG) U.S. Pat. 3739818, June 19, 1973

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**Automatic Wear Compensating Mechanism** — E. H. Del Rio (Palm Beach Div., PBG) U.S. Pat. 3746231, July 17, 1973

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**Grounded Faceplate Kinescope System** — R. F. Sanford (Labs, Pr.) U.S. Pat. 3730991, May 1, 1973

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**Power Control System Employing Piezo-Ferroelectric Devices** — J. H. McCusker, S.S. Perlman (Labs., Pr.) U.S. Pat. 3740582, June 19, 1973

**Television Frame Storage Apparatus** — D. P. Dorsey (Labs, Pr.) U.S. Pat. 3740465, June 19, 1973

**Method of Making Semiconductor Device** — R. S. Ronen (Labs., Pr.) U.S. Pat. 3740280, June 19, 1973

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**Electrically and Optically Accessible Memory** — J. A. Rajchman, W. F. Kosonocky (Labs., Pr.) U.S. Pat. 3742464, June 26, 1973

**Method of Depositing an Epitaxial Semiconductor Layer From the Liquid Phase** — H. F. Lockwood, M. Ettenberg (Labs., Pr.) U.S. Pat. 3741825, June 26, 1973

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**Semiconductor Injection Laser** — H. Kressel, F. Z. Hawrylo (Labs., Pr.) U.S. Pat. 3747016, July 17, 1973

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**Electronic Fence Vehicle Locator Transmitter and System Using Same** — G. S. Kaplan, J. Shefer (Labs., Pr.) U.S. Pat. 3735335, May 22, 1973

**Protected Thermoelectric Elements and Method of Protecting Same** — I. Kudman, C. M. Schmelz (Labs., Pr.) U.S. Pat. 373345, June 5, 1973

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**Vertical Convergence Circuits Uitlizing Positive Feedback for Stabilization** — C. J. Hall (Labs., Pr.) U.S. Pat. 3748525, July 24, 1973

## Electronic Components

**Method and Article for Color Kinescope Screen and Mask Production** — H. B. Law (Lab., Pr.) U.S. Pat. 3730719, May 1, 1973

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**Transcalent Semiconductor Device** — S. W. Kessler, Jr. (EC, Lanc.) U.S. Pat. 3739235, June 12, 1973

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**Ganged Ring Magnets for Coordinated Control of a Plurality of Beams** — J. L. Werst (EC, Lanc.) U.S. Pat. RE27698, July 17, 1973

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**Electronic Device Package** — R. L. Buttle, W. D. Bailey (SSD, Som.) U.S. Pat. 3730969, May 1, 1973

**Radio Frequency Transistor Employing High and Low-Conductivity Base Grids** — H. S. Veloric (SSD, Som.) U.S. Pat. 3736478, May 29, 1973

**Switching Regulator Overload Protection Circuit** — D. M. Baugher, K. W. Awkward (SSD, Som.) U.S. Pat. 3736469, May 29, 1973

**Method of Making a Semiconductor Device** — A. Laker (SSD, Som.) U.S. Pat. 3738880, June 12, 1973

**Liquid Crystal Display** — R. C. Heuner, S. J. Niemiec, D. K. Morgan (SSD, Som.) U.S. Pat. 3740717, June 19, 1973

**Transistor Employing Variable Resistance Ballasting Means Dependent on the Magnitude of the Emitter Current** — D. R. Carley (SSD, Som.) U.S. Pat. 3740621, June 19, 1973

**Voltage Supplies** — W. F. Dietz (SSD, Som.) U.S. Pat. 3740474, June 19, 1973

**Frequency Divider** — S. S. Eaton, Jr. (SSD, Som.) U.S. Pat. 3742248, June 26, 1973

**Circuit for Driving Frequency Standard Such as Tuning Fork** — G. W. Steudel (SSD, Som.) U.S. Pat. 3743960, July 3, 1973

**Reference Voltage Generator and Regulator** — G. W. Steudel (SSD, Som.) U.S. Pat. 3743923, July 3, 1973

**Insulated Gate Field-Effect Transistor with Variable Gain** — J. A. Olmstead (SSD, Som.) U.S. Pat. 3745426, July 10, 1973

**Illumination Activated Transistor Relaxation Oscillator** — A. J. Visioli, Jr., H. A. Wittlinger (SSD, Som.) U.S. Pat. 3748591, July 24, 1973

## Consumer Electronics

**Horizontal Oscillator Control for Plural Operating Mode Television Receivers** — D. H. Willis (CE, Indpls.) U.S. Pat. 3740489, June 19, 1973

**Width Control Circuit for a Television Receiver** — W. V. Fietzgerald, Jr. (CE, Indpls.) U.S. Pat. 3740472, June 19, 1973

**Automatic Chroma Gain Control System** — L. A. Harwood (CE, Som.) U.S. Pat. 3740462, June 19, 1973

**Detector Circuits with Self-Referenced Bias** — L. A. Harwood (CE, Som.) U.S. Pat. 3740461, June 19, 1973

**Electronic Signal Processing Circuit** — L. A. Harwood (CE, Som.) U.S. Pat. 3740456, June 19, 1973

**Video Amplifiers** — D. H. Willis (CE, Indpls.) U.S. Pat. 3742376, June 26, 1973

**Amplitude Control Circuits** — R. D. Altmanshofer (CE, Indpls.) U.S. Pat. 3742126, June 26, 1973

**Automatic Tuning Control Circuits** — T. A. Bridgewater (CE, Indpls.) U.S. Pat. 3743944, July 3, 1973

**Electronic Phase Shifting Apparatus** — E. J. Wittmann (CE, Som.) U.S. Pat. 3743764, July 3, 1973

**Recording Web Guide Apparatus** — H. R. Warren (CE, Indpls.) U.S. Pat. 3744696, July 10, 1973

## Parts and Accessories

**Antenna Structures** — J.D. Callaghan (P&A, Deptford) U.S. Pat. 3739388, June 12, 1973

**Adapter for Coaxial Cable Connector** — J. D. Callaghan, R. M. Wilson (P&A, Deptford) U.S. Pat. 3740453, June 19, 1973

**Indoor Antenna or Similar Article** — J. D. Callaghan, R. Kaysen (P&A, Deptford) U.S. Pat. D227902, July 24, 1973

## RCA Limited

**Method for Separating Chemically-Oxidizable Phosphor Particles from Mixtures with Essentially Nonoxidizable Phosphor Particles** — R. B. Platt, B. B. McCue (Ltd., Midland, Canada) U.S. Pat. 3740342, June 19, 1973

**Protective Switching Circuit for Providing Power to a Load from an Alternating Current Source Having Peak-to-Peak Excursions within or above a Given Range** — H. J. Digneffe (Ltd., Belgium) U.S. Pat. 3742337, June 26, 1973

## Electronic Industrial Engineering, Inc.

**Channel Monitoring System** — J. R. Thompson, R. L. Schoenbeck (EIE, Hollywood) U.S. Pat. 3733430, May 15, 1973

## Patents & Licensing

**Conversion of Base B Number to Base R Number, Where R is a Variable** — C. M. Wright (Pat. & Lic., Cherry Hill) U.S. Pat. 3738412, May 29, 1973

## Special Contract

**Enclosure for a Radio or Television Antenna** — R. Kaysen (Special Contract Inv.) U.S. Pat. D227785, July 17, 1973

# Dates and Deadlines

**As an industry leader, RCA must be well represented in major professional conferences . . . to display its skills and abilities to both commercial and government interests.**

**How can you and your manager, leader, or chief-engineer do this for RCA?**

**Plan ahead! Watch these columns every issue for advance notices of upcoming meetings and "calls for papers". Formulate plans at staff meetings—and select pertinent topics to represent you and your group professionally. Every engineer and scientist is urged to scan these columns; call attention of important meetings to your Technical Publications Administrator (TPA) or your manager. Always work closely with your TPA who can help with scheduling and supplement contacts between engineers and professional societies. Inform your TPA whenever you present or publish a paper. These professional accomplishments will be cited in the "Pen and Podium" section of the *RCA Engineer*, as reported by your TPA.**

## Calls for papers—be sure deadlines are met.

**Ed. note:** Calls are listed chronologically by meeting date. Listed after the meeting title (in bold type) are the sponsor(s), the location, and the deadline information for submittals.

FEB. 13/15, 1974 **IEEE International Solid-State Circuits Conference** — Philadelphia Marriott Motor Hotel. **Deadline info:** (A&S) 10/1/73 **to** G. A. Alphonse, RCA Corporation Princeton, N.J. 08540

MARCH 26/29, 1974 **IEEE International Conventional Convention (INTERCON)** — Coliseum & Statler Hilton Hotel, New York, N.Y., IEEE **Deadline info:** (A&S) 8/10/73 **to** J. H. Schumacher, IEEE, 345 E. 47th St., New York, N.Y. 10017

APR. 16/18, 1974 **Optical and Acoustical Micro-Electronics** — New York, N.Y. G-MTT, G-SU, PIB, **Deadline info:** (abst) 12/1/73 **to** M.R.I. Symp. Comm., 333 Jay St., Brooklyn, N.Y. 11201

APR. 21/25, 1974 **Int'l Circuits & Systems Theory Symposium** — S-CAS, et al, Sir Francis Drake Hotel, San Francisco, Calif. **Deadline info:** (ms) 10/15/73 **to** L. O. Chua, Dept. of EE, Univ. of Calif., Berkeley, Calif. 94720.

APR. 22/26, 1974 **1974 European Conference on Electrotechnics (EUROCON)** — IEEE, Reg. 8 and Convention of Nat'l Soc. of Engrs. in Western Europe, Amsterdam, The Netherlands. **Deadline info:** (abst) 10/15/73 300-500 word threefold **to** EUROCON '74 Office, Local Secretary: Ing. G. Gaikhorst, c/o F.M.E., Massaulaan 13, the Haugue, the Netherlands.

APR. 29/May 1, 1974 **SOUTHEASTCON-IEEE Inventing the Model of the Future** — Sheraton-Towers Convention Center, Orlando, Florida **Deadline info:** 10/15/73 (submit 4 copies 50-word abstract, 250-500 word summary, resume) **to** Technical Program Chairman Dr. Bruce E. Mathews Electrical Engineering Department, Florida Technological University, Box 25000, Orlando, Florida 32816

MAY 20/23, 1974 **1974 International Symposium on Subscriber Loops and Services** — Comm. Soc. of the IEEE Can. Dept. of Comm. & Bell-Northern Res., Ottawa, Canada. **Deadline info:** (abst) 7/1/73 (papers) 12/15/73 **to** General Chairman: Mr. Alex Curran, Bell-Northern Research, P.O. Box 3511, Station C. Ottawa, Canada

JUNE 10/13, 1973 **G-AP Symp. and USNC/URSI Meeting** — Georgia Inst. of Tech., Atlanta, Georgia, G-AP, URSI. **Deadline info:** (ms) 2/4/74 **to** R.C. Johnson, Georgia Inst. of Tech., Engrg. Exp. Sta., Atlanta, Georgia 30332

JULY 1/5, 1973 **Precision Electromagneic Measurements Conference** — IEEE, London, England, Royal Soc., IEE, IERE, G-IM et al. **Deadline info:** (abst) 10/31/73 **to** 1974 CPEM Secretariat c/o Conf. Dept. IEE, Savoy P1., London WC2R OBL England

JULY 14/19, 1973 **IEEE Power Engineering Society Summer Meeting** — S-PE, Disneyland Hotel, Anaheim Conv. Ctr., Anaheim, Calif. **Deadline info: (ms) 2/1/74 to** S. H. Gold, Southern Calif. Edison Co., POB 800, Rosemead, Calif. 91770.

JULY 15/19, 1974 **Frontiers in Education** — IEEE, IEEE G-Ed, IEEE United Kingdom and Rep. of Ireland Sect., IEE Ed. and Management Div., ASEE-Ed Res. & Methods Div. City University, London, England. **Deadline info:** (papers) 10/5/73 (250-word syn) **to** 1974 Frontiers in Education Secretariat, c/o The Conference Department, The Institution of Electrical Engineers, Savoy Place, London, England WC2R OBL **and** Lindon E. Saline, Manager, Corporate Education Services, General Electric Company, Crotonville, PO Box 151, Ossinging, NY 10562 USA

AUG. 26/30, 1974 **Electronics Conference New Zealand (INTERELCON NZ)** — Univ. of Auckland, Auckland, New Zealand, New Zealand Sec., New Zealand Nat'l Soc. et al **Deadline info:** (abst) 12/15/73 **to** D.R. Hutt, IEEE N.Z. Section, POB 6291, Auckland, New Zealand

SEPT. 8/12, 1974 **Jt. Power Generation Tech. Conference** — Deauville Hotel, Miami Beach, Florida, S-PE, ASME, ASCE, **Deadline info:** (ms) 4/26/74 **to** J. J. Heagerty, Gen'l Elec. Co., POB 2830, Terminal Annex, L.A., Calif. 90051

**Ed. Note:** Meetings are listed chronologically. Listed after the meeting title (in bold type) are the sponsor(s), the location, and the person to contact for more information.

SEPT. 17/19, 1973 **Electric & Aerospace Systems Convention (EASCON)** — Twin Bridges Marriott, Washington, DC 8 S-AES, Washington Section. **Prog info:** L. R. Kilty, Fairchild Ind., Germantown, Maryland.

SEPT. 17/19, 1973 **Electro-Optical Systems Design Conference (EOSD)** — SPSE Washington, D.C. 20005, New York Coliseum, New York City. **Prog info:** Society of Photographic Scientists and Engineers, 1330 Massachusetts Ave., N.W. Washington, D.C. 20005

SEPT. 17/19, 1973 **Western Applied Mechanics Conference, Problems in Earthquake Engineering** — ASME, Menlo Park, Ca **Prog info:** Maurice Jones, Manager, Information Services, ASME 212-752-6800 Exts. 748/760

SEPT. 18/19, 1973 **Modulator Symposium**— G-ED, U.S. Army, United Engrg. Ctr., New York, N.Y. **Prog info:** S. Schneider, USAEC; Fort Monmouth, N.J. 07703

Sept. 18/21, 1973 **European Solid State Device Research Conference.** — Munich, Germany, Region 8, EPS, DPG, NTG **Prog info:** H. Weib, Siemens AG, Forschungs laboratorium, D-8000, Munich 80, Balanstr 73 Germany

SEPT. 19/20, 1973 **WFEO Conference on Environmental Engineering in Industrialized and Developing Countries** — United Engineering Center, New York, N.Y. **Prog info:** Marian Herrick, IEEE, 345 E. 47th St., New York, N.Y. 10017.

SEPT. 19/21, 1973 **Joint Materials Handling Conference,** ASME, IEEE, Amer. Inst. of Mining Engineers, Soc. of Packaging & Handling Engineers, Pittsburgh, Pa. **Prog info:** H. Colijn, Consultant Engineer, 423 Franklin Hgts. Dr., Monroeville, Pa. 15146

SEPT. 19/22, 1973 **Fall Meeting of the American Ceramic Society, Structural Clay Prod. Div.** — TraveLodge at 6th South, Salt Lake City, Utah, **Prog info:** The American Ceramic Society, Inc., 65 Ceramic Drive, Columbus, OH 43214.

SEPT. 20/21, 1973 **Broadcast Symposium, Washington Hotel, Washington, D.C. Prog info:** R. M. Morris, 60 Sunset Lake Rd., RD 1, Sparta, N.J. 07871

SEPT. 20/21, 1973 **COLOR: Theory and Imaging Systems** — SPSE, New York Sheraton, New York City. **Prog info:** Society of Photographic Scientists and Engineers, 1330 Massachusetts Ave., N.W. Washington, D.C. 20005

SEPT. 23/26, 1973 **Fall Meeting of the American Ceramic Society,** Basic Science and Ceramic-Metal Systems Div. — William Penn Hotel, Pittsburgh, PA. **Prog info:** The American Ceramic Society, Inc.; 65 Ceramic Drive, Columbus, OH 43214

SEPT. 24/27, 1973 **Intersociety Conference on Transportation** — ASME, et. al. Brown, Palace Hotel, Denver, Colorado. **Prog info:** Ms. Marion Churchill, Manager, Conferences and Divisions, ASME, 345 E. 47th St., New York, NY 10017

SEPT. 25/26, 1973 **Electronic Security Systems Seminar** — IEEE, Statler Hilton Hotel, New York, NY. **Prog info:** Howard Schumacher, IEEE, 345 E. 47th Street, New York, NY. 10017

SEPT. 25/28, 1973 **Automatic Control in Glass** — IFAC, Purdue University, West Lafayette, Indianna. **Prog info:** Purdue University, Div. of Conf. and Continuation Svcs., West Lafayette, IN 47907.

SEPT. 25/28, 1973 **Engineering in the Ocean Environment Conference,** Washington Plaza Hotel, Seattle, Washington, IEEE Oceanography Comm., Seattle Section **Prog info:** Gil Raudsep, Honeywell Inc., 5303 Shilhole Ave., N.W., Seattle, Wash. 98107

SEPT. 30/OCT. 4, 1973 **Electrical/Electronics Insulation Conference** — Palmer House, Chicago, Ill. G-EI, E-MTT, NEMA, NAVSEC **Prog info:** NEMA, 155 E. 44th St. New York, N.Y. 10017

SEPT. 30/OCT. 4, 1973 **Engineering in Medicine & Biology Conference** — Leamington Hotel, Minneapolis, Minn., G-EMB, AEMB **Prog info:** Anthony Sances, Medical Coll. of Wisconsin, 8700 W. Wisconsin Ave., Milwaukee, Wisconsin 53226

OCT. 1/3, 1973 **International Electrical, Electronics Conference** — Automotive Bldg., Exposition Park, Toronto, Canada, IEEE Canadian Region. **Prog info:** N. Coxall, 1450 Don Mills Rd., Don Mills 404, Ontario, Canada

OCT. 3/4, 1973 **Semiconductor Memory Testing Symposium** — Rickshaw Inn, Cherry Hill, New Jersey, S-C **Prog info:** J. R. Brown, Burroughs Corp., S. Randolphfield Rd., Piscataway, N.J. 08854

OCT. 8/10, 1973 **National Electronics Conference,** Regency Hyatt O'Hare, Chicago, Illinois, IEEE Region IV, et. al. **Prog info:** Roger Camp, EE Dept., Iowa State Univ., Ames, Iowa 50610

OCT. 8/11, 1973 **Industry Applications Society Annual Meeting** — Pfister Hotel, Milwaukee, Wisc., A-IA, Milwaukee Section. **Prog info:** G. W. Younkin, 142 Doty St., Fond du Lac, Wisc. 54935

OCT. 15/17 1973 **Switching & Automata Theory** — Univ. of Iowa, Iowa City, Iowa, S-C, **Prog info:** General Weeg, Computer Sci. Dept., Univ. of Iowa, Iowa City, Iowa 52240

OCT. 19, 1973 **Process Control Techniques in the Photographic Industry** — Sheraton LaGuardia Hotel, New York, N.Y. SPSE. **Prog info:** Society of Photographic Scientists and Engineers, 1330 Massachusetts Ave., N.W. Washington, D.C. 20005

OCT. 23/25, 1973 **Radar — Present and Future** — IEE, London, England, IEE, IEEE UKRI Seciton, et. al. **Prog info:** IEE, Savoy Place, London W.C. 2R OBL England

OCT. 24/27, 1973 **Second International Conference on Electrophotography** — Marriott Twin Bridges Hotel, Washington, D.C. SPSE. **Prog info:** Society of Photographic Scientists and Engineers, 1330 Massachusetts, N.W., Washington, D.C. 20005

OCT. 25/26, 1973 **Joint Engineering Management Conference** — St. Petersburg Hilton, St. Petersburg, Florida, G-EM et. al. **Prog info:** H. P. Howard, RCA Astro Elec. Div., PO 800, Princeton, N.J. 08540

NOV. 11/15, 1973 **ASME 1973 Winter Annual Meeting and Forum on "Safety — The Engineers's Challenge",** Statler Hilton and Sheraton Cadillac Hotels, Detroit, Michigan **Prog info:** Maurice Jones, Manager Information Services, ASME, 212-752-6800 Exts. 748/760

# Engineering News and Highlights

## Promotions

**AstroElectronics Division**

**E. M. O'Brien** from Senior Member, Technical Staff to Mgr., Design Engineering (R. J. Monis, Hightstown).

**A. F. Dirsa** from Senior Member, Technical Staff to Mgr., Design Engineering (D. J. Cushing, Hightstown)

**J. J. Harrison** from Senior Project Member, Technical Staff to Mgr., Design Engineering (G. B. Harmon, Hightstown)

J. **Hallal** from Senior Project Member, Technical Staff to Mgr., Project Engineering (R. P. Daly, Hightstown).

**RCA Service Company**

**J. O. Cain, Jr.** from Ldr., Engineers to Mgr., Signature Systems Processing (H. C. Henry, PAFB, Florida).

**Solid State Division**

**F. N. Jones** from Engr. to Engineering Ldr., Product Development (E. M. McElwee, Somerville).

**Electromagnetic and Aviation Systems Divison**

**G. Benedict** from Staff Engineering Scientist to Manager D&D Engineering (H. Hite, Van Nuys).

**Solid State Division**

**J. D. Young** fromEngr. Manufacturing to Ldr. Technical Staff (R. E. Savey, Findlay).

**R. B. Tyler** from Engr., Manufacturing to Mgr., Quality and Hi-Rel Engineering (J. C. LaBerge, Findlay).

**Missile and Surface Radar Division**

**C. Tietz** from Ldr., Engrg. Sys. Proj. to Mgr., TRADEX Site (L. Nelson, Moorestown).

**Communications Systems Division**

**J. O. Sheldahl** from Princ. Mbr. to Ldr. Engineering Staff (D. T. Gross, Camden)

**R. N. Van Delft** from Princ. Mbr. to Ldr., Engineering Staff (J. B. Howe, Camden)

**W. A. Clapp** from Ldr., Engr. Staff to Mgr., Applied Compt. Sys. Lab. (P. E. Wright, Camden)

**Solid State Division**

**S. Mattei** from Member to Leader, Technical Staff (T. Lally, Mountaintop)

**L. Zampetti from** Leader, Technical Staff to Manager, Epi Base Manufacturing (C. Turner, Mountaintop)

**RCA Global Communications, Inc.**

**A. A. Avanessians** from Mgr. to Director, Computer Engineering Projects (P. Schneider, New York)







## Professional activities

**Aerospace Systems Division**

At a dinner meeting of the RCA Burlington Branch of RESA held on June 21, 1973, the following engineers were honored by their induction into membership of The Scientific Research Society of America: **J. M. Bardis, R. J. Bosselaers, A. P. Cortizas, R. T. Cowley, H. E. Fineman, R. E. Hanson, L. R. Hulls, R. J. Kampf, E. C. Lea, W. B. Locke, H. Logemann, Jr., D. M. Priestley, G. J. Sandorfi and E. M. Stockton.**

Officers of the RCA RESA branch, elected for the 1973-1974 year, are: President, **Edwin W. Richter;** Vice President, **Paul P. Nesbeda;** Sec/Treasurer, **Henry L. Fischer;** Exec. Committee, **Edward P. Wallner;** Exec. Committee, **Hans H. Behling;** and Exec. Committee, **Michael J. Cantella**.

**Frank P. Congdon, Jr.,** Administrator of Management Information Systems Operations at the RCA Aerospace Systems Division, has been elected international President of the Association for Systems Management, (ASM).

**Missile and Surface Radar Division**

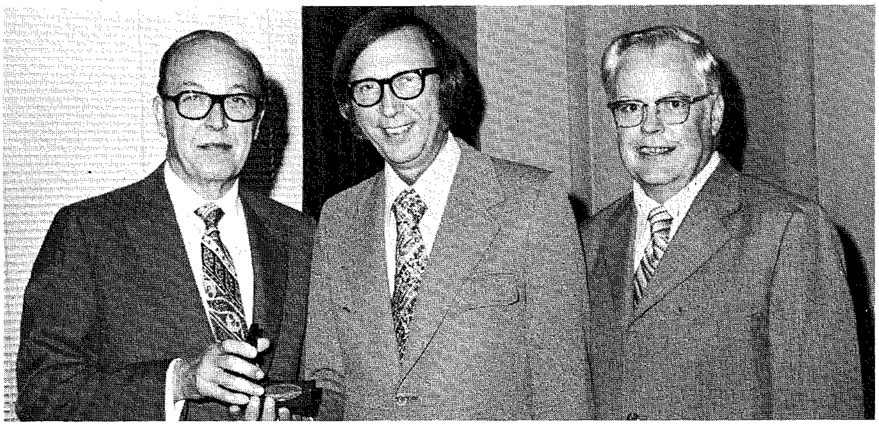
Two members of G&CS Staff and threee MSRD Staff members participated in a special seminar on Management and Systems Concepts for Increasing Engineering Performance held in Philadelphia on June 13, 1973, co-sponsored by the IEEE Philadelphia Section Engineering Management group and the Systems, Man, and Cybernetics Society.

**Merrill W. Buckley, Jr.,** of MSRD was Seminar Chairman, and **John C. Bry, Jr.,** served as Program Chairman. Arrangements and Publicity Chairman was **Fulvio E. Oliveto. David Shore,** Division Vice President Government Plans and Systems Development, was the Keynote Speaker and **Frank Freiman,** Manager Systems Economics, was a panelist on the subject of "Designing to Cost — A New Use for the System Methodology."

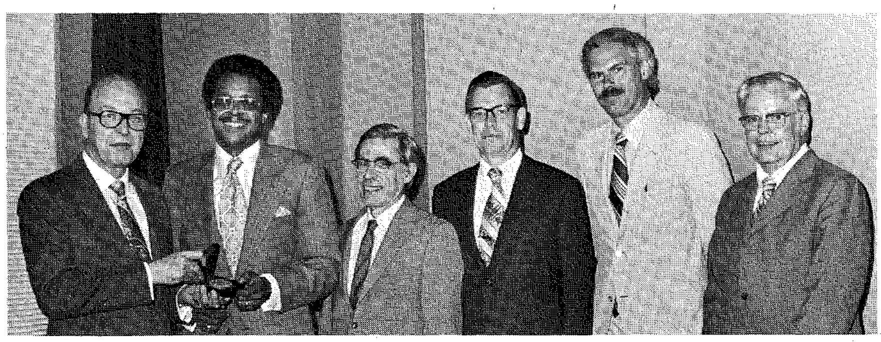
## Engineers and Scientists receive Sarnoff Awards

**Robert W. Sarnoff,** Chairman of the Board and Chief Executive Officer, and **James Hillier,** Executive Vice President of Research and Engineering recently presented the 1973 David Sarnoff Awards for Outstanding Technical Achievement to nineteen engineers and scientists.

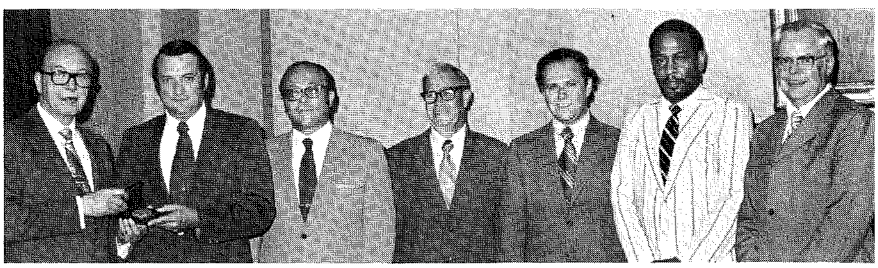
The Awards were announced earlier this year and were described, in some depth, in the April-May 1973 issue of the *RCA Engineer*.



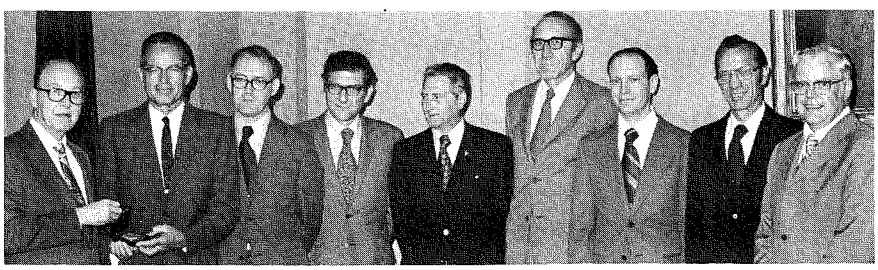
**For outstanding achievement in the development of a highly innovative magnetic tape player:** H. Ray Warren (center) of Consumer Electronics receives gold medal from Mr. Sarnoff (left) as Dr. Hillier adds his congratulations.



**For outstanding team research leading to a new class of integrated semiconductor arrays:** In the photo (left to right) are Mr. Sarnoff, Joseph H. Scott, Charles W. Mueller, Gerald B. Herzog, and Glenn W. Cullen — all of RCA Laboratories, and Dr. James Hillier.



**For outstanding corporate effort leading to an innovative video-by-telephone system:** From left to right, Mr. Sarnoff presents medals to Denis P. Dorsey (RCA Laboratories), Alfonse Acompora (Globcom), William D. Houghton (RCA Laboratories), John T. Frankle (Globcom), and Lewis B. Spann (Globcom) as Dr. Hillier adds congratulations.



**For outstanding technical achievement in color picture tube systems:** From left to right, Mr. Sarnoff presents Award medals to William H. Barkow, John Evans, Josef Gross, Horst E. Haslau, Richard H. Hughes, Walter D. Masterton, and Ira F. Thompson. Dr. Hillier congratulates the group. Messrs. Barbin, Evans, Hughes, and Masterton work at the Electric Components' Lancaster, Pa. facility; Mr. Barkow and Dr. Gross are at the Electronic Components' Materials and Display Devices Laboratory, Princeton, N.J.; and Messrs. Haslau and Thompson are with Consumer Electronics, Indianapolis, Ind.

## Engineering Education Courses for 1973-74

The new Engineering Education Course Catalog for 1973-74 has been distributed to all supervisors of engineers, scientists, and technologists.

This year, the catalog describes 57 courses, all of which are available for scheduled use. Of these, 47 have been prepared specifically for engineers and scientists and ten for technologists. Seven courses are offered for the first time this year.

All courses utilize a video tape format for primary presentation of the subject matter. However, the complete course package also contains a specially prepared study guide for each student, a text, classroom exercises, homework assignments, and examinations. Utilized creatively by a local Associate Instructor, these elements yield high quality education.

These educational materials are developed for use by engineering and scientific departments as an aid in maintaining occupational and professional vitality and in combatting obsolescence and overspecialization. The discipline associated with formal study often provides the needed motivation for maintaining an edge-of-the-art competence.

### Wall elected Fellow of ASQC

**Alfred S. Wall,** Manager of Reliability and Maintainability, Defense Product Assurance, G&CS, was elected to the rank of Fellow of the American Society for Quality Control. Wall was honored at the Society's 27th Annual Technical Conference held recently in Cleveland, Ohio. Election to the rank of Fellow indicates that the member honored has spent at least 15 years in the quality field and has attained distinction in his work within this field.

The citation on Wall's award reads: "A person of high integrity who is dedicated to maintaining a high standard of ethics in his dealings in reliability and quality assurance. He has worked hard to support both section and national activities. His presentations here and abroad are of academic level enhancing the professional stature of the Society." Wall received his BS in electrical engineering from Lehigh University. He is an ASQC-Certified Quality Engineer and Reliability Engineer, and has served from 1971-73 as ASQC Vice President. He is a member of the IEEE Group on Reliability, the AOA, Save and Systems Safety Society.

## Staff announcements

#### Manufacturing Services and Materials

**George A. Fadler,** Vice President, Manufacturing Services and Materials has appointed **Howard W. Johnson** Staff Vice President, Reliability and Quality.

#### Research and Engineering

**George D. Cody,** Director, Physical Electronics Research Laboratory has announced the organization as follows: **Roger W. Cohen,** Head, Physics and Chemistry of Solids Research; **Benjamin Abeles,** Fellow Technical Staff; **Dwight O. North,** Fellow, Technical Staff; **Albert Rose,** Fellow, Technical Staff; **Istvan Gorog,** Head, Optical Electronics Research; **Karl G. Hernqvist,** Fellow, Technical Staff; **Rabah Shahbender,** Head, Applied Electronics Research; **Brown F. Williams,** Head, Quantum Electronics Research; **Richard Williams,** Fellow, Technical Staff.

**William E. Bradley,** Manager, ITD Quality and Reliability Assurance has announced that the Engineering Services Activity, in the Industrial Tube Department, is transferred to the Staff of the Manager, ITD Quality and Reliability Assurance. **Horace A. Kauffman** will continue as Manager, Engineering Services and will report to the Manager, ITD Quality and Reliability Assurance.

**Gust S. Diamantoni,** Manager, Industrial Engineering and Standards has appointed **Thomas M. Wetzel,** Manager, Industrial Engineering.

#### Parts and Accessories

**Paul B. Garver,** Division Vice President and General Manager has announced the following organization: **Edward A. Boschetti,** Director, Materials and Computer Systems Support; **Ray M. Easter,** Director, Finance; **A. Richard Fox,** Manager, Business Analysis and Planning; **William J. Radford,** Director, Industrial Relations; **Paul R. Slaninka,** Director, Commercial Operations; **Walter A. Smith,** Director, Distribution and Operations Services; **Fred G. Wenger,** Manager, New Business Development.

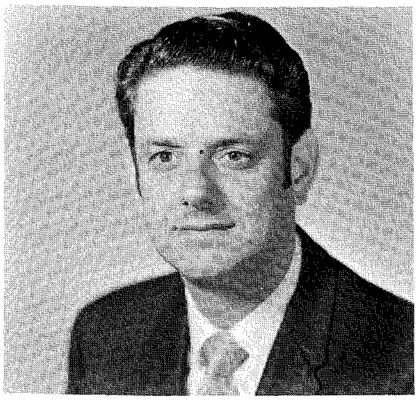
#### Finance and Planning

**George C. Evanoff,** Vice President, Corporate Planning has appointed **Joseph V. Quigley,** Staff Vice President, Business Planning.

#### Government and Commercial Systems

**George D. Prestwich,** Division Vice President, Government Marketing has appointed **Andrew T. Hospodor** as Director, Marketing, Advanced Systems and Technology.

**Stanley S. Kolodkin,** Divison Vice President and General Manager, Aerospace Systems Divison, has appointed Dr. **Donald A. O'Neil** as Manager, Planning, Building Management Systems; **William T. Glover** as Marketing Manager; and **John Hallal** as Manager, Special Sensor Programs.



### Sherman appointed to Research and Engineering staff

**Howard Rosenthal,** Staff Vice President, Engineering, has appointed **Dr. Arthur Sherman** to the RCA Research and Engineering staff at the David Sarnoff Research Center in Princeton, N.J.

Dr. Sherman was graduated from the Polytechnic Institute of Brooklyn in 1953 with the BME. He received the MS in Engineering in 1958 from Princeton University, and the PhD in 1965 from the University of Pennsylvania. While studying at Princeton, he received a Guggenheim Fellowship in 1956.

From 1953 to 1968, Dr. Sherman worked for General Electric Co., and was Manager, MHD Power Generation, at the GE Space Sciences Laboratory. In 1968, he joined Medical Diagnostic Centers, Inc., and subsequently became President and Chief Executive Officer. Prior to joining RCA this year, he served as Vice President of Gourdine Environmental Systems, Inc.

Dr. Sherman is the author of *Engineering Magnetohydrodynamics*, published by McGraw-Hill in 1965. He is an Associate Fellow of the AIAA, a member of the American Physical Society, and is listed in American Men of Science.

## Awards

#### Missile and Surface Radar Division

Three engineers received Technical Excellence Awards during the first quarter of 1973: **A. A. Plumer** — for outstanding technical leadership on the Viking Mars Lander Antenna development program. **R. M. Scudder** — for outstanding achievement in the development, test, and integration of the S-band phased array antenna into the AN/SPY-1 radar. **M. T. Detoro** — for outstanding project engineering effort on the AN/SPY-1 radar signal processor.

### New receiving tube manual avail

The new edition of the *RCA Recei Tube Manual*, which has been in pub tion for over 40 years, is now availab

This 752-page edition contains techr data for over 1400 receiving tubes, cluding industrial types. Data for bla and-white and color picture tubes are included.

The new manual, RC-29, is available fr RCA Distributors at an optional sugges retail price of $2.50.

### New brochure on rf and microwa solid-state devices

RCA solid-state rf and microwave devic are described in a new eight-pag brochure that is available from Solid Sta Division, Somerville, N.J.

In *rf and microwave devices*, publicatio RFT-700L a quick selection guide show power-*vs*-frequency curves for the entir product line, with power levels to 80 watt and frequencies to 3.5 GHz. The electrica characteristics of all the devices are summarized by types. To facilitate comparisor and selection of devices for particula uses, the types are also tabulated by application. Block diagrams illustrate typical circuit applications, and photographs show package styles.

This brochure may be obtained from RCA distributors or from the Solid State Division, Box 3200, Somerville, N.J. 08876.

### Advanced development in processing linear fm signals

A significant technological advance that reduces the complexity and hardware required in the digital processing of linear fm signals has been announced by Missile and Surface Radar Division, Moorestown, N.J. The development was supported under a contract from the Air Force Avionics Laboratory at the Wright-Patterson Air Force Base, Dayton, Ohio.

The new technique, called the step transform algorithm, requires less than one-third the hardware of other methods. This is the first time the concept has been combined with high-speed complex multipliers using silicon-on-sapphire technology to perform pulse compression, linear fm waveform generation, and synthetic aperture processing.

Use of an LSI complementary MOS/silicon-on-sapphire version of the processor, currently being designed, will make possible an additional order of magnitude reduction in size and power.

# Editorial Representatives

The Editorial Representative in your group is the one you should contact in scheduling technical papers and announcements of your professional activities.