RCA Engineer

Vol. 26 No. 7 July/Aug. 1981

Cover design by Louise Carr

The embossed medallion on our cover signals another Anniversary issue of the *RCA Engineer*, complete with this year's David Sarnoff Outstanding Technical Achievement Award citations. This year marks the twenty-fifth anniversary of the establishment of this honor for scientists and engineers of RCA (see p. 4).

September 30, 1956. The Waldorf Astoria's Grand Ballroom in New York. Over a thousand guests gathered for dinner to honor the date in 1906 when a 17-year-old boy — David Sarnoff — joined what would eventually become RCA. The board of directors presented Chairman Sarnoff with a large gold medal like the one you see replicated on the cover, in honor of his fifty years of service to the corporation. At this celebration, Dr. Elmer W. Engstrom, Senior Executive Vice-President, rose to announce the David Sarnoff Award. Then, Sarnoff spoke.

Predictions were Sarnoff's forte, and on that evening he outlined twenty technical developments that he believed would occur within the next twenty years. Surely he would be pleased to see how closely the authors contributing to this past year's issues of *RCA Engineer* have written factually about feats that were just imaginative chimeras in Sarnoff's speech given 25 years ago.

For example, Sarnoff mentioned global, true-color television[1]; private two-way communications with sight and sound[2]; mail guided electronically over long distances[3]; automation that would "under the impact of cheap and abundant power" [the microprocessor?] free millions from arduous and hazardous work[4]; and materials advances for "categories of substances that as yet have no name.[5]"

Sarnoff even foresaw a technology that would replace the TV tube altogether with a thin, flat-surface screen that will be hung like a picture on the wall[6]; performance simulations by computer for new products[7]; the entry of electronics into practical chores at home[8]; and weather prediction for months in advance.[9]

Also, Sarnoff received three gifts from the Labs that night in 1956 — an electronic air conditioner, a true amplifier of light, and an electronic recorder of the television signal. Two of these developments have been refined considerably since then.[10]

We at the *Engineer* are proud to publish the accounts of your engineering achievements, done in the spirit of invention favored by Sarnoff.

***RCA Engineer* References**

1. Jul/Aug 1981, Awards, Drysdale, Inglis; Nov/Dec 1980, all. 2. Nov/Dec 1980, p. 73. 3. Nov/Dec 1980, p. 8. 4. Jan/Feb 1981, p. 6. 5. Jan/Feb 1981, p. 12; Jul/Aug 1981 Awards 6. Jul/Aug 1981, Credelle. 7. Sep/Oct 1980, Jan/Feb 1981, Mar/Apr 1981, May/Jun 1981. 8. Mar/Apr 1981, p. 40; Jul/Aug 1981, Drysdale. 9. Jul/Aug 1981, Schnapf. 10. Jul/Aug 1981, Hedlund, Muller/Haggert; Nov/Dec 1980, p. 42.

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•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.

H. Rosenthal

A vision of excellence

Just twenty-five years ago, Dr. Elmer W. Engstrom announced the establishment of the David Sarnoff Awards in honor of General Sarnoff's fifty years in the radio and television industry. It was felt then that there could be no more fitting expression of appreciation for General Sarnoff's role than to link his name with excellence in an area that he cited so many times as a critical component for the development of society and for the development of RCA.

Progress in science and engineering depends on the few ideas that lead to major breakthroughs, on the many less encompassing ideas that lead to steady improvements, and — increasingly in this ever more complex era — on the ability to weave together teams of people with the different skills, both technical and otherwise, necessary to capitalize on the advancements. It takes an equal amount of imagination to clearly see the business application of new technology. And it takes the marshalling of management, financial, marketing, and other resources to make the business application a success.

General Sarnoff had the necessary vision and determination to assure a number of such successes. And we need only look at the list of the winners of the 1981 David Sarnoff Awards for Outstanding Technical Achievement to recognize that all the necessary components live on at RCA.

Howard Rosenthal

Howard Rosenthal
Staff Vice-President, Engineering
Research and Engineering

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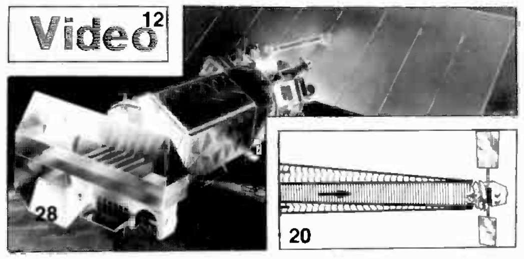
4 **Achievement**

■ **Drysdale** "A group of people from various parts of the RCA family collectively prepared an outlook to 1990."

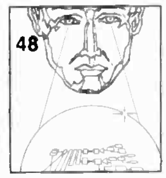
■ **Inglis** "The ultimate shortage of C-band capacity, and the advantages of K-band for certain applications, make it certain that both bands will ultimately experience full development."

■ **Schnapf** "RCA will put up to eight satellites into orbit over the next 12 months."



■ **Adams** "By the time the last *Ticonderoga*-class ship is commissioned, its outward appearance may well have changed considerably, but its concept of operation will remain the same."

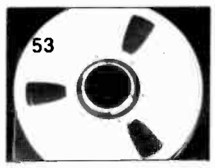
■ **Carver** "In the aerospace/military marketplace, the ATE requirements can only go one way — up."

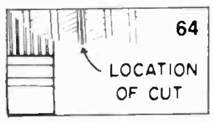


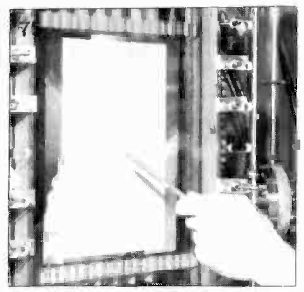
■ **Hedlund** "The use of microprocessor technology has allowed us to pack a host of valuable features in a very compact package."

■ **Muller|Haggart** "From the production point of view, a *good edit* is one that you don't notice. A *good edit system*... does the job without overshadowing the tape editor's aesthetic and creative goals."

■ **Credelle** "For years, science fiction writers have been predicting that hang-on-the-wall television will be an integral part of the home of the future."



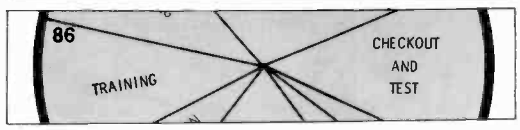




■ **Ratay** "It is very important to construct a system that will have built-in quality."

■ **Haik,** *et al.* "This group is perhaps unique in that, while performing a highly specialized function within the corporate scheme, it represents a wide range of occupational skills and disciplines."

82 PQI = PLANNED QUALITY IMPROVEMENT



■ **Rodman|Waas** "The implementation of digital telephony by means of integrated circuits will result in lower cost, more versatile systems capable of more reliable performance."

■ **Bakas** "These formats are competitive with the older North American T-1 or the International CCITT standards in efficiency and fidelity."

■ **Mirsch** "My job at RCA Laboratories... calls for precise, detailed work, characteristics that were a plus in my new pursuit."

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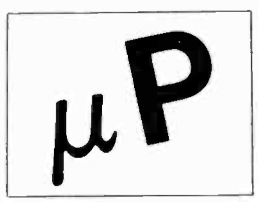
in future issues...

microprocessor applications,
SelectaVision® VideoDisc,
manufacturing engineering,
productivity



1981 David Sarnoff Awards for Outstanding Technical Achievement

"In my years of association with scientists and engineers, I have acquired a deep respect for their creative faculties, their constant search for knowledge and facts, and their integrity of purpose. I have tried in my small way to stimulate and encourage them in their work, to share with them their dreams and disappointments, and to rejoice in their triumphs."

— David Sarnoff

At a golden anniversary dinner held on September 30, 1956, to commemorate David Sarnoff's fifty years of service to radio, television and electronics, Dr. Elmer W. Engstrom, Senior Executive Vice-President, announced the establishment of what has become David Sarnoff Outstanding Technical Achievement Awards.

The first award was made for the year 1957. Since then, RCA has given outstanding scientists and engineers over 330 gold medals that resemble the embossment on our cover. After a quarter of a century, the award still stands for high ideals espoused by a man who had visionary faith in long-term technological solutions to "impossible" problems. He combined this faith in science and engineering with a practical business sense. Though not an engineer or a scientist, he was an industrialist with a brilliant understanding of technical work, and the motivating ways in which the creative aspirations of the human spirit are fundamentally expressed in technological achievement. He delineated this "philosophy" in many speeches throughout his career.

Many younger engineers at RCA may not have been born in 1953 when Sarnoff addressed the graduating class of the Drexel Institute of Technology, in Philadelphia. "The principles it [science] uncovers are taken over by engineers who proceed to fashion them into instrumentalities for mankind to enrich our everyday life," he said.

"For some, engineering will remain merely a trade, like any other trade," he continued. "But for others, the more imaginative and courageous, it can be a noble and satisfying dedication . . . [These engineers] will assume its responsibilities in a spirit of mission, in the awareness that they are starting out on a great adventure. It is this difference in approach, believe me, that will determine whether engineering will be just a

(Continued on page 11)

For key contributions to the development of the CED VideoDisc System.

Achievement

Todd J. Christopher
Manager,
Electrical Design,
SelectaVision VideoDisc
Operations

Jon K. Clemens
Director,
VideoDisc Systems Research,
RCA Laboratories

Pabitra Datta
Member Technical Staff,
VideoDisc Materials and
Diagnostics,
RCA Laboratories

Leonard P. Fox
Head,
VideoDisc Applied
Process Research,
RCA Laboratories

Jerome B. Halter
Member Engineering Staff,
Signal Generation
Systems Development,
SelectaVision VideoDisc
Operations

Eugene O. Keizer
Staff Scientist,
VideoDisc Systems Research,
RCA Laboratories

Marvin A. Leedom
Director,
Manufacturing Systems and
Technologies Research,
RCA Laboratories

Michael E. Miller
Manager,
Stylus Cartridge Design,
SelectaVision VideoDisc
Operations

Frederick R. Stave
Manager,
Mechanical Design,
SelectaVision VideoDisc
Operations

On March 22, 1981, RCA introduced the SelectaVision® VideoDisc Capacitance Electronic Disc (CED) System. In many ways, the achievements of the large group of engineers and scientists working on the project are obvious and need little introduction. The VideoDisc system is an engineering and scientific feat on the broadest scale. A project on this scale is successful only if everyone is performing superbly.

But within any group, some individuals must stand out. The awards committee selected the following nominees on the VideoDisc team for their particularly outstanding performance.


Christopher


Clemens

Personalities

Todd J. Christopher

Mr. Christopher has been a key technical participant in the VideoDisc project since 1973. His principal contributions have been in the development of practical electronic circuits for the player. In addition, he has contributed to the development of the signal encoding standards for the system. Twelve patents have been issued in his name, three of which are applicable to the VideoDisc system.


Datta


Fox


Halter


Keizer


Leedom


Miller


Stave

Jon K. Clemens

Dr. Clemens has devoted essentially his entire professional career to the development of the RCA CED VideoDisc system. He is one of the key architects of the system as a whole, and he played the principal role in selecting the method used to encode the picture and sound information. In the latter phases of the project, Dr. Clemens managed a group at Princeton which helped solve many of the difficult problems encountered in bringing the VideoDisc system to a commercial reality. Dr. Clemens received the prestigious Rhein Prize for his contributions to video disc technology.

Pabitra Datta

Dr. Datta has been involved in the VideoDisc program for about six years, working on surface characterization and control, and compound formulation of the disc. His discovery of the efficacy of a special carbon as a conductive filler led to a practical demonstration of the viability of the conductive disc concept. This breakthrough provided the direction for developing a manufacturable disc technology which is employed in the present product.

Leonard P. Fox

Mr. Fox has been actively engaged in VideoDisc research for approximately ten years and has contributed to various materials developments. His major contribution was to continually champion the non-coated, conductive disc concept—he kept this technology alive through a series of feasibility demonstrations which contributed to its adoption in 1977. In addition, he has made technical contributions to matrix development and to compounding technology.

Jerome B. Halter

Mr. Halter has been on the VideoDisc project since the late 1960s. His principal contribution to the program has been the development of electro-mechanical cutting heads capable of operating at frequencies in the video band. During the early 1970s, when RCA's major video disc effort was directed at electron beam recording, he was essentially a one-man development team on high-frequency cutterheads. His work led to the development of a recording method that was more reliable, easier to operate and gave a better signal-to-noise ratio in finished discs than electron beam recording. Our present disc recording system is an outgrowth of his work. He has four patents, all used in the introductory system.

Eugene O. Keizer

Mr. Keizer has been a major contributor to the RCA VideoDisc System for over sixteen years. His work centered on the making of disc masters and on the design of the diamond playback stylus. A key concept developed by Mr. Keizer is that of the keel-lapped stylus—the method used today in production to obtain long stylus life. During the final two years of the VideoDisc project, Mr. Keizer played an important role in transferring the technology from Princeton to Indianapolis. Mr. Keizer received the prestigious Rhein Prize for his contributions to video disc technology.

Marvin A. Leedom

Mr. Leedom has been associated with the VideoDisc project for more than twelve years, and during that period he has made significant technical contributions to several elements of this system. His patent record includes one for player electronics, seven for player mechanical design, six for cartridge/stylus design and manufacture, and one for disc replication technology. Four of these fifteen patents apply directly to the introductory system, and Mr. Leedom is credited with the original concept of the caddy, which is an essential component in the VideoDisc system. During the most recent phases of this project, he has made general technical contributions through the management of several technical activities engaged in mechanical and manufacturing technologies.

Michael E. Miller

Mr. Miller has been a technical catalyst in advancing the stylus/cartridge art from feasibility to a production reality. He defined the architecture for the stylus/cartridge and associated mechanism, and he provided the technical guidance and insights to transform those components from the early concepts to production designs. He has eight patents, of which four relate to the VideoDisc system.

Frederick R. Stave

Mr. Stave has been a technical contributor to the VideoDisc program since 1973. He has been responsible for much of the technical development of the mechanical design of the player and for the disc/caddy interface with the player. He has been issued eight patents, seven of which are related to the VideoDisc system.

For the development and implementation of a CCD comb filter integrated circuit in color TV receivers.

Achievement

James E. Carnes
Director,
New Products Laboratory,
RCA Consumer Electronics

Jack S. Fuhrer
Manager,
Baseband Signal Processing,
RCA Consumer Electronics

Walter F. Kosonocky
Fellow of Technical Staff,
IC Technology Research,
RCA Laboratories

William A. Lagoni
Senior Member
Engineering Staff,
Baseband Signal Processing,
RCA Consumer Electronics

Peter A. Levine
Member Technical Staff,
IC Technology Research,
RCA Laboratories

Dalton H. Pritchard
Fellow of Technical Staff,
Consumer Electronics
Research,
RCA Laboratories

Donald J. Sauer
Member Technical Staff,
IC Technology Research,
RCA Laboratories

This team developed the first charge-coupled device (CCD) comb-filter integrated circuit to be used in a mass-produced color television receiver. The circuit produces a cleaner picture with significantly improved resolution. In addition, this development has made possible a new, unique feature called vertical peaking that adds a new dimension to the sharpness of the picture produced by a color television receiver.

Most competitive television receivers having comb filters do not have RCA's vertical peaking feature and have performance inconsistencies that result from classical glass delay line approaches. The CCD comb filter IC has provided RCA with a performance feature which will allow the company to maintain industry leadership in a time of strong demand and in the face of severe competitive pressures.

The development by the RCA Laboratories of an advanced *n*-channel process that combines high-performance buried-channel CCDs with digital and linear NMOS circuitry was the groundwork for a system suitable for consumer electronics. The practical embodiment of the comb filter IC in a color television receiver by the Consumer Electronics Division was a notable achievement. A unique, patented nonlinear processing circuit optimized the vertical peaking feature to provide maximum picture enhancement while minimizing undesirable interference patterns.

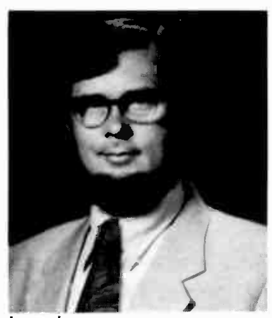
The comb filter in a television receiver permits increased luminance bandwidth and minimizes luma-chroma interference effects found in conventional TV receivers. The effects include erroneous colors in picture scenes having luminance information at spatial frequency near the 3.58 MHz color subcarrier — known as "cross color" or the "umpire shirt effect" — and chrominance dot crawl on the luminance edge transitions.

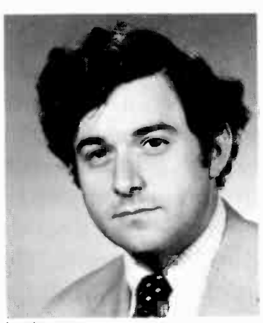
The RCA comb filter was first used in the 1979 RCA Limited Edition TV receivers and was marketed commercially as the Dynamic Detail Processor.


Carnes

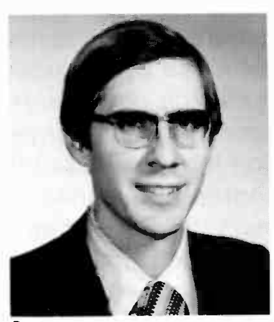

Fuhrer


Kosonocky


Lagoni


Levine


Pritchard


Sauer

Overall, horizontal resolution is increased to at least 330 TV lines, compared with 280 lines in TV receivers without comb filters. This improvement, combined with the vertical peaking feature, resulted in significantly improved picture quality and sharpness.

This receiver was recently included in a group of top-of-the-line console receivers evaluated by a leading consumer magazine. The CCD set was rated the best and special mention was made of the comb filter.

Personalities

The CCD comb filter IC described here is the culmination of over five years of research and development at RCA Laboratories and Consumer Electronics. During this period, many people have made important contributions to the success of this project but the seven people nominated for the 1981 David Sarnoff Outstanding Technical Achievement Award have made outstanding individual contributions in the following manner.

James E. Carnes

Dr. Carnes was overall project leader for the development of the CCD comb filter IC. In addition to project leadership, he was primarily concerned with the application of special CCD video signal processing techniques which involved device development, device layout, device testing and evaluation. This work led to directly applicable pending patents on the comb filter IC.

Jack S. Fuhrer

Mr. Fuhrer contributed significantly to the success of the comb filter project in both an engineering and management capacity. As an engineer, he was responsible for identifying many of the early pitfalls which were associated with the new vertical peaking feature. He suggested and helped implement solutions which made this feature practical in a television receiver. He was instrumental in coordinating the integration of the comb filter function into the rest of the television receiver. He contributed significantly to early demonstrations to marketing management and helped formulate our Dynamic Detail Processing advertising strategy. His leadership was a key factor in the successful completion of this project.

Walter F. Kosonocky

Dr. Kosonocky has been involved with the research and development of CCDs for signal processing applications. This work has led to contributions in basic device performance limitations such as interface trapping, fringing field drift, free-charge transfer and device noise. In addition to his basic work on CCDs, he was the principal architect of the buried-channel, double-level polysilicon-gate NMOS CCD wafer fabrication process. This high-performance, state-of-the-art, *n*-channel process is essential for the production of CCD comb filter ICs.

A number of patented inventions made by Dr. Kosonocky alone and some made jointly with others, are incorporated in the comb filter. These include the so-called "fill and spill" input circuit to the CCD, CCD structures for charge addition and subtraction, and others.

William A. Lagoni

Mr. Lagoni was the key engineer responsible for the product design of the comb filter function in the television receiver. His many long hours were instrumental in the eventual success of the project. He has several innovative patents which were key to the success of the project. Since this was a new TV function, there was no prior art on which to rely for guidance in formulating these exacting specifications. He solved severe interference (RFI) problems resulting from the use of on-chip clock drivers required by the comb filter IC design. He has several issued patents and pending patent applications concerning a nonlinear vertical detail signal processing system used in the receiver.

Peter A. Levine

Mr. Levine was instrumental in the development of innovative and novel techniques for the measurement of device and circuit performance of CCDs in video signal processing applications. These unique circuit evaluation techniques played a key role in the rapid evaluation and improvement of the circuits incorporated in the comb filter IC. Patent applications were filed covering a number of inventions incorporated in the comb filter made solely by Mr. Levine or in which he is a joint inventor, and many have now issued as patents. These include the gain control circuit at the input to the CCD, a charge limiting circuit and a number of others.

Dalton H. Pritchard

Mr. Pritchard was principally responsible for the development and evaluation of analog techniques for employing the CCD comb filter technology in the color TV receiver signal processing system. This work on the video processing system implications of the comb filter was essential to the successful incorporation of this filter in TV receivers. He has several issued patents and pending patent applications concerning inventions applicable to the use of the CCD comb filter IC in the receiver. The subject matter of these inventions relate to generating and properly synchronizing the comb filter timing signal, structuring the CCD comb filter system to achieve predictable signal delays, and restoring vertical image detail information to the luminance signal.

Donald J. Sauer

Mr. Sauer had a leading responsibility for the exact circuit designs and implementations that were incorporated in the comb filter IC. In this role, he was responsible for detailed circuit analysis, design, layout and characterization of the CCD and the other sub-circuits required in this video signal processing application. Mr. Sauer's contributions include a number of inventions which are incorporated in the comb filter IC and a number of patent applications were filed, some for Mr. Sauer alone and some jointly with others, covering these inventions which have issued as patents. These include the automatic bias control circuit for the comb filter, a differential amplifier circuit and a number of others.

For achieving dramatic increases in the capacity of the RCA domestic satellite system.

Achievement

Walter H. Braun
Director,
Systems and Advanced Technology Engineering,
RCA American Communications, Inc.

Marvin R. Freeling
Principal Member Engineering Staff.
Regulatory Technical Support,
RCA American Communications, Inc.

Krishnamurthy Jonnalagadda
Member Technical Staff,
Communications Analysis,
RCA Laboratories

Leonard Schiff
Head,
Communications Analysis,
RCA Laboratories

This team increased the transponder capacity of the RCA Satcom satellite from 1992 voice-grade-equivalent channels to 2892 channels, thus permitting concomitant growth in revenues per transponder.

The loss of the RCA Satcom F3 spacecraft in December, 1979 immediately jeopardized the 1980 Business Plan for RCA Americom's Commercial Services by essentially halting the expansion in private leased-channel service because of transponder shortages. The cited program was conceived and commenced immediately following this catastrophic loss. An accelerated development program moved from initial theoretical analyses to empirical verification of analytical design, manufacture of high-performance earth-station ground communications equipment, and final field installation and operation within nine months. As a result, the Commercial Services product line actually exceeded their Business Plan for private leased-channel services, despite the loss of the F-3 satellite.

Specifically, the installation of compandors into RCA Americom's voice-channel transmission plant resulted in fundamental changes in basic FM transmission theory and enabled the creation of a new industry standard. The team recognized that frequency deviations could be increased well beyond the bandwidths previously used by all major carriers under the well-known Carson's (tradi-

Jonnalagadda

Schiff

Braun Freeling

tionally referred to as the occupied bandwidth). Since compandored channels are rendered relatively insensitive to distortion noise introduced by nonlinearities of transmission channel filters, it was believed that the technique of *overdeviation* could help to increase system capacity. Given this premise, the team undertook an extensive analytical and test program to evaluate the feasibility of this approach. New ground communications equipment with bandwidths and performance superior to that of previous generations was developed, tested and proved prior to preparation of detailed specifications for quantity production by selected vendors. The realization of this new generation of earth station equipment involved use of recently available hybrid solid-state circuitry and was accomplished on an accelerated program.

Concomitant with the effort on overdeviation techniques, other approaches which offered promise were pursued and eventually implemented. The program used simple, effective and clever techniques requiring very modest capital investments but resulting in dramatic increases in system capacity.

Personalities

Drs. L. Schiff and K. Jonnalagadda were basically responsible for the initial theoretical analyses and predictions, and Messrs. Braun and Freeling were responsible for the empirical verification efforts, the development of the new equipment, and operational deployment of the system, as described in greater detail below.

Walter H. Braun

At the outset, Mr. Braun evaluated the initial theory behind the attempt to expand the transponder capacity via changes in deviation from Carson's Rule, and made the key finding that additional channels could be added with changes in peak factors and the development of new pre- and de-emphasis networks. He also made the important program decision that the predicted results could be achieved within a tight cost/schedule envelope and recommended to his management that appropriate funds be committed. He directed the test programs conducted at Comtech Laboratories and Scientific Atlanta, Inc., and at the two Americom earth stations containing their respective equipments, Vernon Valley and Atlanta, to determine their characteristics with respect to the planned expansion. He performed all the management aspects with respect to liaison among three groups: Americom Engineering, Purchasing, Law Department and Profit Center; and the David Sarnoff Research Laboratories. He directed the design review that resulted in the necessary earth station modifications. He personally saw to it that Americom Engineering and the vendors accelerated their efforts to assure the shortest possible delivery time for the modifications, then turned the program over to the Americom PMO. Finally, he supervised the field tests conducted on the first new equipments located at the Lake Geneva, Wisconsin, Earth Station.

Marvin R. Freeling

Mr. Freeling was given the assignment to determine the maximum capacity of a single satellite transponder for transmission in the FDM-FM mode. In this context, capacity connotes the number of one-way voice-grade channels. He performed a study and analysis of six capacity expansion techniques: companding; overdeviation; assumption of average-talker power of less than the conventional -15 dBmo; group delay equalization; use of peaking factors other than the conventional 10 dB; and use of unconventional pre- and de-emphasis networks.

Although a body of literature exists for the first four techniques, to his knowledge no one had previously reported on the latter two for channel capacity expansion. The results of his analysis led to the conclusion that transponder capacity could be expanded to 2892 channels, possibly as high as 3012 channels (the work leading to this analysis had indicated that a maximum capacity of only 2700 channels could be achieved for the Satcom system).

Companding had already brought the capacity up from a base of 1092 channels to the existing 1992 channel capacity. He designed non-standard pre- and de-emphasis networks, designed in-orbit NPR and group delay tests for determining transponder capacity, determined the characteristics of the Comtech-equipped Americom earth station at Vernon Valley, New Jersey, conducted tests of the existing characteristics of this equipment at both Vernon Valley and Comtech Corporation, and then devised the specifications for the required Comtech modifications. Following the equipment modifications, he performed iterative in-orbit tests at Vernon Valley from which were derived the optimum parameters for 2892 channel capacity. He then repeated these tasks at the Scientific Atlanta-equipped Americom earth station at Atlanta, Georgia.

As a result, Comtech and Scientific Atlanta made final modifications to the tested prototypes and retrofitted the Lake Geneva Earth Station equipment. It was at this site that the final live-transmission tests using production equipment were performed successfully, leading to the implementation at all Americom earth stations.

Krishnamurthy Jonnalagadda

Dr. Jonnalagadda developed the analytical tools vital to the proof of the theoretical advancements being proposed. Existing analytical techniques developed to predict capacity were too inaccurate to give proper answers to the question of increase in distortion noise as channels were added. In addition, the then available computer simulations took too much time to run. A timely analytical proof was necessary if the program was to commence at all.

Working under a time constraint, Dr. Jonnalagadda developed the algorithm that significantly cut running time on the computer, which enabled all the worst case conditions to be run. The initial capacity predictions were substantiated analytically.

Dr. Jonnalagadda also developed the analytical simulations for improvements in equalization settings and predicted the proper setting for maximum efficiency.

Leonard Schiff

As part of the continuing joint Americom/David Sarnoff Research Laboratories advanced development programs, Dr. Schiff has been heavily involved in increasing traffic capacity through Americom's system. When it became clear to him that the two-for-one capacity program was going to be successful, he continued his efforts to develop other techniques to increase capacity even beyond the then projected 1800 channels per transponder. It was at this stage that Dr. Schiff made the perception that use of a conventional Carson's Rule design in a companded system was inefficient.

He realized that some additional channels could be added with enough deviation to maintain tone-to-thermal noise ratios up to the point when distortion noise increased to a reasonable level (tone-to-distortion noise in the low 40s). The unknown at this time was how fast distortion noise increased as channels were added. It was in this area that Dr. Jonnalagadda made his contribution as noted later.

Dr. Schiff also participated in the study to determine what capacity could be gained by altering equalizer settings as part of the joint effort. He directed the analytical simulations which showed that for worst case operation (that is, adjacent transponders on but carrying no, or very low-power, traffic with worst-case delay) possibly a few hundred more channels could be carried.

(Continued from page 4)

treadmill — or a fascinating highway to knowledge and achievement. In this, even more than in other areas of effort, the more you put into it — in terms of work and devotion — the more you will get out of it."

Sarnoff knew the nature of creative minds — they form new combinations and conceive new applications. He knew the ways these creative people could be stimulated — through encouragement and exposure to a variety of intellectual disciplines. And he recognized creative characteristics among the fraternity of doers — constant-inquiry, problem-solving ability, and wide interests. Members of the selection committee for this year's award looked for many of the same kinds of abilities as they chose the winners.

As in the recent past, members of the engineering staffs of RCA Divisions and subsidiary companies, and members of the research staffs of the RCA Laboratories were eligible. No specific limitation on the number of awards was made. The Selection Committee considered both individual and team efforts. Originally, in 1956, two awards were announced — an "engineering" award for outstanding achievement, and a "science" award for outstanding research achievement. A fuller recognition of the role of manufacturing engineering and a closer bond between RCA Laboratories and the other business operations contributed to the elimination from the award in 1973 of the distinction between science and engineering. At the same time, efforts to recognize personal technical excellence redoubled.

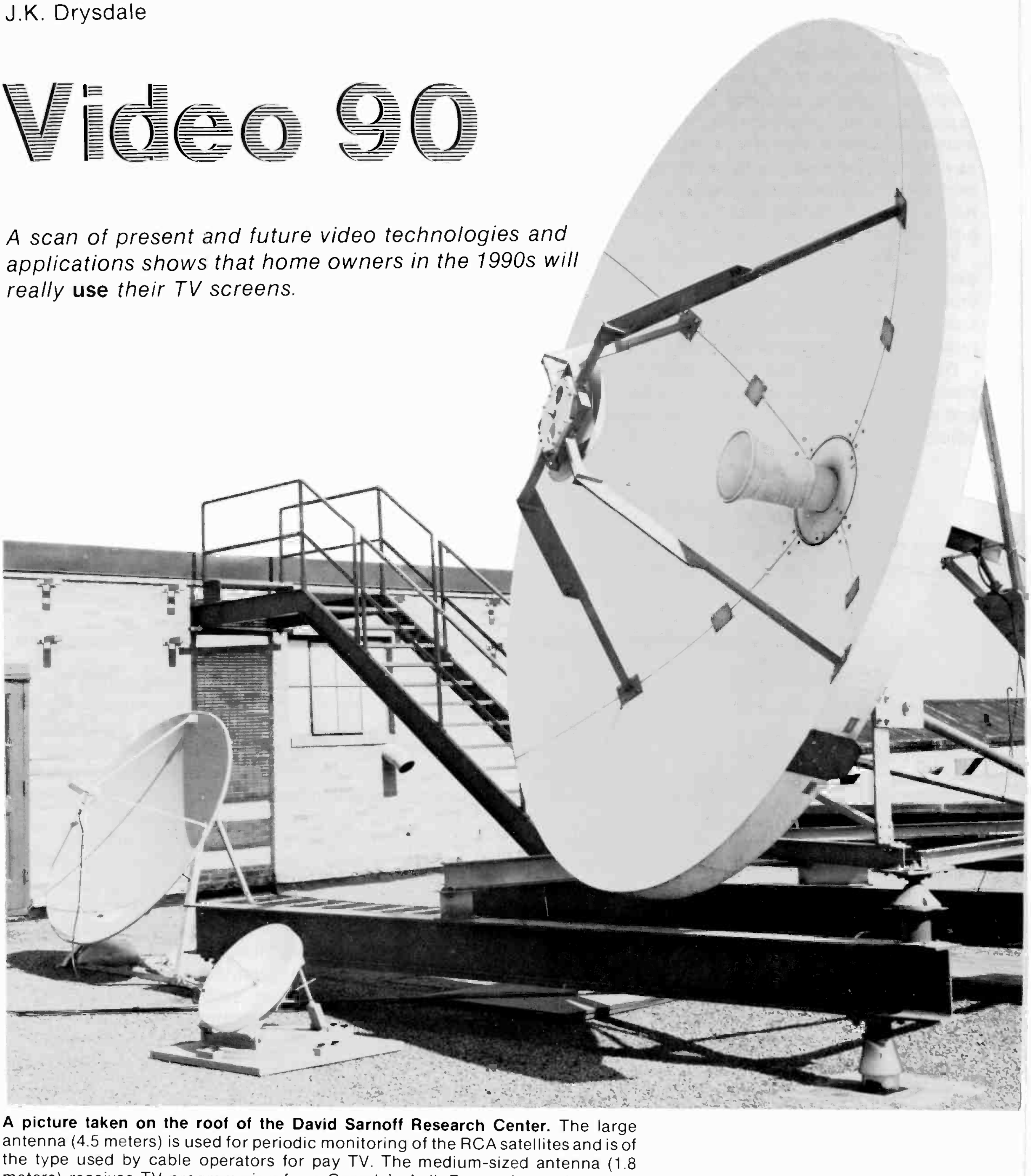
Generally, the Chief Engineer, Research Laboratory Director, or the equivalent submits nominations from an activity. The Selection Committee, consisting of the following people, then determines the Award Winners: W.C. Hittinger, Executive Vice-President, Research and Engineering; G.H. Fuchs, Executive Vice-President, Industrial Relations; J.V. Regan, Staff Vice-President, Patent Operations; H. Rosenthal, Staff Vice-President, Engineering; and W.M. Webster, Vice-President, Laboratories. The award consists of an engraved medal, a citation certificate, and a monetary award for each individual or team member.

With mighty help from his scientists and engineers, David Sarnoff's driving personality and pervasive influence dominated the electronics industry for more than 50 years. This year, the cited Achievements and the Personalities that merited the Sarnoff Award show that RCA's scientists and engineers continue to build on achievement.

J.K. Drysdale

Video 90

A scan of present and future video technologies and applications shows that home owners in the 1990s will really ***use*** *their TV screens.*



A picture taken on the roof of the David Sarnoff Research Center. The large antenna (4.5 meters) is used for periodic monitoring of the RCA satellites and is of the type used by cable operators for pay TV. The medium-sized antenna (1.8 meters) receives TV programming from Canada's Anik B experimental satellite while the small (0.6 meter) dish is a mock-up of the type to be used in a satellite direct broadcast system.

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My name is George. I'm an engineer. Today is Saturday, the day to finish the basement. After the usual, it's time to get started at 9:00 a.m. Fortunately, planning should be simple because Acme Lumber sent me a disc with some ideas. I put it on the player and fill in the blanks to get the list of materials needed. It also shows the tools — a big help. I dial up Teletext Warehouse operated by Acme. Place an order and give them the credit card number. The completed order will be ready for pick-up in an hour.

Time to review the plan. Projection TV unit in corner. Video cassette built into the wall. Video disc on the other side. Cabletext feed is ready to go into the receiver.

Disc, game and tape libraries go above the VCR. Well, the home computer goes into the den. Can't think straight with the whole family around me. The direct broadcast satellite feed goes into the converter over by the book case.

If the foregoing fantasy sounds unlikely to you, think again. No inventions are needed and every device mentioned is available somewhere. Home satellite TV plans have been filed with the Federal Communications Commission (FCC). Pay cable, video discs, video cassettes, subscription TV, and home computers are on the market today. Teletext over the phone is available and broadcast teletex has been filed for with the FCC.

Putting some semblance of order into this view of video's future, a group of people from various parts of the RCA family collectively prepared an outlook to 1990. The perspective of the consumer, the TV broadcast station, the network, the cable TV operator, the movie producer, the TV receiver manufacturer, the broadcast equipment manufacturer, the video cassette manufacturer, the video disc manufacturer, the satellite program distributor, and finally the cable television equipment manufacturer were all investigated.

Abstract: *A group of RCA people prepared an outlook on video's future from a technical, applications and marketing point of view. Total viewing of networks and their affiliates will continue to increase, while viewing of a variety of new video systems will escalate rapidly.*

Consumers

To gain the perspective of the consumer, the first step was simply to project the penetration of the various video delivery systems. Of course any ten-year projection can only represent, at best, one view of the future and this picture will change as more data come to our attention. There are, however, certain items that are relatively easy to forecast. One of these is the change in the population that will occur during the next ten years.

In 1979, there were 76.3 million TV homes and this will increase to 91.6 million homes in 1990. This is largely because members of the baby boom of the forties and fifties will become the home owners of the 1980s. Also, this age group is likely to favor activities in the home as opposed to going out, resulting in a real growth in electronic entertainment devices of about 6 percent per year. This means that the total market will double, in real terms, in about eleven years. Such a growth rate provides more than enough disposable income for the following forecasts.

Shown in Table I is the present and expected penetration of the various video delivery systems. The sources of these forecasts include both operating divisions and subsidiaries of RCA as well as independent outside sources. These forecasts parallel the history of similar product groups that have been introduced in the past, tempered with the judgment of the people from the various divisions preparing the forecast.

By combining the household penetration numbers with an estimate of viewing hours per week of those households with access to a particular delivery system, the overall share of total viewing can be computed for each system (Table II). In 1980, the networks and their affiliates accounted for 86 percent of total U.S. viewing, with 11 percent of total viewing going to independents and the remaining 3 percent distributed amongst PBS, cable, pay cable, subscription TV, video cassettes and home computers.

Projecting to 1990, the audience shares shift considerably. Viewing of networks and their affiliates, under this scenario, accounts for 74 percent of total viewing, independents account for 13 percent, and the other delivery systems attract 13 percent of total viewing. Due to the projected overall growth of households viewing the total viewing of networks and their affiliates will continue to increase, while viewing of the new video systems will escalate rapidly.

It is now possible to come to some conclusions. One is that broadcast is going to stay dominant over the period that we are looking at, but cable will be available to over half of the nation's homes. Over 45 percent of the homes

Table I. Homes with new video delivery systems are expected to increase rapidly over the next ten years. The average home will have between one and two new systems, thus creating an increasing demand for software.

	Household Penetration (% of TV Homes) 1979	1990
Network Stations	100	100
Independents	71.0	80.0
PBS	90.0	92.0
Cable	20.0	50.0
Pay Cable	7.5	35.0
Subscription Television	0.9	7.7
Direct Broadcast Satellite	—	5.0
Video Cassette Recorders	1.6	17.0
Video Disc Players	—	28.0
Home Computers	0.6	13.0
Games	14.0	20.0
Teletext/Viewdata	—	33.0

will have video disc or video tape machines. Pay TV will be in 35 percent of the homes. Subscription TV will be in 8 percent of the homes, and it will be increased by the introduction of direct-to-the-home, broadcast satellites. A point of interest is color cameras: they are used along with a VCR, and will be in 4 percent of the homes. This is the same as 8-mm movie cameras now. In terms of units, we anticipate that the electronic color camera market for 1990 will be as big as the 8-mm business today.

Home computers are estimated conservatively as the students of the 1970s become the home owners of the 1980s. The notion of the home computer will change from being esoteric to just another home appliance with 13 percent of the homes having one.

Teletext/viewdata will have made significant inroads by 1990. These services will provide the consumer with access to 100 pages of information per channel using a broadcast TV receiver. Sports results, financial markets and news headlines, to mention a few, will be accessible to the consumer. A channel dedicated to this service (over the air or on cable) could expand the service to 10,000 or more pages. Also, on cable, the system can become interactive, allowing the consumer to purchase items, submit responses to questions, or conduct his banking. If we include the telephone as the source of data, the pages available become almost unlimited.

Table II. Competition for an audience growing from 76.3-million TV homes in 1979 to 91.6-million homes in 1990 will result in a change in viewing habits. The figures shown are an average of those people with and without the new services. Research to date suggests that new delivery systems increase viewing.

	1980 *Average Weekly Viewing Per Household (hours)*	*Share %*	1990* *Average Weekly Viewing Per Household (hours)*	*Share %*
Network Stations	39	85.8	35	73.8
Independents	5	11	6.4	13
PBS	0.9	2	0.8	2
Cable Originated	0.1	0.1	1	2
Pay Cable	0.3	0.8	2.1	4
Subscription TV			0.3	1
Direct Broadcast Satellite			0.1	0.2
Video Cassette			1	1
Video Disc	0.1	0.3	0.8	2
Home Computer			0.2	0.4
Teletext/Viewdata			0.3	0.6
	45.4	100.0	48.1	100.0

* Based on weighted availability and expected age.

Teletext/viewdata will lead to the growth of a new business. Information providers, such as newspapers, stock exchanges, and the like, will have to reach their audiences through "systems operators." Already, we see these developing with companies like Prestel, Infomart, and Time, Inc. currently positioning themselves in this area. These organizations will be similar to computer centers in their technical orientation, but they will be dealing with the general public and information providers. They will provide the means for information providers to reach the consumer. Perhaps the first market will be "closed user groups" such as stock brokers, doctors, or individual investors.

Greater choice will result in more individual viewing with more displays per home. We anticipate that with the many new add-on devices including cable converters, direct broadcast satellite terminals, subscription TV descramblers, teletext and viewdata decoders, alarms connected to the cable system and telephone feeds to the TV, a modular concept will likely develop.

Glossary

Network stations	Includes ABC, CBS, NBC, and their affiliates.
PBS	Public Broadcasting System.
Independents	All other TV broadcasters excluding pay services.
Cable	A basic cable service is made up of programs distributed by network stations, PBS, and independents.
Pay cable	This is a subset of cable service and includes, for a premium, homes receiving additional channels designed for this service.
Subscription TV	This is an over-the-air pay service, using a scrambled signal. Descramblers can be rented from the signal originator.
Direct broadcast satellite	This is a subscription service, using a satellite to transmit to the home. Programming is paid for monthly. It could be advertiser supported.
Video cassette recorders	Video recorders are used to record and play back TV programming and play back purchased or leased tapes.
Video disc players	Play back devices using a recording on a disc, and home TVs for display.
Home computers	Computers, with programming capability, that may also be used for video games and videotex.
Games	Games using the TV as a display.
Teletext/videotext	Systems that use broadcast TV, cable, or the telephone lines to transmit pages of information to the home TV.

TV networks

Now, let us examine the environment of the networks. In the 1980s, evolution of the new technologies will begin to provide the American household with more entertainment alternatives. For the networks, however, the franchise of providing mass entertainment to the mass audience and attracting mass advertising revenues, appears to be relatively secure. The networks efficiently finance many hours of very expensive programming and combine this programming into a schedule providing a highly entertaining, free service to a mass audience. At this time, it does not appear likely that another entity would risk the huge amounts of capital necessary for entry into this free, mass entertainment market. For these reasons, we project only slightly diminished network revenue growth.

For the new video technologies, the growth is projected to be quite rapid. The demand especially for programming will escalate dramatically over the next decade. In anticipation of this, all three networks are taking steps to prepare non-broadcast programming for the new media. ABC and CBS have been particularly aggressive in developing cultural cable services, although research indicates that such specialized programming services, offered on an advertiser-supported basis, may not be economical. RCA has just announced its entry into the pay cable area in a joint venture.

We identified several potential threats to the commercial television networks during the next decade from new "over-the-air" broadcasters. It is argued that the increased availability of satellite channels will dramatically reduce the costs of program distribution from those charged by AT&T for land-line service for occasional network use. Thus, access to the network's audiences could be relatively cheap. But distribution costs are only a small part of overall network costs, and any reduction would only slightly change the overall economics of the business for a potential competitor.

The most immediate perceived threat to the television networks is from increased demand for, and hence higher cost of, programming. Over the last several years, network programming costs have increased substantially. As the new technologies continue to demand more programming, the demand for all aspects of production — talent, directors, crew, facilities — will increase. This increased demand for limited resources will put even more upward pressure on programming costs.

Broadcast stations

Local broadcast stations are going to be faced with competition via cable from distant stations. Also, satellites

Video widens scope

Services available on an experimental basis to some TV viewers—electronic shopping and billing, merchandise catalogs, fire and burglary alarms—should be available to many more, according to Stanley E. Basara, Division Vice-President, Video Systems, CCSD.

"It seems clear that with all the stirrings in the video industry, our TV sets are not going to remain plain old TV sets much longer," Mr. Basara said.

One recent change in the use of television is RCA's video disc. RCA introduced the video disc system in March and in the first five weeks consumers bought 26,000 players and 200,000 discs. By comparison, in the first year of availability, consumers bought 5,000 color televisions, and 30,000 microwave ovens.

RCA expects to sell some 200,000 players in the first year, and by 1990, the company foresees video discs as a $2.3 billion industry, supported by consumers who want more control over their television programming.

Other advances in the use of television called "teletext" and "viewdata" are likely to become more widespread, Mr. Basara said.

Teletext experiments, underway in several U.S. cities and in Europe, can provide hundreds of pages of printed information on such topics as weather, movie schedules, and traffic reports. The viewer uses a small decoder to select the information for display on his TV screen.

Viewdata, the name for a system that links the home television with information stored in a computer, has the potential to bring the library into the home or provide electronic shopping and billing.

Cable television, in addition to its multitude of channels, can provide two-way interactive services. A growing number of cable television systems offers burglar, fire and medical alarm signals that travel 'upstream' on the two-way cable to a central control point where the signal is monitored. Another use of cable's two-way capability allows viewers to answer questions by pressing the buttons on a small device in the home.

"A major task will be to channel the new developments of our time into areas that will contribute to man's well being," Mr. Basara said. "I think all of us can agree that how well we manage our new technology will have a strong bearing on the course of our economy and our social progress."

will give homes access to additional programming. The stations are going to be more automated. The signal processing that is going on with this change will become more and more digital. The growth of teletext (pages of information) will result in additional revenue for the broadcast station. It is anticipated that production activity will increase. Also, the drive for automation will increase because of rising labor costs.

Cable TV operators

The cable TV operator is going to find it more difficult to expand his business by installing more wire. Right now we have about 50 percent of the homes passed by cable connected. This puts a ceiling on the business at about 50 percent penetration, if this ratio holds. Pay TV however, will lead to higher penetration. Also, the number of channels will increase. Additional services, such as burglar alarms and home information systems, will result in growth. Shopping and accessing news through cable systems will become commonplace.

Satellite programs distributors

The satellite program distributor is a new "player" in the system. Home Box Office and Showtime are two of the thirty-one program streams being carried. We anticipate that satellite capacity will increase rapidly. Currently, stemming from the growth in subscription TV and pay cable, there is sufficient backlog in demand to justify four or five new satellites.

Direct-to-the-home satellite transmissions are now broadcasting on an experimental basis in Canada (Fig. 1). RCA has applied to the FCC for permission to launch such a system. One must remember that only a limited number of satellites can be put in orbit. Positions technically acceptable to this

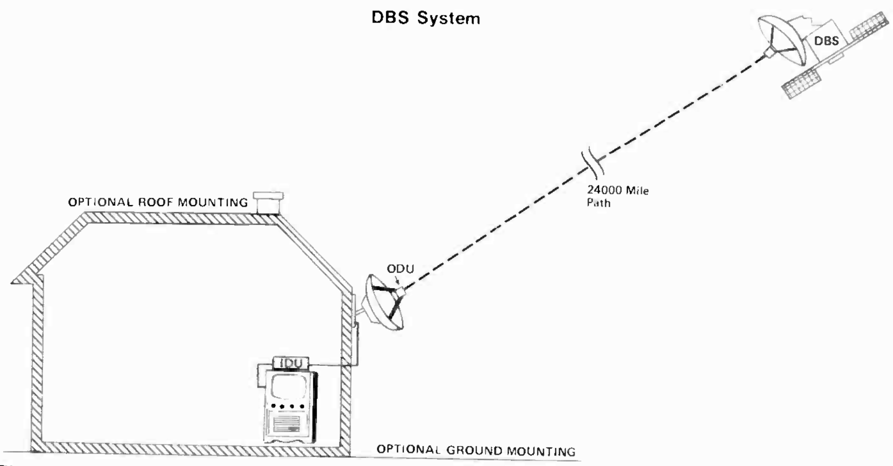

Fig. 1. Using receiving units with receiving dishes that are one meter or less in diameter, homes will be able to receive additional TV channels. Filings have been submitted to the F.C.C. using 12 GHz downlink transmission and 17 GHz uplink, the system costs a subscriber roughly $25/month. With 10 percent penetration of U.S. homes, this is a 2.7-billion-dollar-per-year business.

service are finite and may be scarce due to the need to provide service to all countries in the Western hemisphere. This business may, at least in the initial stages, be a form of subscription TV feeding both cable systems and consumers.

Video cassette manufacturers

Video cassette recorders will be available with cameras. We have made the assumption that at the planned price levels they will not compete directly with the video disc and will be in 17 percent of the homes by 1990. We anticipate growth in the area of features.

Video disc manufacturers

We anticipate 28-percent penetration of U.S. homes by the video disc. Discs cost $15 to $25 and the players cost under $500. This device will appeal to the specialty areas as well as the mass market. Stereo and features, such as freeze frame, will be introduced.

Feature film producers

There is another profitable business growing out of all this video development — feature film production. Video delivery systems will create a tremendous demand for software, and the producers will be in a position to pick and choose customers. We have the growth of subscription television, pay TV, discs, cassettes, and so on. Producers are going to be in a seller's market. We have an expected release sequence of distribution based on fees per viewer. To get the maximum income per viewer, the producer will release their shows first to the theatres, then to video disc, cassettes, pay cable and, finally, the networks and syndication.

Cable installations

A number of items are changing in the cable business. You will recall that this is a fast-growth business and cable now has to be put in on a two-way compatible basis. You do not have to activate it immediately — we have modules that snap in place to do this. Hence, the systems now being installed are compatible with the installation of such items as burglar and fire alarms.

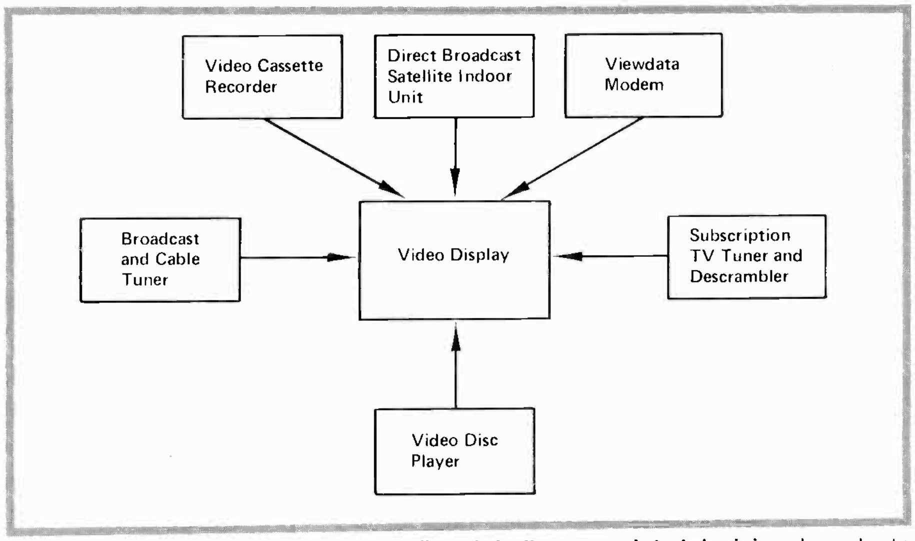

Fig. 2. The major components of the "modular" approach to television. In order to have a manageable system, the consumer needs something other than today's wired connecting systems. Also, packaging of the various black boxes must be improved upon to make multiple options viable.

Cable operators

There are two supplier groups to the cable business — traditional cable suppliers, and the satellite and earth station vendors. We anticipate that local origination will grow and it will be important to deal with the few consolidated operators that are left.

We also see a data base opportunity for the cable operator. Using a frame-grab system, it is possible to put 10,000 pages on a cable-TV channel. This is the equivalent of five daily newspapers. The consumer can then select information of interest through a key pad. This can be thought of as a new means of distributing newspapers and is known as cabletext.

TV set manufacturers

The internal design of TV sets probably will change significantly. Digital electronics will be used, resulting in more accurate, stable, and economical products. Also, more features will be possible. The growth of cable will result in additional channels being inserted between channels 6 and 7, and 13 and 14. Of course, the market for add-ons will grow. Converters for cable, antennas for direct broadcast satellites, subscription TV descramblers, teletext and viewdata decoders, and finally, telephone feeds will contribute to this burgeoning market. Multiple set demand will grow. Of course, there will be a continuation of demand for improved quality and cost reductions. The growth of video discs will result in stereo and bilingual audio in TV and we anticipate the growth of a modular concept. The growth of video cassette recorders, video discs, teletext decoders, viewdata, cable text decoders, security systems connected to cable systems, home computers, and subscription TV will antiquate the current method of putting add-on devices beside or on top of TVs. Instead, something akin to the modular concept now realized in stereo will result in the need for such features as remote switching and video inputs and outputs (Fig. 2).

Size of opportunity

To put these various opportunities in perspective, we developed Table III to show the areas of growth. It should be

Table III. The size and growth rates of the video businesses. Areas of fast growth, where market shares are not established, and no single company has obtained a dominant share, are the best areas for market entry (Figures given in millions of dollars).

		1979	1990	*ACGR** (*percent*)
Advertising Revenues				
Network		4265	6831	
Spot		4592	3635	
Local		2305	5564	
	Total	9162	16030	5.2
Receiver Sales to Distributors				
Color		3615	5764	
Black and White		565	706	
Large Screen		100	260	
	Total	4280	6730	4.2
Pay TV (in Consumer Payments)				
Cable		1331	3985	
Pay Cable		479	2696	
Subscription TV		180	1705	
Direct Broadcast Satellite		0	1104	
	Total	1990	9490	15.3
Home Video Entertainment/Information Sales to Distributor				
VCR and Cameras		346	1500	
Video Disc		—	2300	
Home Computers		175	700	
Games		120	25	
Viewdata/Cabletext, Teletext		—	1200	
	Total	641	5725	22.0
	Grand Total	16073	37975	8.1

* *Average Compound Growth Rate*

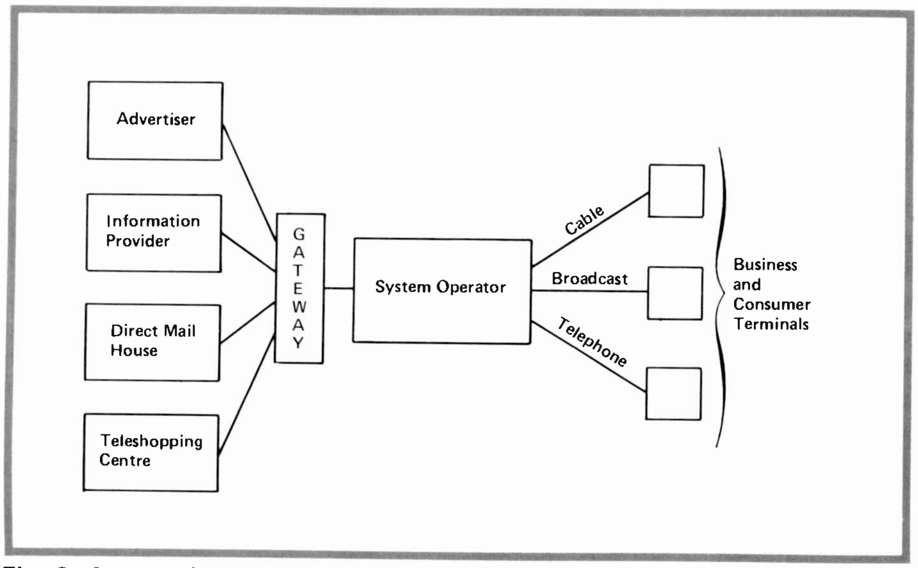

Fig. 3. A new, developing business is based on the "Systems Operator" that interfaces between various data providers and end users. Using a monthly revenue figure of $20 per subscriber (revenue can come from advertisers and consumers) industry participants forecast a market of $12 billion by the mid 1980s. This system allows access to games, advertising, newspapers and teleshopping—a system whereby you can order products from catalogues. The system can be two-way over cable and phone lines with one-way data being put up on TV channels using the vertical blanking lines available.

stressed that these amounts are in constant dollars.

Of some interest is the experience of firms entering new businesses. According to a recent study, entrants into mature markets recorded the worst financial performance. Also, entrants into highly concentrated markets (that is, dominated by a few firms) had a poor record. Entry on a small scale also caused failures. Hence, it appears that success is most likely if the market is fragmented and has high growth and a major commitment is made. This is particularly true if the marketing of the product is similar to the approach already used by the firm in other areas. It is apparent that the major growth opportunities lie in the last two groups where growth is high and market shares are fluid.

With this background, let us look at some marketing changes that will occur. First, although the total viewing of network TV will grow, viewing per home will fall. To some extent this will be picked up by independent broadcasters resulting in TV being more local in nature. However, much bigger changes will occur.

Teletext and viewdata will result in a different approach to advertising. Figure 3 shows the essence of a new business growing out of this. The systems operator (AT&T, for example) allows advertisers, information providers, direct mail houses, and teleshopping centers to reach business and consumer terminals. The consumer will be able to interact with his TV to call up pages with a keypad. Access to over 100,000 pages is expected. Teletext and viewdata will bring a complete new world to advertising on TV. The viewer first must want to look at a page of information. Secondly, the information provider must learn a new approach to graphics. A few illustrations of this are possibly worthy of discussion. Shown in Fig. 4 is a possible advertising page. Note the detailed graphics. A second approach is shown in Fig. 5.

The possibilities of these services are enormous. Have you considered the possibility of a retailer deciding on advertising specials on slow days and

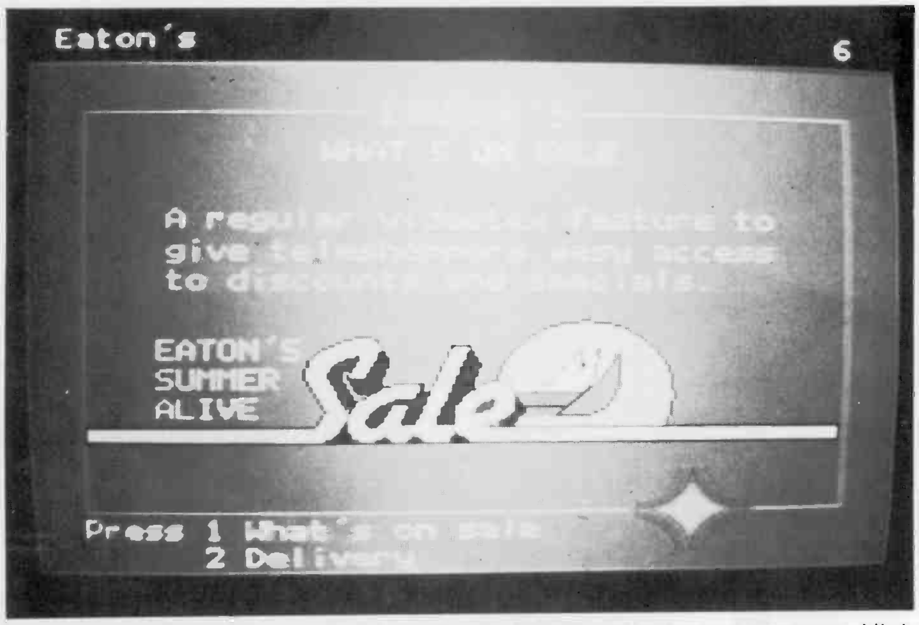

Fig. 4. Advertising is expected to make major use of videotext systems. High quality graphics will play a role in this area.

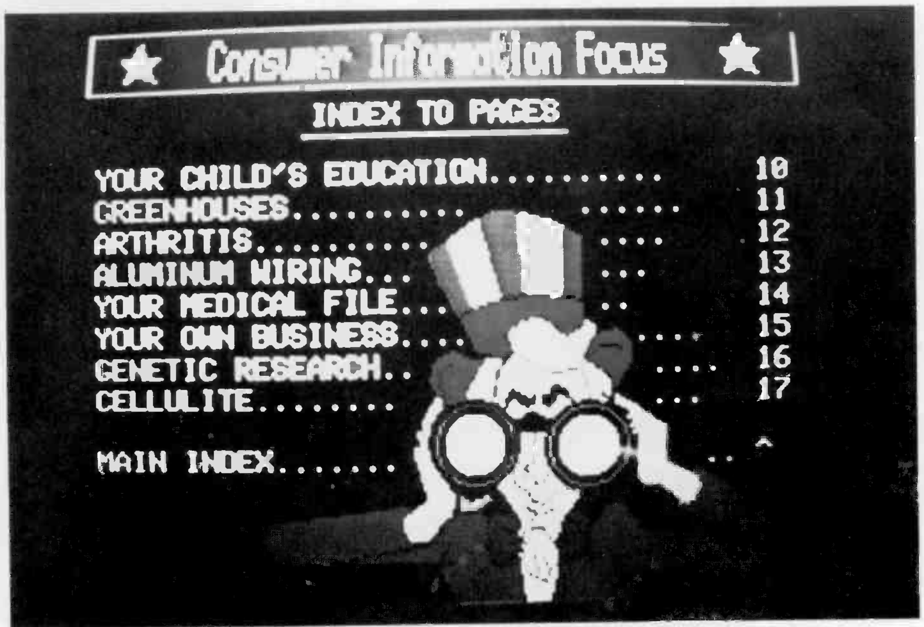

Fig. 5. Using index pages in sequence, it will be possible for systems users to work their way down to detailed information such as a single item in a catalog.

having them on the air within an hour. Think of the direct mail applications. To put this in perspective, direct mail alone is already a 35- to 45-billion-dollar-a-year business.

Cable programming from satellite networks will be reaching more than a third of the consumers and maybe as many as half. The firms that develop early long-term agreements to advertise in this medium will clearly have a major national edge.

Subscription TV from local transmitters and satellites also will provide new possibilities. A penetration rate of 12 percent aimed at a high income group should offer possibilities to target special markets.

Video discs and video cassettes offer special opportunities. Tennis lessons brought to you on subsidized media by major equipment suppliers or home repair instructions brought to you by material suppliers are going to be the domain of those who are quick to get started.

Keith Drysdale is Director on the staff of the Electronic Business Development Committee. He is responsible for the identification of new business oportunities and the preparation and implementation of related entry strategies. In 1961, he joined RCA Limited as Administrator, New Product Development. In 1964, he was awarded a David Sarnoff Fellowship and obtained the MBA in 1966.

He held a variety of management positions at RCA Limited. In 1977, he was transferred to Indianapolis where he spent a year as Manager, Product Analysis. Then in October of 1978, he transferred to New York to assume his present position.

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If one thinks that these changes are peripheral to the marketer's ways of reaching the consumer, notice that it is the major newspapers who are among the first to move into these areas. Harte Hanks, Dow Jones, the owners of *The New York Times,* and *The Toronto Star* are among the many who are experimenting today. They are positioning themselves for the 1990s. Clearly, there will be a major shake out of those institutions and people who do not prepare.

If one steps back and looks at these opportunities, one cannot help but be certain that RCA is in a unique position to take advantage of them. But financial constraints will make it impossible to proceed with them all. The important thing will be to select a few items and do them well. The tough decisions are ahead.

A.F. Inglis

Satellite television distribution

Ten years ago, satellite television was an interesting toy. Now, there's a waiting line for satellite service.

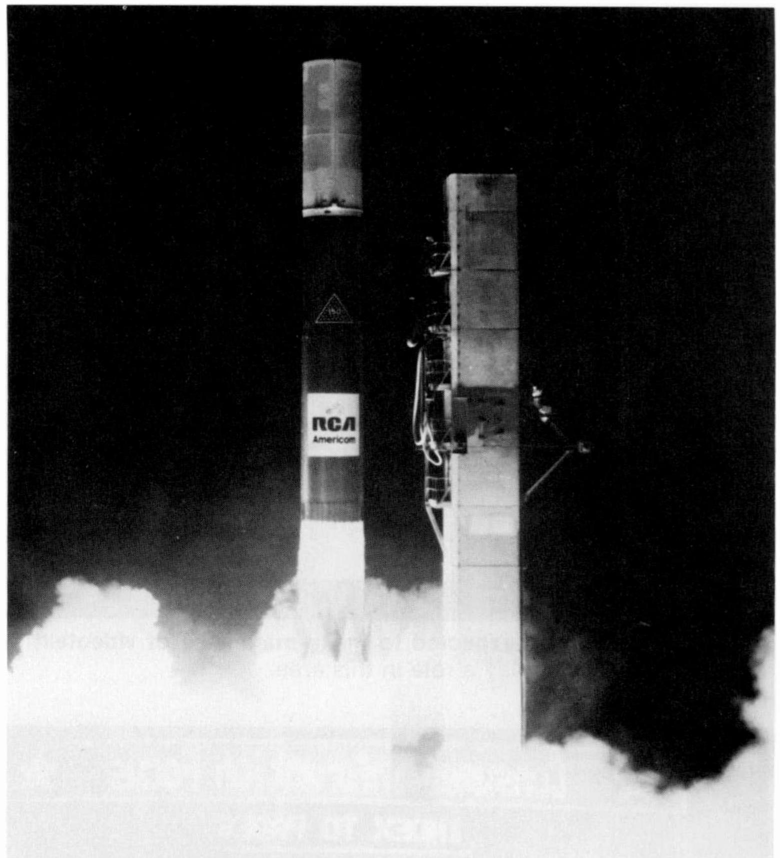


Fig. 1. RCA SATCOM launch.

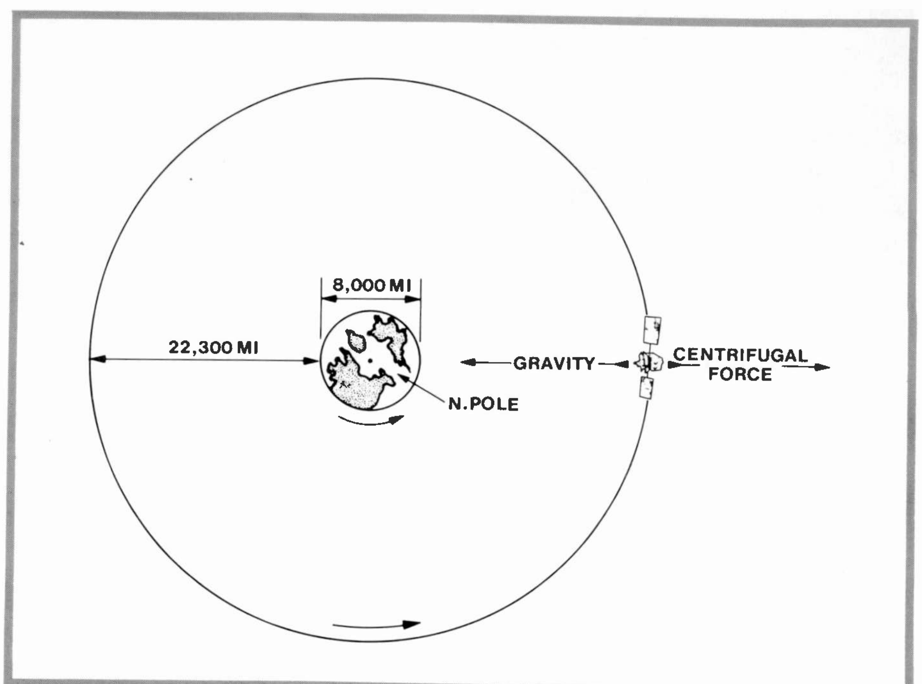
Abstract: *This paper discusses the evolution of the communications satellite from its beginnings as an interesting, but not-too-useful, relayer of special events to its position today as an indispensible television and radio communications link. Today's demand for satellite services far outstrips the supply, and new ways of increasing the efficiency of communications satellites are being explored.*

The launching of a communications satellite is a spectacular, indeed, an awesome sight. Figure 1 shows the launch of an RCA SATCOM satellite (Fig. 2) into orbital position 22,300 miles above the equator, where it will remain for seven years or more.

Technical overview

Geosynchronous satellites

All United States communications satellites are "geosynchronous"—they are located at an altitude of 22,300 miles above the equator. At this distance, the gravitational and centrifugal forces on the satellite are precisely balanced when it is revolving at the same angular velocity as the earth, that is, one revolution per day. Under these conditions, the satellite will be at a fixed location over the earth. Thus, unlike earlier communications satellites that were non-synchronous with the earth's rotation, the earth station antennas can be pointed in a fixed direction, making it unnecessary for them to track the satellite as it traverses space.



Geosynchronous satellite.

Reprint RE-26-7-3
Final manuscript received March 30, 1981.

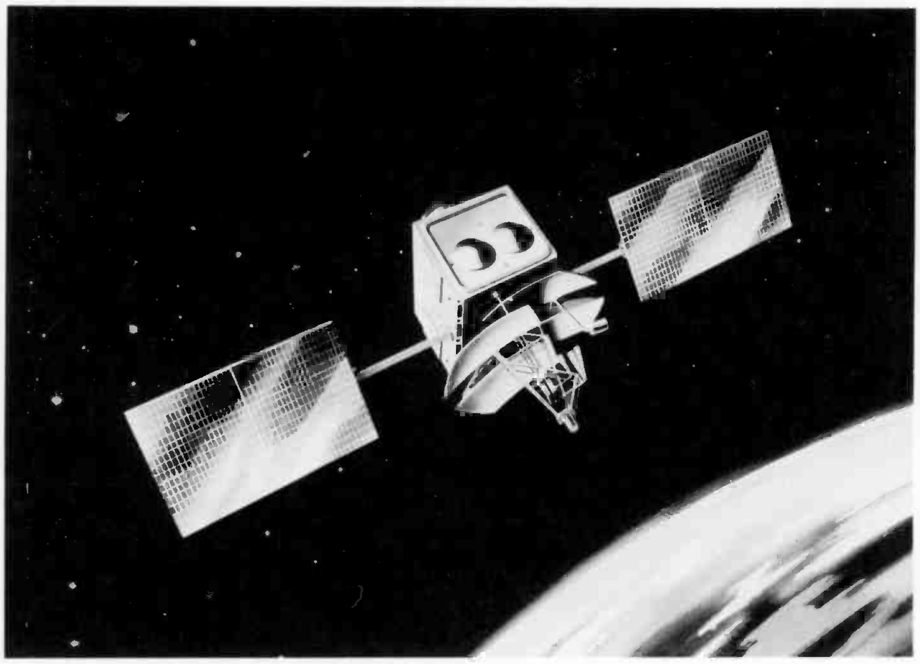


Fig. 2. RCA SATCOM orbital position.

Communications satellite operation

The basic operation of a communications satellite is shown in Fig. 3. The signal is transmitted to the satellite from the earth station in a narrow, intense beam, typically 0.1° in cross-section. It is received by the satellite, shifted in frequency, and amplified in a transponder that has an output power of 5 to 10 Watts. The signal is then directed back to earth. The return beam can be broad, for wide-area coverage, a narrower spot beam, or a combination. RCA satellites now serving the United States employ wide-area coverage, although these are sometimes supplemented by low-power spot beams to cover small isolated areas, such as the Hawaiian Islands.

Frequency allocation and orbital spacing

The frequencies currently allocated for satellite communications in the United States are designated as C-band or K-band, as shown in Table I. The choice of orbital spacing is a difficult and critical one. Because adjacent satellites in the orbital arc use the same frequencies, spatial separation is necessary to avoid inter-satellite interference. As satellites are placed closer together, larger and more costly earth station antennas must be employed to eliminate this interference. On the other hand, closer spacing also increases the satellite capacity of the orbital arc. The best compromise between earth-station cost and spatial separation is 4-degree orbital spacing and receiving antennas with a diameter of 5-meters or less. As the demand for satellite communication increases, there will be increasing pressure to reduce even this orbital spacing.

A portion of the K-band has been set aside for direct-to-the-home broadcasting. The orbital spacing for this may have to be greater than for communications satellites because home receivers will have to use very small antennas to be economically feasible. These very small antennas cannot discriminate between signals from adjacent satellites as well as the larger antennas can.

Both C-band and K-band have advantages and disadvantages. With K-band, smaller, less expensive antennas can be employed, and orbital spacing can be reduced — both definite advantages. Because this portion of the spectrum is not shared with terrestrial microwave systems, there is no regulatory limit to the power density of the downlink. In C-band, the power density is limited by the FCC in order to avoid interference to microwave systems, placing a lower limit on the cost of earth-station receivers. Finally, the absence of frequency sharing in K-band makes it unnecessary to consider the location of existing microwave systems when determining the sites for satellite earth stations. However, heavy rainfall can cause severe attenuation of K-band signals, at the very least degrading them, and sometimes causing loss of service. Rainfall can also cause rotation of the plane of polarization, possibly affecting the use of cross-polarization in K-band. C-band is relatively free

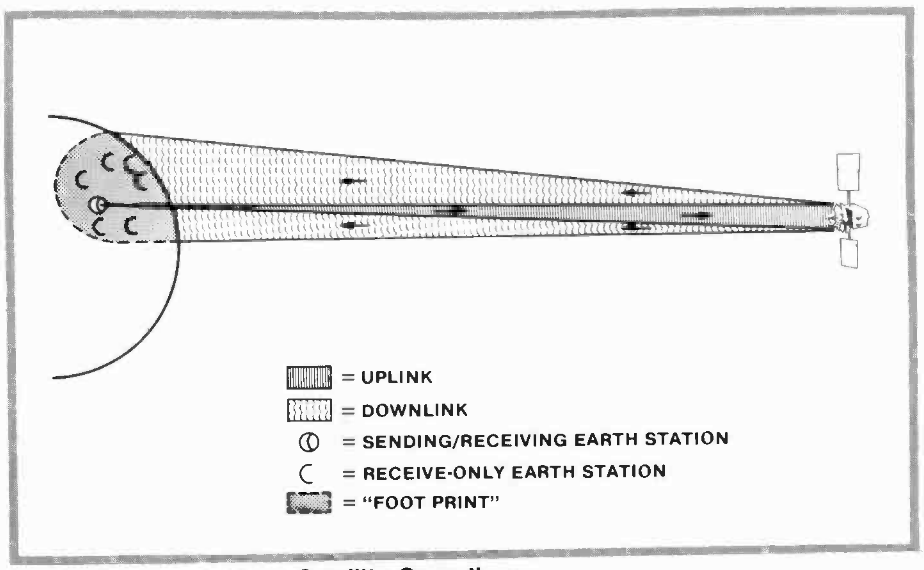


Fig. 3. Communications Satellite Operation.

Table I. Satellite frequency allocation.

C-Band Communications	
Uplink	6 GHz
Downlink	4 GHz
Orbital Spacing	4 degrees
(Canada uses 5 degrees)	
NB: These frequencies are shared by terrestrial microwave systems.	
K-Band Communications (Ku Band)	
Uplink	14 GHz
Downlink	12 GHz
Orbital spacing	3 degrees
K-Band Direct Broadcast	
Uplink	17 GHz
Downlink	12 GHz
Orbital spacing	To be established

from atmospheric interference, particularly rainfall, so it can very effectively use cross-polarization. This technique can double the capacity of a satellite system.

Until very recently, all United States carriers had chosen C-band, but Satellite Business Systems, a new communications common carrier, has just launched a K-band satellite. The ultimate shortage of C-band capacity, and the advantages of K-band for certain applications, make it certain that both bands will ultimately experience full development.

Spectrum utilization

With 500 MHz at their disposal for each satellite, the pioneering satellite systems engineers had the problem of deciding how best to use it and, specifically, of determining the optimum bandwidth and number of transponders per satellite. They chose twelve 36-MHz transponders, each with a 4-MHz guard band. Even with repeated study of this question, and after several years of operating experience, the conclusion is the same — 36 MHz is the optimum bandwidth, especially for a multipurpose satellite system.

With this bandwidth, each transponder has the capacity of one television channel or approximately 1,000 duplex voice channels, with currently used modulation techniques. Great progress has been made in transponder utilization, and further advances are expected in the future.

Cross-polarization doubles the capacity of a satellite. Twelve transponders are operated on each polarization. The frequency assignments are shown in Fig. 4. The channels are staggered so that the center of each channel, where the power density is greatest, is located on a guard band for the opposite polarization. This channel staggering, together with the isolation provided by cross-polarization, permits frequency reuse with a minimum of interference effects. The staggering also provides frequency space for satellite tracking, telemetry, and command (TT&C) services.

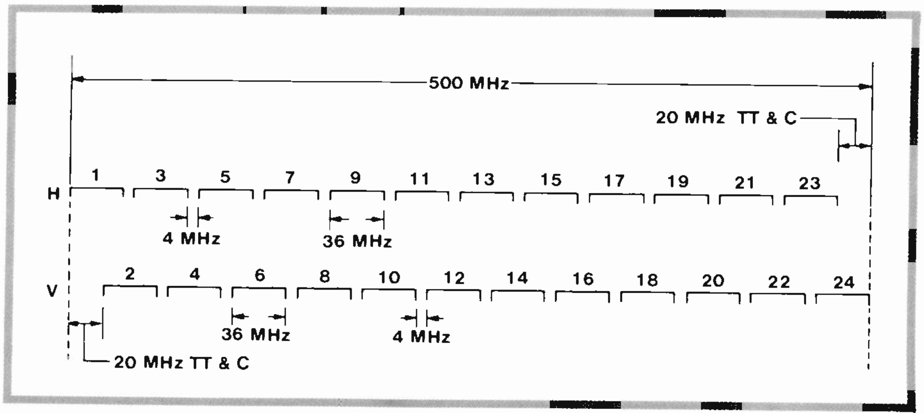


Fig. 4. Cross-polarization transponder frequency assignment.

The current United States satellite system

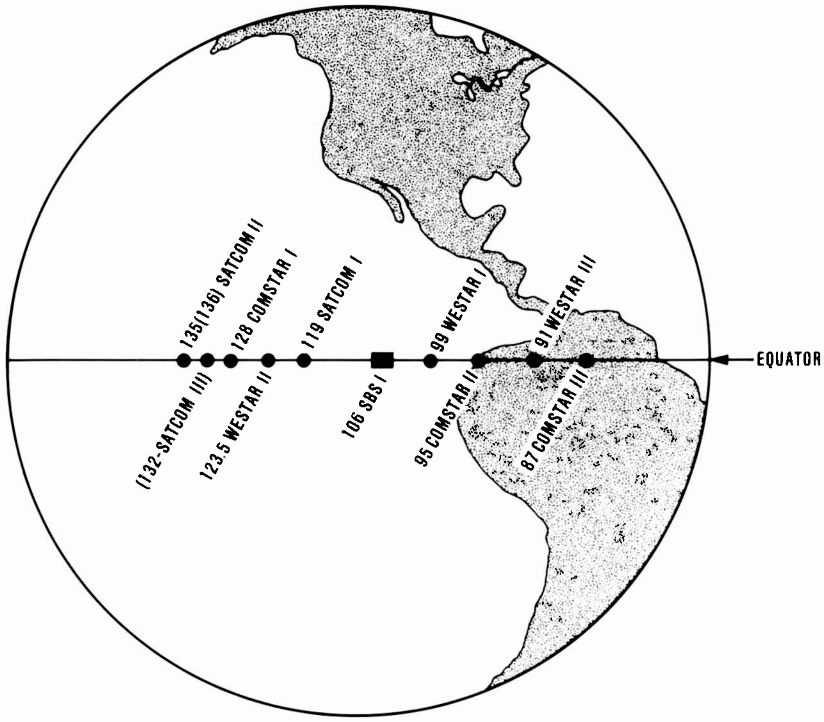
Regulatory policy

The regulatory environment is summarized in two words: "Open Skies." This policy, first established by the FCC in 1972, provides that any qualified legal entity can apply for a permit to construct a satellite system and can become a satellite carrier offering specialized communications services. This right was not limited to established carriers, and particularly not to AT&T. In fact, the FCC went a step further and placed a three-year moratorium on AT&T's right to use its satellites for private-line services, the marketplace to be addressed by the specialized satellite carriers. The purpose was to give the smaller specialized carriers a running start against their huge competitor. This purpose was served, and the moratorium expired in July 1979.

Orbital locations

Nine communications satellites now serve the United States — eight are C-band and one is K-band. The K-band satellite is owned by SBS, a parternship of IBM, COMSAT General and Aetna Life and Casualty Co. AT&T is the licensee of the three COMSTAR satellites, while Western Union owns and is the licensee of three WESTARs with plans to share ownership with American Satellite Company (AMSAT)). RCA Americom is the owner and licensee of the SATCOM series.

Most of these satellites are located to the west of center of the continental United States. These westerly locations are required to provide service to Alaska and Hawaii.



Domestic satellites serving the U.S.

Usage

AT&T leases the three COMSTAR satellites from Comsat General, the non-regulated subsidiary of COMSAT. Each satellite has 24 transponders. The system is shared by GT&E's telephone subsidiary. AT&T uses one satellite as an in-orbit spare, which is used only for preemptible traffic such as occasional TV and teleconferencing. It is being used temporarily by RCA (until its next satellite is launched later this year).

AT&T uses the other two satellites primarily to augment its long-haul (over 1,000 miles) intercity microwave network. Their importance in this application can be judged by AT&T's recent filing for second generation satellites to replace the COMSTAR series.

Western Union has three satellites of an older design with 12 transponders each. They do not employ cross-polarization. Five transponders are leased to AMSAT, which is owned jointly by Fairchild Industries and Continental Telephone. AMSAT offers voice and data private-line service in competition with RCA and Western Union. RCA Americom's two satellites were launched in late 1975 and early 1976. They employ cross-polarization and have 24 transponders each. In addition, 11 transponders are leased temporarily from AT&T on the COMSTAR system. The RCA Americom system is given in Table II.

The seven message traffic transponders are used primarily for voice. Two of the government transponders carry specialized wide-band data circuits for the Department of Defense and for NASA; the other one is used by the American Forces Radio and Television Service (AFRTS) to distribute television programs to American personnel stationed outside the United States. This service currently is confined to the western hemisphere, but in the future, it will be extended to Europe and the Far East through the Intelsat system. Fourteen transponders are employed for Alaskan traffic, and the remaining transponders are used for CONUS television traffic, most of them in the two cable-TV networks.

Pending applications with the FCC

The current demand for satellite capacity far outstrips the supply. The FCC has been swamped during the past year with applications to construct satellites and for orbital slots. Table III summarizes the applications currently on file and awaiting FCC action. SBS, with one K-band satellite in orbit, plans to complete its system with two more. GTE, which has the largest independent telephone company in the United States, has applied for a three-satellite, K-band system. Western Union has applied for its fourth and fifth satellites, which will have 24 transponders each — WESTAR IV will replace WESTAR I and II. Western Union is constructing

Table II. RCA Americom satellite system.

Satellite	*Number of Transponders*
SATCOM I	24
SATCOM II	24
COMSTAR D-2 (leased)	11
	59
Transponder Loading	
—Message traffic	7
—Government service	3
—Alaskan traffic	14
—Television	
Cable net 1	20
Cable net 2	11
Major networks	1
—Inoperable	3
	59

Table III. Satellite applications on file.

Applicant	*Satellite*	*Band*
SBS	SBS II	K
	SBS III	K
GT&E	GTE I	K
	GTE II	K
	GTE III	K
Western Union	WESTAR IV (to replace I and II)	C
	WESTAR V	C
	AW I	C & K
	AW II	C & K
AT&T	D-4	C
	D-1R*	C
	D-2R*	C
	D-3R*	C
RCA	SATCOM IIIR	C
	SATCOM IV	C
	SATCOM V	C
	SATCOM IR	C
	SATCOM IIR	C
Hughes	HUGHES I	C
	HUGHES II	C
	HUGHES III	C
Southern Pacific	SPI	C & K
	SPII	C & K
	SPIII	C & K
	SPIV	C & K

*R designates replacement.

two other satellites designated as "Advanced WESTAR." These are hybrids — C- and K-band — and they were piggy-backed to provide tracking and telemetry circuits for the Space Shuttle.

AT&T has filed applications for replacements for its current COMSTAR satellites. In addition, the company launched its ground spare, D-4, in 1981. It will co-locate with D-2 and, by sharing its load, extend its life.

RCA expects SATCOMs IIIR and IV to be launched later in 1981. In addition, RCA has applied for SATCOM V and replacements for SATCOMs I and II.

There are two companies entering the satellite business for the first time: Hughes Communications, a subsidiary of Hughes Aircraft (a major satellite manufacturer); and Southern Pacific Communications, a subsidiary of the Southern Pacific Company, which operates a major railroad system. SPC is a leading specialized common carrier and is presently a major customer of RCA for intercity trunk circuits.

These 25 satellites will be launched over the next five years. After they are all in place, the capacity of the United States satellite communications system will be more than doubled. They will represent a total satellite investment of approximately two billion dollars.

Broadcast television

Major networks

The key to truly widespread use of satellites by the broadcast industry would be its adoption as a primary distribution method by the major networks — NBC, CBS, and ABC. This has not happened yet for several reasons.

The most powerful immediate impediment, perhaps, is the fact that there is an extensive terrestrial microwave system. This system is generally satisfactory, although it does not meet uniformly high standards of signal quality in all locations. Given this situation, the networks are not under pressure to make a rapid change to satellites.

A more fundamental problem is that satellites do not provide a cost-effective means of fulfilling all of the extraordinarily complex distribution needs of the major TV networks. A typical distribution system for a major network is not a simple point-to-multipoint system. It is an intricate matrix with a multiplicity of local loops and intercity trunks interconnected through the system's switching centers. Extensive studies have been made of satellite systems that would meet all of the requirements of the major TV networks. In each case, the conclusion has been the same — an all-satellite network would require an enormous capital investment, and when completed would, at best, provide no economic advantages over the present system.

The answer is a judicious combination of satellites and terrestrial facilities, each being used where it has the advantage of cost or performance. The networks are moving in that direction now, and each one is making use of satellites for limited point-to-point service.

Specialized networks

The specialized networks are a different picture. These networks are operated on a more modest scale, and their programming is directed toward limited segments of the viewing audience. Their distribution requirements are quite different from those of the major networks. Specifically, their needs are primarily for the one-way, point-to-multipoint circuits for which satellites are so well suited.

Two independent networks that use satellite distribution are the Public Broadcasting Service (PBS) and the Spanish International Network (SIN). PBS offers a program schedule directed at an audience with above average literary and musical tastes. It leases three transponders and provides service to 212 affiliates through 170 earth stations.

SIN directs its programming at the Spanish-speaking segment of our population. It has 53 affiliates that include full-power stations and a network of low-power translating stations that broadcast to areas with a high concentration of Spanish-speaking residents.

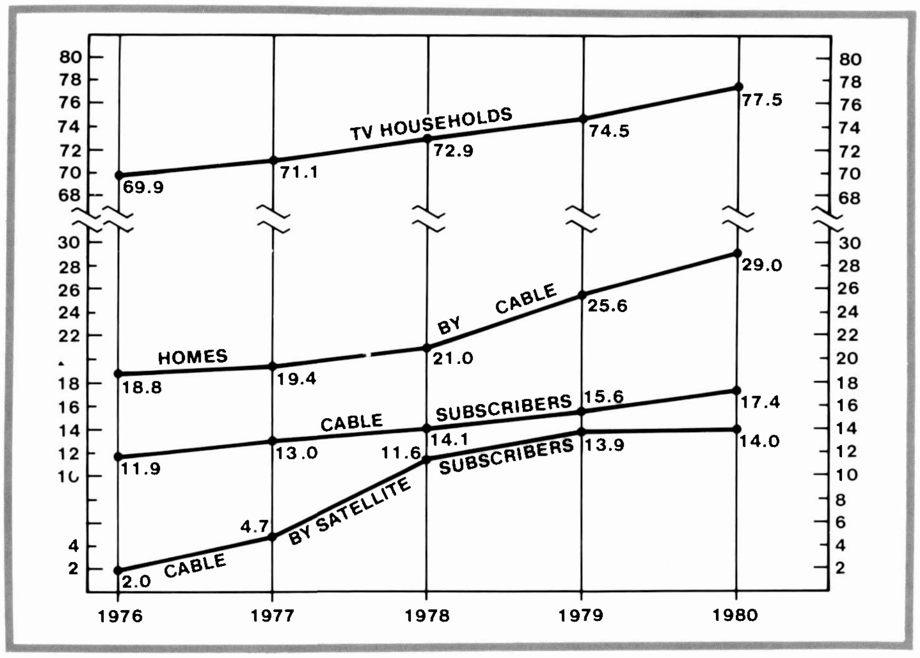
There is also an increasing use of satellites for what might be described as *ad hoc* networks. These are temporary networks formed to cover a single event or series of events. Satellites often provide the most economical method of distribution for these networks.

A word about SMARTS

Selective Multiple Address Radio and Television Service (SMARTS) was first introduced by RCA in 1979 as an end-to-end service that could be leased by anyone wishing to distribute programs to a group of television stations. This could be a major network, an independent network, or a program syndicator — an organization that sells prerecorded programs to TV stations and that now distributes them by shipping the tapes from station to station, a system known as "bicycling."

RCA can install an earth station on the premises of each TV station and then recover its cost by leasing the station to the program distributor as part of the end-to-end service from the originating point to the participating local stations. The TV signal can be transmitted in scrambled form and selectively descrambled at the receiving TV stations on command from the control center. Thus, the program distributor can select the precise complement of stations that he wishes to receive his program.

SMARTS received a great deal of attention, but is is proceeding rather slowly, for a number of reasons. The selective descrambling system requires considerable technical development, and this is now under way in a test system installed in the four Post-Newsweek stations in Hartford, Detroit, Jacksonville and Miami. The



Growth of cable TV.

market itself is growing slowly, but the prospects for this service are good — we expect major growth in the years ahead.

Cable television

Cable TV growth

During the past four years, the synergistic relationship between cable TV and satellites has been one of the most dramatic and revolutionary developments in the history of television. Cable television has been in use in the United States for more than 30 years. Its original purpose was to bring television service to areas which, because of geographic or distance barriers, were not receiving off-the-air broadcasts. Typically, an entrepreneur in a town in a valley would erect a receiving antenna on a nearby mountain top, bring the signal into town by cable or microwave, and distribute it through the town by cable. He charged an installation fee and a monthly rental.

After a few years, cable TV covered most of the areas' broadcast stations, and its growth would have slowed greatly had it not been for a second development — distant signal importation. Cable operators began bringing signals in by microwave from stations far outside the normal viewing range, sometimes several hundred miles. This practice permitted the cable operator to offer a greater selection of programs, even in areas that had satisfactory off-the-air service from local stations.

This development was controversial from a regulatory point of view, and it was the subject of extended litigation by the FCC and in the courts. The government's policy, however, has been to encourage the availability of the largest possible number of program sources to the public. Consistent with this policy, distant signal importation has been permitted, although with some limitations.

In spite of this development, however, the number of cable systems began to level off by the mid-seventies. The areas without cable were, for the most part, in or near major metropolitan centers where a multiplicity of satisfactory off-the-air signals were available. Cable could add little or nothing for the subscriber in these areas.

But then came the satellites. They provided an economical means of distributing program material, and they had the potential for bringing new program sources into even the largest metropolitan centers. Whereas cable had previously been confined to areas

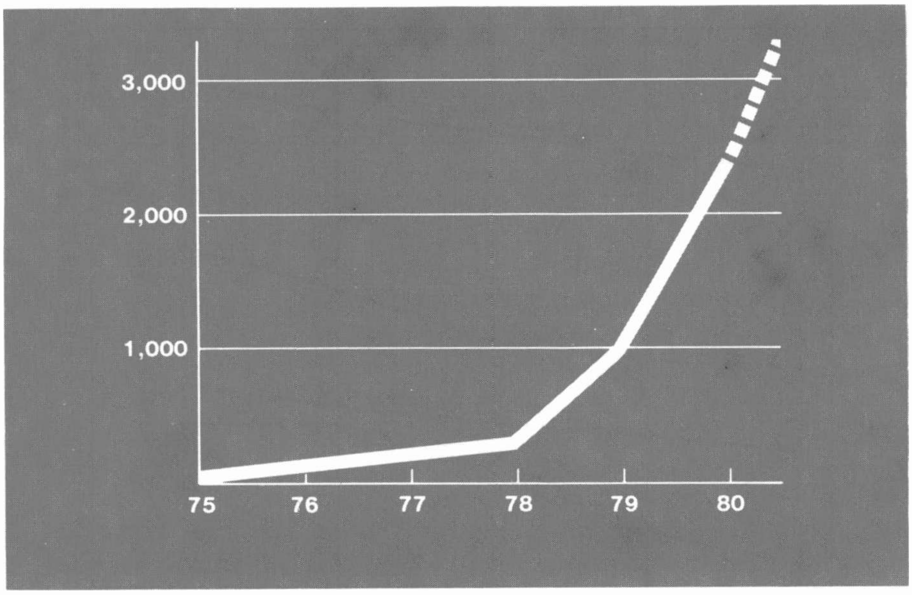


Fig. 5. Number of CATV earth terminals.

with limited local broadcast services, it now has become economically feasible everywhere except in the most sparsely populated areas.

Originally, the FCC required a minimum antenna diameter of 10 meters and an elaborate licensing procedure for cable television stations, but these requirements have been relaxed. The minimum diameter has been reduced to 4.5 meters, and compulsory licensing has been abolished. The relaxation of regulatory requirements, together with the proliferation of available program sources, has led to an explosion in the number of earth stations (Fig. 5).

Since 1976, the number of homes for which cable is available has increased by 55 percent, from 18.8 million to 29.0 million, and the number of subscribers with access to at least one satellite-distributed program has increased from zero in 1975 to nearly 14.0 million. The potential market for cable television is estimated to be at least 50 million homes.

A future development — direct broadcast service

No technical development has stimulated more interest, both within the industry and with the general public, than broadcasting from a satellite direct to the home. There is something exciting about the idea of a tiny antenna, located perhaps in the attic, picking up programs from a satellite more than 22,000 miles in space.

The major technical issue facing direct broadcast service is really an economic one. Can a satellite be put into orbit that is sufficiently powerful to provide satisfactory service with a small, inexpensive earth-station receiver in the home? Table IV shows an order-of-magnitude comparison of the technical parameters typically employed in existing cable systems and those that might be achieved in a hypothetical direct broadcasting system.

The present C-band transponder output could be increased to 400 Watts in a direct broadcast satellite (DBS), providing an advantage of 19 dB. An additional advantage could be achieved by using a more directional antenna on the satellite, concentrating the energy in a single time zone rather than spreading it over the entire continental United States. This would increase the signal level by 6 dB. The total signal level increase from the DBS satellite would be 25 dB.

For the home, assume an antenna diameter of 0.6 meter — this is 1/70 of the area of the typical 5-meter antenna used by cable systems, and it would result in a relative loss of 18 dB. The other costly element in the receiver is the amplifier. Engineers rate these with an arcane criterion known as equivalent noise temperature. A low equivalent temperature is good — and also expensive. This assumes a 120 K (Kelvin scale) cable-system receiver and a cheaper one, 30 K, for the home receiver. The total amplifier loss would be 4 dB. The resulting signal-to-noise ratio would be about 50 dB, a very satisfactory level.

It is immediately apparent that many other combinations and tradeoffs are possible. For example, the same bandwidth and modulations index have been assumed for DBS and for cable service. The World Administrative Radio Conference (WARC), however, recommends a narrower bandwidth for DBS, which would increase the system capacity. The adoption of this standard would result in a lower signal-to-noise ratio, assuming that the size of the downlink and home antenna remain the same, and the 300-K amplifier is used.

DBS offers the same potential

Table IV. Cable satellite vs. DBS satellite.

	Cable	*DBS*	*DBS/Cable*
Satellite			
Transponder power	5 Watts	400 Watts	19 dB
Coverage	Continental United States	Single Time zone	6 dB
			25 dB
Earth Station			
Antenna diameter	5 meter	0.6 meter	−18 dB
amplified equivalent temperature	120 K	300 K	− 4 dB
			−22 dB

augmentation of conventional broadcast service as cable — more channels and a greater diversity of program material. DBS, therefore, would find itself in competition with cable (Table V). Note that in areas where cable can be installed for $500 or less per home, it wins on every count.

The largest potential market for DBS would be where cable TV is unavailable. This could be in sparsely populated areas where the cost of cable is prohibitive, highly congested urban areas where technical problems of interference arise, and areas where cable is delayed indefinitely by local franchise problems. Another smaller market would be in areas where the local cable operator does not provide a full range of service. And there are the hobbyists, not an insignificant market, who would install receivers just for the excitement of receiving signals directly from a satellite.

This can be a very large market, perhaps in the range of 15-million to 30-million homes in the United States. A market of this size could very well support a healthy DBS system, an exciting prospect for the future.

Table V. Competitive comparison.

	Cable	*DBS*
Antenna system cost	$300 - $500	$500
Number of channels available	12 - 96	24 40
Local programming	Possible	No
Programs available:		
Broadcast	Yes	No
Non-broadcast	Yes	Yes

Andrew F. Inglis has been President of RCA American Communications, Inc., since 1977. Prior to his present position, he served as Division Vice-President and General Manager of RCA's Commercial Communications Systems Division. He joined RCA in 1953 as Manager, Studio Equipment Product Planning, later holding positions of increasing responsibility in the corporation's closed circuit television and broadcast equipment operations.

In 1958, Mr. Inglis was named Manager of the RCA Closed Circuit TV Department. He was appointed Division Vice-President of Communications Products Operations in 1963, and was located at the RCA engineering and manufacturing facility at Meadow Lands, Pa. He returned to Camden in 1966, as Division Vice-President of Engineering and Merchandising for the CES line of broadcast equipment.

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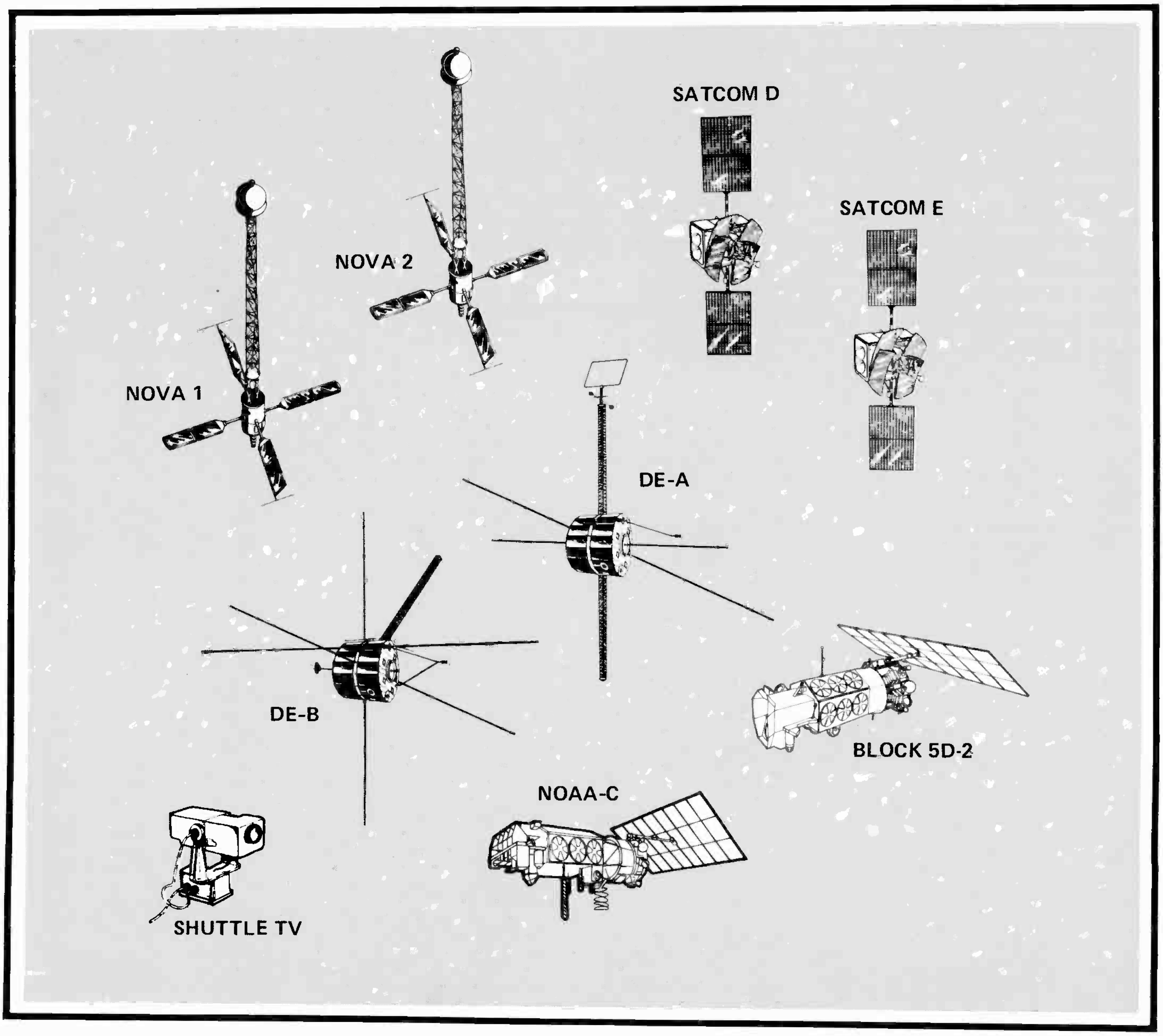
A. Schnapf

The 1981 RCA space constellation

RCA will put up to eight satellites into orbit over the next 12 months. Twenty-two years of experience help to make it look almost easy.



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Final manuscript received June 9, 1981

The constellation of spacecraft being readied at RCA Astro-Electronics for launch in 1981 will undertake a variety of missions including: commercial communication services from geostationary orbit; meteorological studies in low-earth orbit for the civilian and military organizations; navigational aids for the U.S. Navy, government, and commercial users; and magnetosphere measurement from a near-earth orbit to an orbit at a distance of 5 earth radii.

Up to eight spacecraft are planned for launch in 1981: the RCA Satcom D and E commercial communication satellites, the U.S. Navy NOVA 1 and 2 navigation satellites, NASA's Dynamics Explorer A and B scientific satellites, the U.S. Department of Commerce NOAA-7 operational meteorological satellite, and the Department of Defense DMSP Block 5D-2 operational meteorological satellite. Additionally, a number of RCA color television camera systems will be carried on the Space Transportation System to aid the astronauts in the inspection and deployment of cargo from the cargo bay and to provide video transmission of engineering and public relations activity in the Shuttle crew compartment. Table I summarizes the planned launches for 1981.

Dynamics Explorer

The Dynamics Explorer A and B spacecraft will be launched from the Western Test Range in the summer of 1981 to investigate the strong interactions coupling the hot, convecting plasmas of the magnetosphere and the cooler, denser plasmas and gases co-rotating in the earth's ionosphere, upper atmosphere, and plasmasphere. The specific mission objectives of DE-A and DE-B will be to determine:

- electric-field induced convection;
- electric currents;
- energy coupling;
- mass coupling; and

Abstract: *RCA will put up to eight spacecraft into orbit in 1981. Two are commercial communications satellites, two are navigation satellites, two are NASA scientific satellites, and two are operational meteorological satellites. In addition, a number of RCA color television cameras were mounted in the Space Shuttle. The missions of each of these satellites are described, and a description of each is given. Comparisons are made between these new satellites and satellites already in orbit.*

- wave-particle plasma interactions.

To achieve those objectives, RCA Astro-Electronics has designed and built two Dynamics Explorer spacecraft patterned after the highly successful Atmosphere Explorer C, D, and E spacecraft launched in 1973 and 1975. The DE-A and DE-B, shown on Fig. 1, will be equipped with a total of 15 unique instruments provided by

Table I. RCA 1981 constellation in space.

Satellite	*Date Approx. Launch*	*Launch Vehicle*	*Launch Site*	*Orbit*	*Owner*	*Mission*
NOAA-7	6/23/81	Atlas E/F	WTR	470 nmi 98.8° incl.	NOAA	Operational Meteorological Satellite (TIROS-N Series)
NOVA-1	5/15/81	Scout	WTR	600 nmi	U.S. Navy	Operational Navigation Satellite (Transit System)
RCA Satcom-D	4th Qtr	Delta/PAM-D	ETR	19,105 nmi Geostationary	RCA Americom	Operational Commercial Communication System
Dynamics Explorer DE-A DE-B	3rd Qtr	Delta 3910 Dual-Stacked Launch	WTR	364 nmi x 13,424 nmi 165 nmi x 702 nmi	NASA/GSFC	Scientific Satellite to Investigate Magnetosphere
RCA Satcom-E	4th Qtr		ETR	19,105 nmi	RCA Americom	Operational Commercial Communication System
NOVA-2	1st half, 1982	Scout	WTR	600 nmi	U.S. Navy	Operational Navigation Satellite (Transit System)
DMSP BL 5D-2	4th Qtr	Atlas E/F	WTR	450 nmi	U.S. Air Force	Operational Military Meteorological System
CCTV — Cameras	4/12/81 and 4th Qtr	Space Shuttle	ETR	160 nmi	NASA-JSC	Remote Control TV for STS

NOTE: The above projected launch schedules are subject to change due to launch vehicle availability or program redirection.

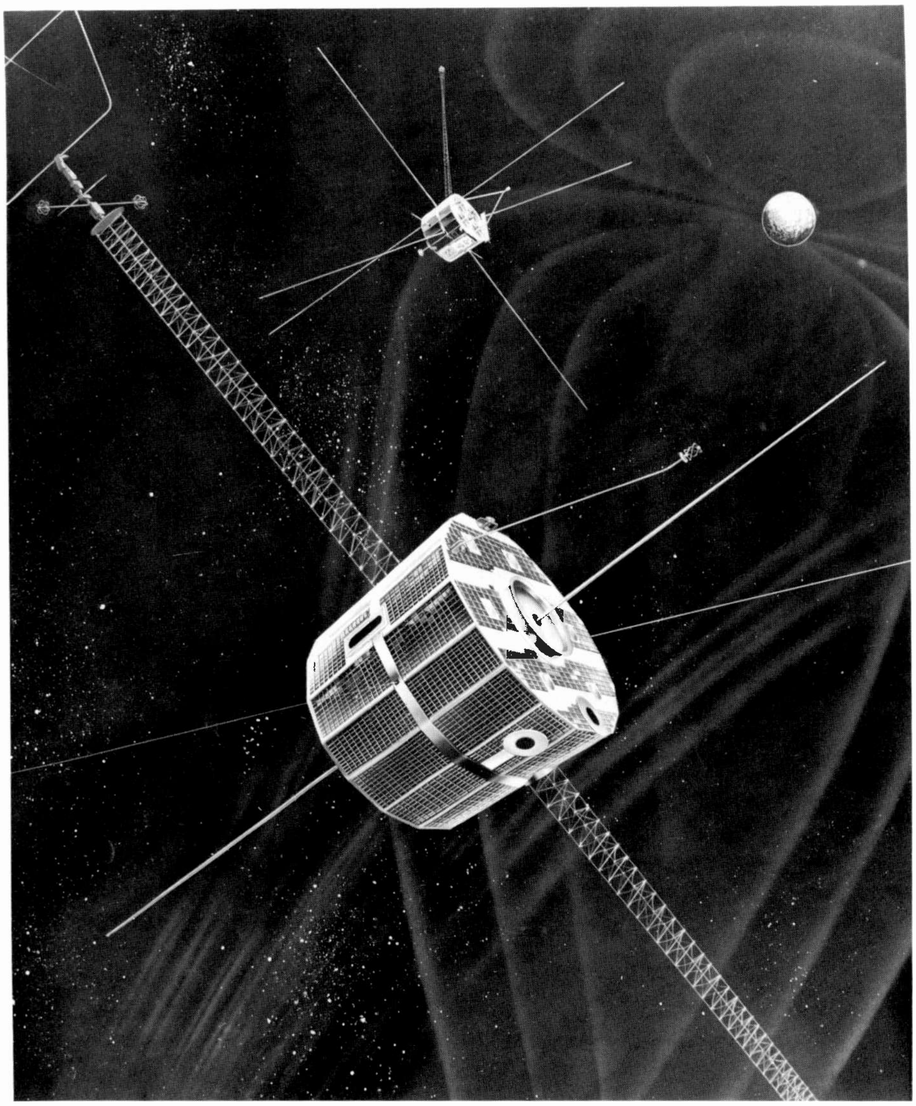


Fig. 1. Dynamics Explorer DE-A and DE-B.

NASA/GSFC. The DE-A and DE-B spacecraft will be launched on a single Delta 3913 launch vehicle and placed into polar coplanar orbits.

DE-A, the high-altitude orbit spacecraft, will have a perigee of 364 nmi (675 km) and an apogee of 4.95 earth radii (13,424 nmi, 24,874 km) geocentric. This highly elliptical orbit will permit the spacecraft to make measurements extending from the hot magnetospheric plasma through the plasmasphere to the cool ionosphere. At apogee the satellite will perform global imaging, auroral wave measurements in the heart of the magnetosphere, and will cross the auroral field lines at several earth radii. Measurements will be made for significant periods along a magnetic field flux tube.

DE-B, the low-altitude orbit spacecraft, will be placed in an orbit with perigee at 165 nmi (305 km) and apogee at 702 nmi (1300 km). In this orbit, measurements will be made in the cool ionosphere and upper atmosphere regions. At perigee, measurements will be made of the neutral particles and at apogee (above the interaction region for suprathermal ions), measurements of plasma flow at the feet of the magnetospheric field lines will be made. These objectives will be achieved by a selected instrument complement for each spacecraft, as listed in Table II.

Spacecraft design

The DE-A and DE-B spacecraft design was based on the design of the predecessor spacecraft, Atmosphere Explorer. However, the requirement for coplanarity of the DE-A and DE-B spacecraft and obvious cost benefits dictated that both spacecraft be launched from a single booster. Table III summarizes the System parameters. The modified design permits the dual mounting of the DE-A and DE-B spacecraft in a single stack. It also accepts different instrument complements and layouts and is configured with a large number of deployable devices, such as booms, masts, and antennas.

Power System. The basic power for DE-A and DE-B comes from solar cell arrays on the sides and ends of the spacecraft. Approximately 40 square feet (3.7 square meters) of surface provide up to 100 watts for each spacecraft. Two nickel-cadmium batteries on each spacecraft have a nominal storage capacity of 6 ampere-hours.

Communications. The DE communications subsystem includes NASA standard S-band (STDN and TDRSS) transponders. The S-band transponders are used for command reception, real-time data transmission, playback of stored data, and turn-around ranging signals.

Spacecraft Configuration. The DE spacecraft is a 16-sided polyhedron, 53.5 inches (135.9 cm) in diameter and approximately 48 inches (122 cm) high before the appendages are deployed. The external surfaces (except for instrument viewing ports and spacecraft structural attachment areas) are covered either with solar cells or with conductive surfaces that provide for spacecraft field grounding or function as thermal control surfaces. Each spacecraft, like Atmosphere Explorer, is configured with machined baseplates attached to a center column, the lower end of which mates with the adapter for the launch vehicle or the second spacecraft.

In mission mode, the DE-A spacecraft deploys the plasma wave instrument antennas. These consist of three wire antennas — two are 328 feet (100 meters) long and the third is 23 feet (7 meters) long. Additionally,

Table II. Dynamics Explorer instrument complement.

Instrument	*Responsible Investigator*	*Institution*
	DE-A (High-Altitude Mission)	
Fields		
1. Magnetometer-A	Sugiura	Goddard Space Flight Center
2. Plasma Wave Instrument	Shawhan	University of Iowa
Optical Emissions		
3. Spin-Scan Auroral Imager	Frank	University of Iowa
Charged Particles		
4. Retarding Ion Mass Spectrometer	Chappell	Marshall Space Flight Center
5. High Altitude Plasma Instrument	Burch	Southwest Research Institute
6. Energetic Ion Composition Spectrometer	Shelly	Lockheed
	DE-B (Low-Altitude Mission)	
Fields		
1. Magnetometer-B	Sugiura	Goddard Space Flight Center
2. Vector Electric Field Instrument	Maynard	Goddard Space Flight Center
Neutral Particles		
3. Neutral Atmosphere Composition Spectrometer	Carignan	University of Michigan
4. Wind and Temperature Spectrometer	Spencer	Goddard Space Flight Center
Optical Emissions		
5. Fabray-Periot Interferometer	Hays	University of Michigan
6. Ion Drift Meter	Heelis	University of Texas at Dallas
7. Retarding Potential Analyzer	Hanson	University of Texas at Dallas
8. Low Altitude Plasma Instrument	Winningham	Southwest Research Institute
9. Langmuir Probe Instrument	Brace	Goddard Space Flight Center

Table III. Dynamics Explorer system parameters (DE- A and DE-B).

	DE-A	*DE-B*
Apogee: nmi (km)	13,424 (24,874)	702 (1300)
Perigee: nmi (km)	364 (675)	165 (305)
Inclination: degrees	90°	90°
Period: minutes	439	101
S/C Weight: lb (kg)	888 (403)	901 (409)
Payload Weight: lb (kg)	187 (85)	214 (97)
Power Array: max. watts	108	125
Power Payload: watts	63	91
Attitude Control	Spin Stabilized	3-Axis Momentum Bias
Instruments	6	9

two 19.7-foot (6-meter) booms are deployed for the plasma wave instrument antennas and the magnetometer. The DE-B spacecraft deploys six antennas, each 36 feet (11 meters) long, to measure the vector electric field. A single 19.7-foot (6-meter) boom is deployed for the magnetometer.

NOVA

The U.S. Navy's Transit Navigation Satellite System, which has evolved over the past two decades, has pioneered in geodesy, navigation, and doppler surveying. Its constellation of

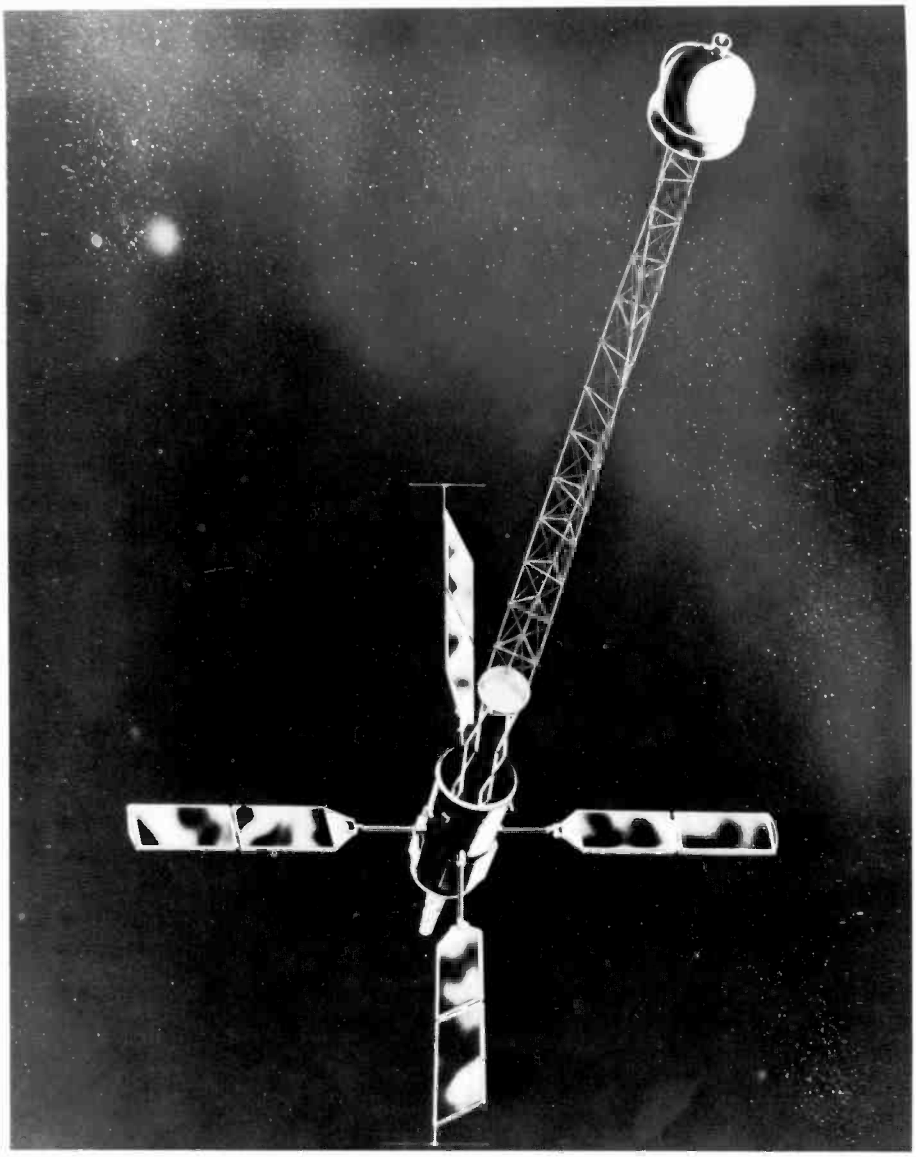


Fig. 2. NOVA Navigation Satellite.

Table IV. Transit/NOVA system parameters.

Spacecraft	*Transit*	*NOVA*
Launch Vehicle	Scout	Scout
Orbit: nmi (km)	600 (1111)	
Inclination	90°	90°
Period	110 min.	110 min.
S/C Weight: lbs (kg)	130 (60)	360 (163)
S/C Weight - dry: lbs (kg)	130 (60)	2S0 (127)
S/C Power: watts	50	90
Payload Power: watts	15	38.5
Attitude Control	Gravity Gradient	Gravity Gradient plus Orbit Adjustment and Active Momentum Control

five satellites is providing reliable, precision operational navigation data on a worldwide basis to the U.S. Navy and commercial shipping. Over the past few years, the Navy has developed the Transit Improvement Program (TIP) to enhance the present system. Three developmental satellites have been launched, and the resultant design improvements have been incorporated in a new generation, the NOVA spacecraft, now in limited production at RCA. Figure 2 shows the NOVA spacecraft in mission mode. The first of the three spacecraft in this series was launched by a 4-stage Scout launch vehicle from the Western Test Range on May 15, 1981. Table IV compares the Transit and NOVA system parameters. The following design improvements have been included in NOVA:

- improved time and frequency control;
- improved satellite signal power and antenna patterns;
- on-board propulsion to provide a more precise circular orbit;
- a Disturbance Compensation System (DISCOS) for minimizing in-orbit errors caused by external forces, such as atmospheric drag and solar pressure; and
- ion engine — pulse-plasma Teflon thrusters.

Spacecraft description

The NOVA spacecraft weighs approximately 360 pounds (163 kg), almost three times heavier than the Transit satellite. It will be placed into an initial orbit of 185 by 400 nmi (343 by 741 km). The on-board propulsion system will circularize the orbit at 600 nmi (1111 km). The main structure is octagonal, 20.5 inches (52.1 cm) wide and 15.5 inches (39.4 cm) high, topped by a cylindrical attitude control section 10.5 inches (26.7 cm) in diameter by 30 inches (76.2 cm) long. Four hinged body-mounted adjustable solar panels are deployed 90 degrees apart to provide 65 watts of power for the system. A 12 ampere-hour nickel-cadmium battery powers the spacecraft during the eclipse phase.

The NOVA spacecraft's attitude control

The attitude control system satisfies the mission performance requirements during a sequence of three post-launch phases: (1) a spin-stabilized phase, (2) a magnetically stabilized phase, and (3) a two-axis gravity gradient phase. The principal components of the attitude control system include: (1) a magnetic coil for spin-axis maneuvering during the spin-stabilized phase and for magnetic field tracking during the magnetically stabilized phase; (2) a magnetic spin-despin system for increasing or decreasing the spacecraft spin rate during the first phase; (3) a demagnetizer for removing spurious magnetic dipoles; (4) a momentum wheel for yaw control during the magnetically stabilized and gravity gradient phases; (5) two ball-in-tube nutation dampers for passive damping of the spin-stabilized satellite's nutational or wobbling motion; (6) four magnetic hysteresis rods for passive damping of spacecraft oscillation during the latter two phases; (7) an erectable Z-axis boom, 24.5 feet (7.5 meters) long, for gravity gradient stabilization to keep the spacecraft continuously oriented with respect to local vertical; (8) a 3-axis vector magnetometer, a spinning digital solar attitude detector, and three non-spinning digital solar attitude detectors to provide attitude determination; (9) a momentum wheel in the 3-axis stabilization mode for yaw control; (10) an orbit adjust transfer system using hydrazine propulsion to provide impulse upon command to circularize the orbit and correct booster errors; and (11) the single-axis DISCOS system, a cylindrically shaped located at the center of mass in the orbital configuration, to counteract environmental disturbances due mainly to solar radiation pressure and atmospheric drag in the orbit plane of the satellite. A proof mass suspended within this body is free of external distrubance forces. An optical sensor detects the proof mass position and provides a signal to fire one set of the pulse plasma teflon thrusters if the spacecraft is moved relative to the proof mass. This allows the spacecraft to follow the nearly pure gravitational orbit of the proof mass along the orbit velocity vector.

Doppler System. The prime functional purpose of the doppler subsystem is to provide signal generation and certain signal conditioning, which is then transmitted as navigation data to users. Telemetry data is also made available for ground control of the spacecraft. A dual 5-MHz ultra-stable oscillator provides a precision frequency source for use throughout the spacecraft. An incremental phase shifter, programmable by ground command, compensates for oscillator drifts.

Computer System. A computer/memory system processes telemetry data for delayed commands, and it stores the spacecraft ephemeral data. The magnetic core memory provides programmable storage for 16k words of 16 bits each.

Command System. The NOVA command system, which is fully redundant, performs the remote execution of relay commands, pulse commands, digital data commands, and fast and slow loading of the computer memories. Redundant command receivers provide redundant reception and demodulation of the amplitude-modulated command signals.

RCA Satcom

The RCA Americom Satellite Communication System (Satcom) has been in U.S. domestic operation since 1975. The RCA Satcom F1 and F2 satellites are in geostationary orbit at 119°W and 135°W Longitude. Each provides efficient, low-cost telecommunications services to all 50 states. The commercial service includes private line and message toll service, commercial television and radio, digital data, cable television (CATV), and specialized voice, video and data services. The five-year-plus operational flight performance of the RCA Satcom 3-axis stabilized spacecraft has been quite successful. Performance of the attitude control, propellant utilization, and power subsystems has exceeded specifications. Each satellite is equipped with 24 transponders and features cross-polarization and frequency reuse to maximize C-Band (6/4 GHz) capability in orbit. RCA Satcom F1, which was launched by Delta 3914 in December 1975, is the first commercial domestic communication satellite with power and propellant capacities for continuous operation of all channels for eight years in orbit. The first two 24-channel RCA Satcom satellites have been highly used. The next satellites of this series, RCA Satcom D and E, are now being readied for an ETR launch on a Delta 3910/PAM-D in October and December 1981. Figure 3 shows the on-orbit configuration of RCA Satcom D. These new spacecraft have been designed for compatibility with STS/PAM-D or Delta 3910/PAM-D launch vehicles. With the Star 30 apogee motor, the total transfer orbit weight is 2,385 lbs (1082 kg) as compared to 2,000 lbs (907 kg) for the earlier satellites. The baseline for RCA Satcom D and E is for 24 TWTA channels with an additional four TWTAs for redundancy.

Other improvements have been incorporated to extend the orbit life of these spacecraft. Increased TWTA power in all channels (5.5 watts in 18 and 8.5 watts in 6) provides improved EIRP and the operational flexibility to assign some customers higher-power channels. The power system has been improved to handle the higher-power transponders. The solar array has increased from 75 to 90 square feet (6.97

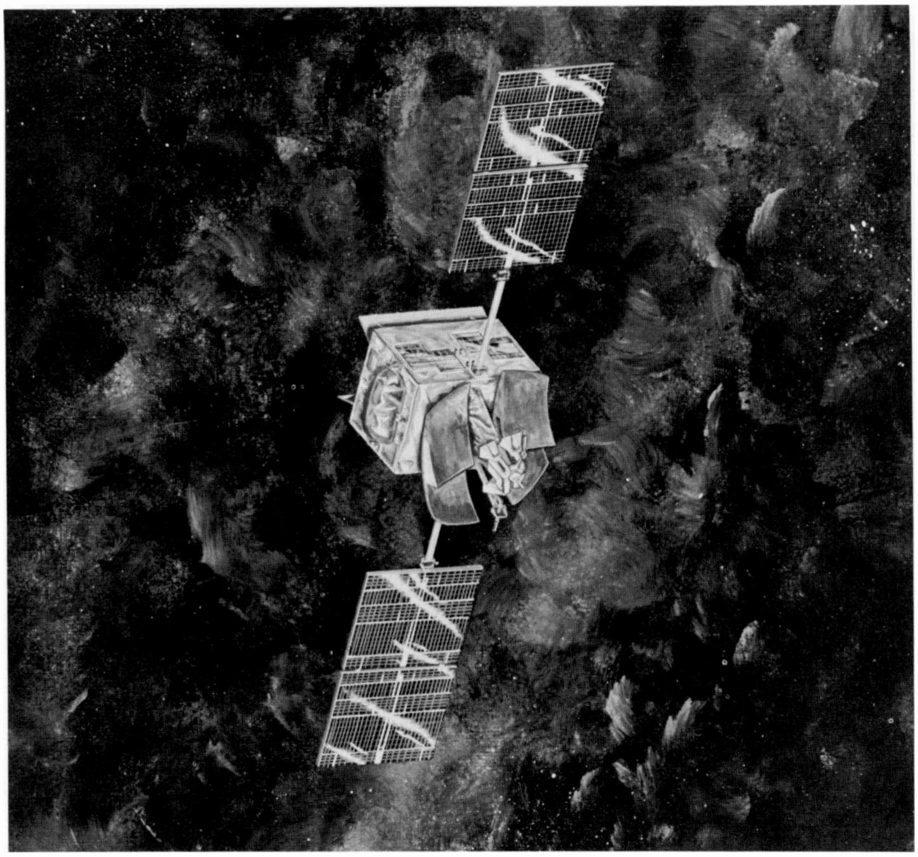


Fig. 3. RCA Satcom D Communication Satellite.

to 8.36 square meters), the average solar cell efficiency has been increased, and the battery capacity has been increased from 12 to 17 ampere-hours. Attitude control system modifications have been introduced to simplify operational procedures, improve pointing performance of the magnetic torquing system, and decrease ground control activity. A modified reaction-control system provides increased propellant storage capacity to insure that the longer projected life in orbit is met.

Table V highlights the system parameters of the earlier RCA Satcom F1 and F2, as compared to RCA Satcom D and E. Further improvements will be introduced in the next generation — RCA Satcom F, G, and H — which will be put into service in 1982-83. This system will still employ the space-proven 3-axis stabilization and power system technology, but the structure will be enlarged for a larger and more efficient communication payload that will use solid state GaAs FET amplifiers in lieu of TWTAs.

TIROS/NOAA meteorological satellite

The TIROS/NOAA (National Oceanic and Atmospheric Administration) meteorological satellite has been the principal U.S. operational polar-orbiting system for the past two decades. The current fourth generation in the TIROS series, designated TIROS-N, was put into operational service in October 1978. A companion satellite, NOAA-6, was successfully placed into service in June 1979. These complementary satellites are providing the U.S. Department of Commerce's National Oceanic and Atmospheric Administration with daily orbital observations of the earth's cloud cover, ground and sea surface temperature, and atmosphere temperature from sea level to an altitude of 20-mile (32.2 km). They collect and locate data from fixed and moving platforms and monitor the solar energetic particles in the vicinity of the earth.

The TIROS family of satellites is built by RCA for NOAA under the technical management of NASA.

NOAA provides operational control of these satellites after they are in orbit. A broad group of users in this country and the world at large have access to the satellite data, either through direct real-time acquisition of data from the satellite as it travels overhead, or from data stored for playback, processing, and dissemination by NOAA at Suitland, Maryland.

To fulfill the mission requirements, NOAA-7 spacecraft is similar to the TIROS-N/NOAA-6 series, and is equipped with a complement of instruments, data processors, and storage devices to assure timely, reliable acquisition and transmission of global weather data routinely on a 24-hour basis. Figure 4 shows the NOAA-7 configuration and Table VI highlights the system parameters.

Table V. RCA Satcom system parameters.

Spacecraft	*Satcom F1 and F2*	*Satcom D and E*
Orbit: nmi (km)	19,105 (35,402)	19,105 (35,402)
Launch Vehicle	Delta 3914	Delta 3910/PAM D
Weight: lb (kg)		
Transfer Orbit	2,000 (907)	2,385 (1,082)
Geostationary Orbit	790 (358)	942 (427)
Payload	220 (100)	248 (112)
Propellant-Hydrazine	230 (104)	340 (154)
Array Power BOL Watts	755	985
EOL Watts	650 8 yrs	830 10 yrs
Total Transponders	24	28 (4 redundant)
Transmit Freq-MHz	3700-4200	3700-4200
Receive Freq-MHz	5925-6425	5925-6425

The TIROS-N/NOAA A-G series is launched by an Atlas E/F launch vehicle from the Western Test Range. They operate in near-polar, circular, sun-synchronous orbits with a nominal altitude of either 450 or 470 nmi (833 or 870 km). In the operational configuration, two satellites are positioned with a nominal orbit plane separation of 90 degrees.

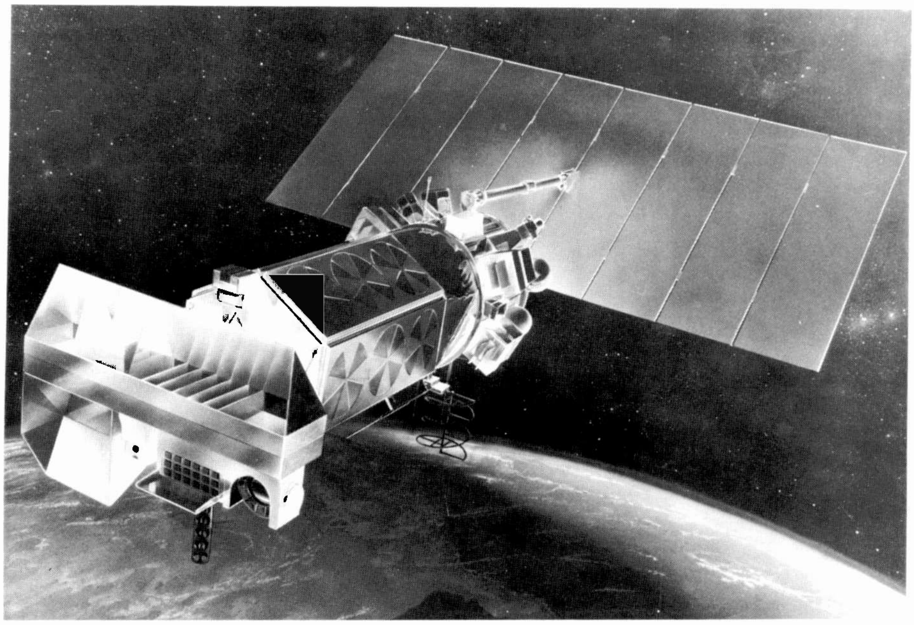


Fig. 4. NOAA-7 Meteorological Satellite.

Instrument payload

The principal instrument payload for NOAA-7 is as follows:

1. The Advanced Very High Resolution Radiometer (AVHRR), a four-channel, cross-track scanning instrument, provides image and radiometric data in the visible, near-infrared, and far-infrared portions of the spectrum, and was used on TIROS-N and NOAA-6. The AVHRR is used to observe clouds, land-water boundaries, snow and ice, temperature of clouds, and land and sea surface. A fifth channel has been added to NOAA-7 to enhance sea surface temperature measurements.

2. The TIROS Operational Vertical Sounder (TOVS), a subsystem consisting of three instruments, provides temperature profiles of the atmosphere from sea level to 20 miles (32.2 km), water vapor content, and total ozone content. The three TOVS instruments are:

   •The High-Resolution Infrared Sounder (HIRS/2), a 20-channel, step-scanned, visible and infrared spectrometer. This produces tropospheric temperature and moisture profiles.

   •The Stratospheric Sounding Unit (SSU), a 3-channel, pulse-modulated, step-scanned, far-infrared spectrometer. This produces temperature profiles of the stratosphere.

   •The Microwave Sounding Unit (MSU), a 4-channel, step-scanned spectrometer with response in the 60-GHz oxygen band. This produces temperature profiles of the atmosphere in the presence of clouds.

3. The Data Collection System (DCS) is a random-access system for the collection of meteorological data from *in-situ* platforms, both movable and fixed, such as buoys, balloons, and remote weather stations.

4. The Space Environment Monitor (SEM), a 3-instrument multi-detector unit, is used to monitor solar particulate energies in the vicinity of the satellite. The SEM measures solar proton, alpha particle, and electron flux density energy in the vicinity of the satellite.

Spacecraft description

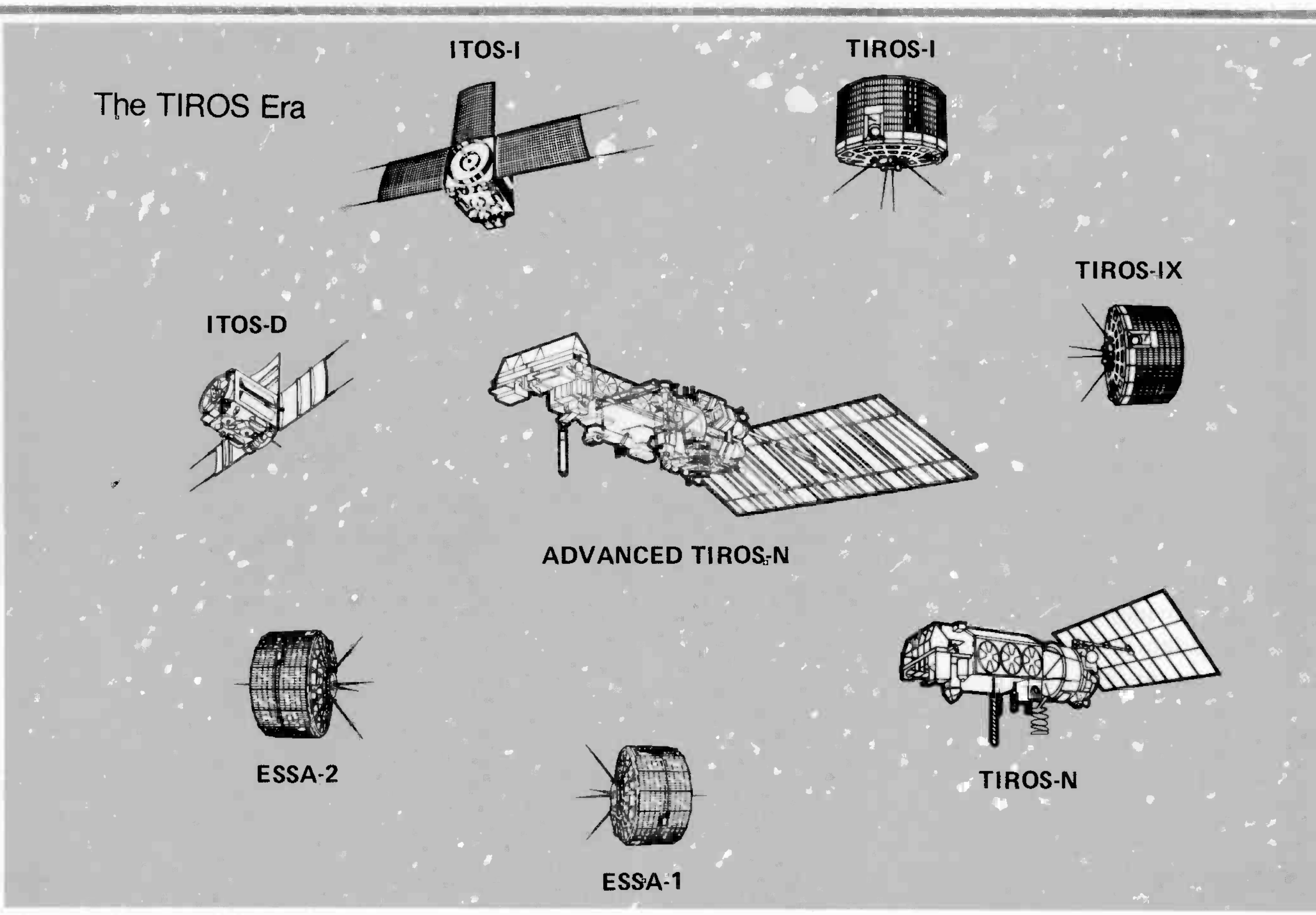
The NOAA-7 spacecraft is an integrated system designed for controlled injection into a nominal circular, near-polar, sun-synchronous orbit at an altitude of 470 nmi (870 km) and an inclination of 98.9 degrees. After burnout of the Atlas E/F first-stage, second-stage propulsion is provided by a solid rocket motor (TEM 364-15) that is integral with the satellite. The Atlas guidance system controls the first stage during launch. The spacecraft system monitors the launch parameters and controls the flight after separation from the Atlas vehicle. Body rates and accelerations are provided to the central processing unit (CPU) by the inertial measurement unit (IMU), which is composed of rate integrating gyros and accelerometers. The CPU uses a stored set of equations to determine the optimum flight profile. The reaction control system consisting of hydrazine and nitrogen thrusters, provides spacecraft control during the second stage burn and coast periods and trims orbital velocity after spacecraft insertion into orbit.

The structure consists of four sections:

1. The reaction system support module, which supports the solid motor, the reaction control equip-

Table VI. NOAA-7 system parameters.

Orbit: nmi (km)	470 (870)
Inclination: degrees	98.8
Period: minutes	102
Launch Vehicle	Atlas E/F
Integrated S/C Stage	TEM 364-15
Lift-Off Weight: lb (kg)	3,127 (1,418)
On-Orbit Weight: lb (kg)	1,700 (771)
Array Power BOL: watts	1,250
Average Power: watts	320
Payload Power: watts	200
Attitude Control	3-Axis Zero Momentum



On April 1, 1960, TIROS-1 (Television Infra-Red Observation Satellite) was orbited successfully from Cape Canaveral, Florida. It was the world's first meteorological satellite, ushering in a new era in meteorological observations. From its very first orbit around the earth, TIROS demonstrated the ability of the satellite to perform global observations on a timely basis. The TIROS meteorological satellite system was designed and built at RCA Astro-Electronics, Princeton, New Jersey, for the National Aeronautics and Space Adminsitration (NASA). With the success of TIROS-1, there followed an orderly growth and evolution of the TIROS family of meteorological satellites over the next two decades. A total of 28 TIROS/ESSA/ITOS (TIROS-M)/NOAA series of satellites were orbited successfully, all meeting or exceeding the mission requirements. From 1960 to 1965, ten TIROS Research and Development

ment tanks, and the mounting structure to the launch vehicle;

2. The equipment support module (ESM), which houses electronic components, tape recorders, transmitters, momentum wheels and coils;
3. The instrument mounting platform (IMP), which provides a precision mounting surface for the various instruments, the IMU, and the attitude sensing devices; and
4. The solar array and it's supporting boom, which contains the solar array drive that orients the 125-square feet (11.61-square meters) planar array towards the sun.

NOAA-7 was successfully launched on June 23, 1981 from the Western Test Range. Additional NOAA and advanced TIROS-N spacecraft will be launched as required to fulfill operational requirements at least until 1986.

Defense Meteorological Satellite Program (DMSP)

The U.S. Department of Defense has had the Defense Meteorological Satellite Program (DMSP) in operational service since the mid-sixties. The DMSP polar-orbiting satellite system is under the management of the U.S. Air Force. The DMSP satellites are designed to meet unique military requirements for worldwide weather information, and the processed data is readily available to Air Force, Navy, Army, and Marine installations.

The satellite observations and data can be transmitted in real-time to these installations and to naval vessels at sea. This data is received in the U.S. acquisition sites and relayed to the Air Force Global Weather Center at Offutt Air Force Base, Omaha, Nebraska for spin-stabilized satellites were placed in orbit to provide data for researchers and the U.S. meteorological community. TIROS-VIII, launched in 1963, with its special automatic picture transmission (APT), provided the first real-time direct readout of the satellite's observations to simple ground stations located in various parts of the world.

The world's first operational meteorological satellite (as well as the world's first operational application satellite) was introduced into service in February 1966 with the successful launch of ESSA 1 and 2. The ESSA spin-stabilized satellite series provided two satellite configurations, one for direct readout and real-time readout of observed data to relatively low-cost earth receiving stations located throughout the planet, and a second ESSA-type capable of remote sensing and storage of data and playback to the two principal U.S. Command and Data Acquisition stations. Each satellite viewed the entire planet on a daily basis. A total of nine ESSA satellites were orbited successfully between 1966 and 1969.

The third generation of TIROS satellites, TIROS-M (ITOS), was placed into orbit in December 1970. ITOS, by means of infrared scanning radiometers and television cameras, provided day and night observation of the entire planet. Further improvements were introduced in this 3-axis stabilized satellite with the ITOS-D series. The Very High Resolution Radiometer and the Vertical Temperature Sounding instrument were added for 1-km resolution in visible and IR channels, and for temperature profiles of the atmosphere from sea level to 30 km. Each of the ITOS satellites was capable of observing the planet every twelve hours. A total of six ITOS/NOAA satellites were placed into operation between 1970 and 1976.

NOAA (National Oceanic and Atmospheric Administration) owned and operated the operational ESSA and ITOS/NOAA satellites. NASA developed the initial spacecraft and managed the procurement of the satellites.

The fourth satellite generation, TIROS-N, was introduced into service in October 1978, and its companion satellite, NOAA-6, in June 1979. A third satellite, NOAA-7, was placed into orbit on June 23, 1981. These new, sophisticated environmental satellites were configured with improved sensors that provided more refined observation, a data collection platform, and a solar energetic particle monitor. The satellites were on station to support the first GARP (Global Atmospheric Research Program) global weather experiment (FGGE) during 1978-1979. Additional satellites are under construction to assure continuous global observation into the mid-1980s. Already under way are further developments in the Advanced TIROS-N, the last three of the TIROS-N series. These will have additional payloads to monitor the earth's ozone and measure radiation gains and losses to the planet for climatology use. They will also have an experimental search and rescue payload for locating downed aircraft and ships in distress.

The TIROS series of satellites will continue to provide beneficial data to the United States and the world community. The meteorological products for this highly successful program have grown. Initially gathering daytime cloud observations in 1960, TIROS today provides data used for atmosphere temperature and moisture profiles, sea surface temperature, and sea ice and snow cover observation. It collects and locates data from fixed or moving platforms, and monitors electron and proton particles emanating from the sun. Its broad international acceptance and use is unmatched. Over 900 stations in over 100 countries receive TIROS data, directly and routinely.

processing and distribution to various users, both military and civilian.

Four of the current DMSP Block 5D-1 satellites have been orbited since their introduction into service in 1976.

An improved version, designated DMSP Block 5D-2, is now being readied at RCA for launch late in 1981 from the Western Test Range. The 5D-2 spacecraft is 20 inches (51 cm) longer, the structure has been strengthened, and changes have been made to the electronic system so that more and larger sensors can be added. These changes have increased the expected operational life of the spacecraft. Figure 5 shows the 5D-2 configura-

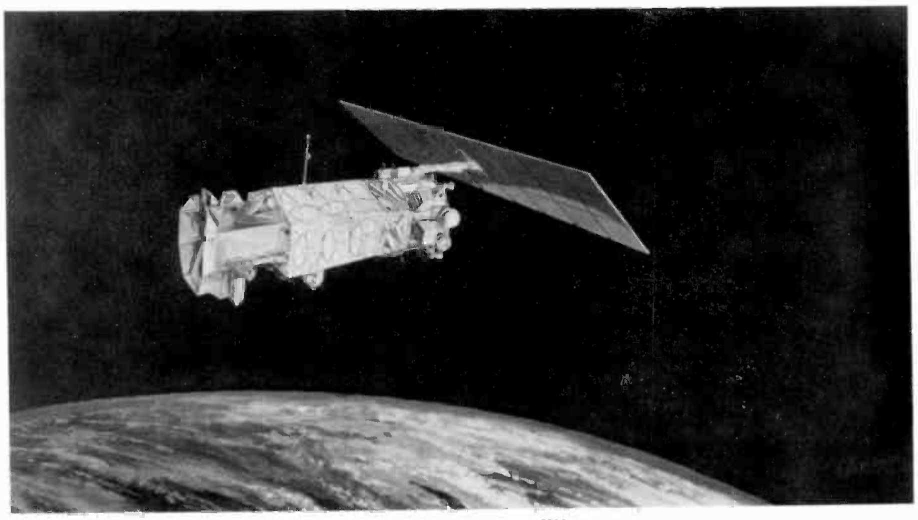


Fig. 5. DMSP Block 5D-2 Meteorological Satellite.

tion, and Table VII compares system parameters of 5D-1 and 5D-2.

Spacecraft description

The DMSP Block 5D-2 and the TIROS-N/NOAA spacecraft designs have many of the same subsystems such as power, thermal control, on-board computer, and the attitude stabilization system. The 5D-2, however, can achieve even greater pointing accuracy with its star mapper. The operational line scan system is the primary sensor on board for visible and infrared imagery. Additional sensors, including the temperature/moisture sounder and the precipitating electron spectrometer, are used to forecast the location and intensity of the aurora.

Table VII. DMSP system parameters. The in-orbit weight of the spacecraft has been increased by approximately 500 lbs (226 kg). The prior series utilized a Thor (LV-2F) booster. The DMSP Block 5D-2 will utilize the Atlas E/F. The change in launch vehicles resulted in the elimination of one of the two solid motors (TEM-364-4) employed with the 5D-1 spacecraft. The 5D-1 spacecraft weighed 5,900 lbs (2676 kg) at lift-off. 5D-2 will weigh approximately 3,127 lbs (1418 kg).

Spacecraft	*Block 5 D-1*	*Block 5 D-2*
Orbit: nmi (km	450 (830	450 (830)
Inclination: degree	98.7	98.7
Period: minutes	101	101
Launch Vehicle	Thor LV-2F	Atlas E/F
S/C Integrated Stage	TEM364-4 TEM 364-15	— TEM 364-15
S/C Lift-Off Wt: lb (kg)	5,900 (2,676)	3,127 (1,418)
On-Orbit Weight: lb (kg)	1,131 (513)	1,656 (751)
Payload Weight: lb (kg)	300 (136)	550 (249)
Array Power BOL: watts	1,000	1,250
S/C Average Power: watts	260	330
PayloadPower: watts	140	180
Attitude Control	3-Axis Zero Momentum	3-Axis Zero Momentum

Closed circuit television (CCTV) system

The Space Transportation System will be equipped with a number of RCA closed circuit television systems to insure proper payload handling, inspection, deployment, retrieval, storage, and monitoring of critical mission activities in the crew compartment and the cargo bay.

The CCTV system is compatible with standard broadcast rates and quality, and it is used by the NASA Public Affairs Office in disseminating information of interest to the general public. It will also enhance maximum real-time participation by engineers and scientists on the ground during experiment operations, engineering tests, and in-orbit problem solution. All on-board video signals are also ground selectable for viewing and distribution by NASA Mission Control and Public Affairs Office.

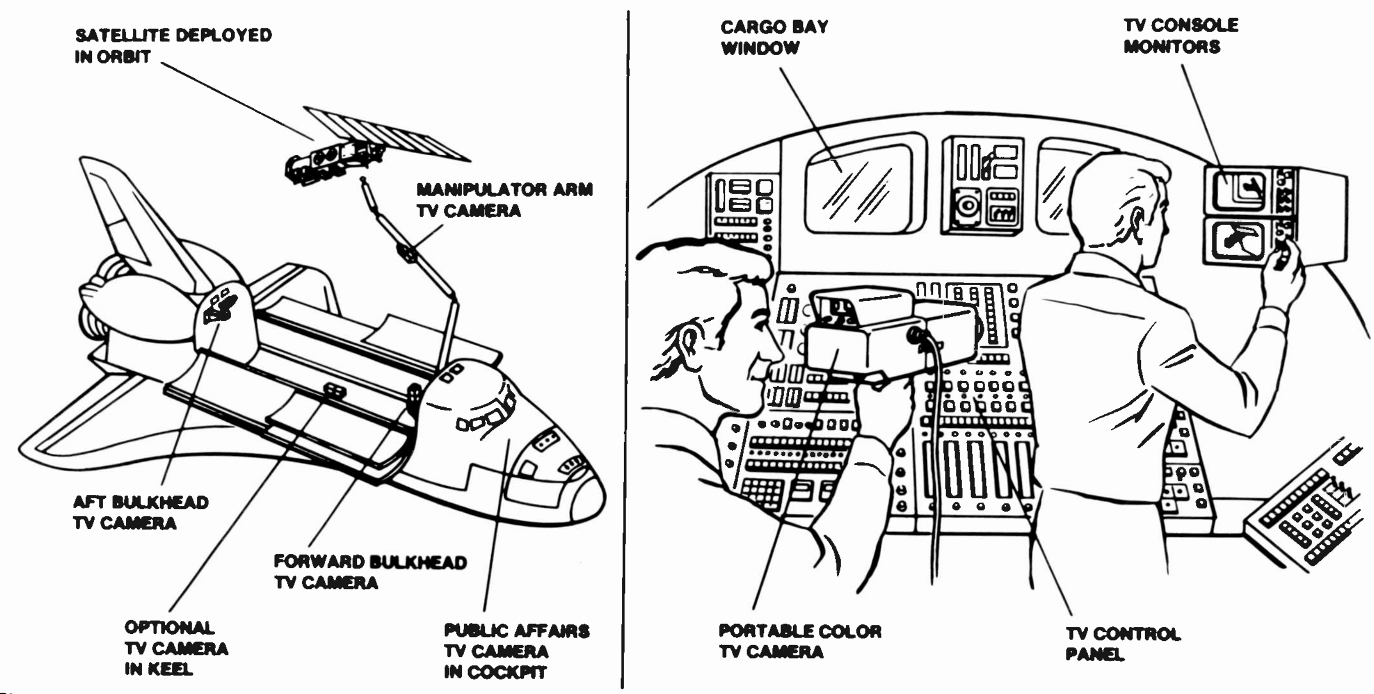


Fig. 6. Space Shuttle Closed Circuit Television System.

The complement of cameras on the Shuttle will vary with mission needs. Initially, two cameras will be located in the crew compartment and three in the cargo bay (two on the forward bulkhead and one on the aft). Future flights will have two cameras on the wrist of the remote manipulator arm. Figure 6 shows the CCTV in one of its configurations on the Space Shuttle, and Table VIII lists a complement of the CCTV equipment.

The CCTV is a modular design, which means that the camera can be converted to color or black and white, lens assemblies can be changed, it can be used as a hand-held camera, or it can be mounted on the pan/tilt assembly for almost spherical coverage. A dual 8-inch monitor assembly is provided for the crew compartment to display the TV signals to the crew.

The CCTV camera contains a 1-inch silicon intensified vidicon (SIT) image sensor for sensitivity under low light-level conditions in the cargo bay. The CCTV system was developed and manufactured by RCA for the NASA Johnson Space Center. The CCTV was successfully used during the inaugural flight of STS-1, launched on April 12, 1981. Excellent TV coverage was provided during the two-day orbital flight of STS-1. Figure 7 is a photograph of a CCTV image taken on the Columbia.

Fig. 7. CCTV picture on STS-1 flight. Astronaut Captain John Young conversing with Vice-President George Bush.

Table VIII. CCTV system elements.

Unit	*Weight (lbs)*	*Power (watts)*	*Quantity Used on STS*
Camera Assembly	9.5	21	5
Monochrome Lens Assembly	7.0	—	1
Color Lens Assembly	7.5	—	4
Viewfinder Monitor	3.5	7	1
Pan/Tilt Unit	9.5	14	3
Video Switching Unit	19.0	28	1
Remote Control Unit	19.0	28	1
Television Monitor	20.0	35	2

Conclusion

The diversified missions that are planned for the RCA 1981 constellation of satellites will provide beneficial service to people in the United States and throughout the world.

References

1. Schnapf, A., "The TIROS Era — 1960-1980 and the Decade Ahead," XXXI-IAF Congress, International Astronautical Federation, Tokyo, Japan (Sept. 24, 1980).
2. Hoskins, G.W., "The Future Navy Navigation Satellite System," 2nd International Geodetic Symposium on Satellite Doppler Positioning, Austin, Texas (Jan. 22, 1979).
3. Yermack, L.P. and Huffmaster, N.U., "Where Are We? — A Brief Discussion of the Navy Navigation Satellite System," *RCA Engineer*, (June/July 1979).

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His previous assignment was Manager, Satellite Programs, in which he directed all the NASA Programs, including TIROS-N/NOAA, Nimbus and Landsat, and the Atmosphere and Dynamics Explorer Programs. He also directed RCA Satcom, Telesat and NOVA Programs, and the Japanese Satellite studies. Previously, he directed the highly successful TIROS, ESSA, ITOS, and NOAA weather satellite programs.

He received the RCA David Sarnoff Award for outstanding achievements in engineering in 1970, the NASA Public Service Award in 1969, and the Annual Award in 1968 by the American Society of Quality Control and Reliability. He was elected a Fellow in the American Institute of Aeronautics and Astronautics in 1971.

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F.G. Adams

The countdown to an operational AEGIS ship, measured in years for more than a decade, is now a matter of months. The U.S. is...

Putting AEGIS to sea

Two recent circumstances have brought the AEGIS project into special prominence. On the one hand, with an increased emphasis on U.S. defense preparedness, the AEGIS project has become a keystone in the revitalization of the United States Navy. Of a more ceremonial nature, Mrs. Nancy Reagan recently christened Ticonderoga, *the first AEGIS-class guided missile cruiser. This paper updates* RCA Engineer *readers on the AEGIS project and on RCA's participation in AEGIS, the largest defense contract in the Corporation's history.*

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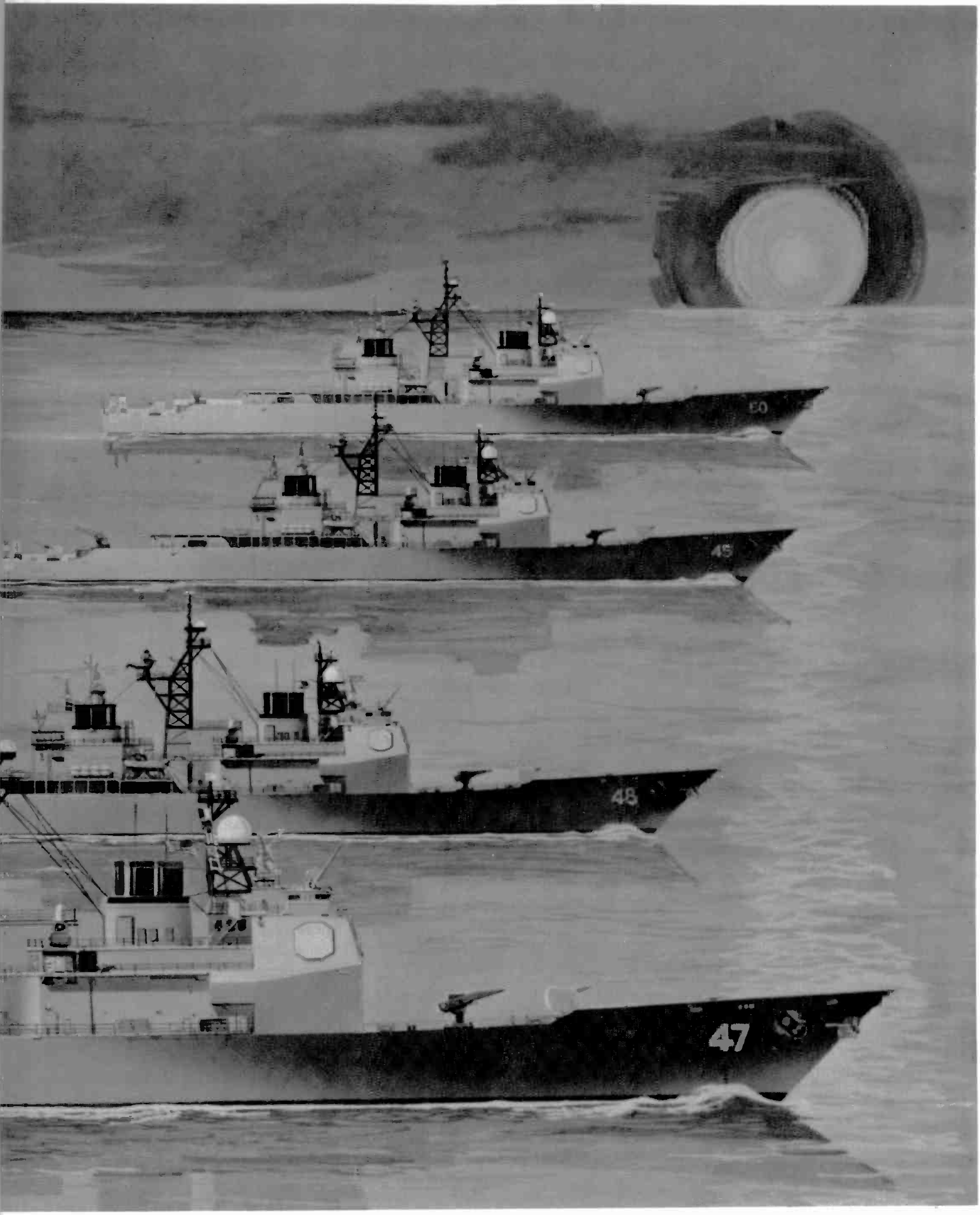

60
45
48
47

The first AEGIS Guided Missile Cruiser, *Ticonderoga* (CG 47), is now in the water. In January 1983, she will commission and go on active duty as a first-line man-of-war. During 1984 and 1985, she will be joined by three sister ships, CG 48, 49, and 50. And if the fiscal year 1982 Defense Appropriations Bill is passed as contemplated, three more *Ticonderoga*-class AEGIS cruisers (CG 51, 52, and 53) will hoist their commissioning pennants in 1986. AEGIS is going to sea!

These events assume special significance in the perspective of our increasing reliance on foreign sources for critical amounts of oil and other vital raw materials. Today, the United States is more vulnerable to the actions of other nations than at any time in its history. Admiral Sergei G. Gorshkov, Commander in Chief of the Soviet Navy, has declared, "The flag of the Soviet Navy flies over the oceans of the world. Sooner or later the United States will have to understand it no longer has mastery of the seas."

Only a strong U.S. Navy can keep the sea lanes of the world open to trade in peacetime and safe from aggression in war. Against the threats of the 1980s and 1990s, AEGIS provides the defensive core around which our fleets can counter threats as they materialize. Indeed, AEGIS is playing a major role in enabling our Navy to preserve the traditional freedom of the seas.

Two steps closer...

The "float off." Tugs move the *Ticonderoga* to its outfitting berth following submergence of the special launch pontoon in the Pascagoula River.

The AEGIS Shipbuilding Program recently achieved two more milestones in its march toward fleet operational status.

The first was the "float off," or launching of *Ticonderoga,* CG 47, the lead ship in the AEGIS class of guided missile cruisers. Float off represents an unusual method of launching a ship because of its construction methods.

Most ships are built on ways or in graving docks and are then launched by sliding them down the ways or by flooding the dock. Ingalls Shipbuilding uses a modular construction technique to fabricate the hull in three sections, each section being assembled on a cradle. The cradles are then joined and the hull sections welded together. The hull and its cradle are moved via railroad wheel assemblies onto a special launch pontoon which is winched into the channel of the Pascagoula River and submerged. The buoyant

The surface Navy

Surface "ships of the line" were written off as primary combatants following World War II. Nuclear submarines armed with ballistic missiles, manned aircraft, and ICBMs provided strategic deterrence. Manned aircraft offered a superior offensive strike capability to the alternative of bombardment by surface ships. The combination of attack submarines and manned aircraft was assigned the task of denying the sea to the enemy; carrier-based aircraft assumed the primary responsiblity for task-group air defense. Surface ships carried out defensive and supporting roles — as escorts for aircraft carriers, convoys, and mobile support forces operating in secondary threat areas; as communications coordination and control bases; and as instruments for "showing the flag" and conducting rescue operations.

This scenario for surface ships began changing in the late 1960s and early 1970s with the realization that we had become dependent upon sea commerce to fuel our economy and ensure our national survival. It became imperative that we maintain control of the seas — the classic role of the Navy as delineated by Captain Alfred Thayer Mahan in 1890 in his treatise *The Influence of Seapower upon History*. The surface man-of-war has assumed expanded responsibility, both in quality and quantity. It has to project a global presence not achievable by the submarine or carrier, and it has to survive and defeat an enemy that has grown markedly more sophisticated and formidable in recent years.

The *air threat,* exponentially in step with an advancing technology, includes low-altitude, sea-skimming, submarine-launched cruise missiles that pop up at short range to avoid detection and interception; and high-speed high-altitude, air-launched cruise missiles that attack their targets from steep angles under the cover of heavy jamming.

The *surface threat* presents a technically complex challenge of defense against surface ships that can fire surface-to-surface missiles from below the horizon from ranges that make retaliation difficult. The Soviets' main batteries are now surface-to-surface missiles.

Finally, the opponent's *submarine efficiency* has increased sharply. Under hull "floats off," and then tugs shift the hull to an outfitting berth for further work.

Ingalls Shipbuilding uses the modular fabrication technique, contending that it is faster, more cost-effective, more efficient, and permits more hulls to be built simultaneously within the shipyard confines than is possible with traditional hull construction methods.

Ticonderoga floated off on Saturday, April 25.

Three weeks later, on May 16, Nancy Reagan christened the ship: "In the name of the United States, I christen thee *Ticonderoga.*" This major event saw many dignitaries participate. Featured speakers included Mr. Leonard Erb, President of Ingalls Shipbuilding; Rear Admiral Richard J. Grich, Supervisor of Shipbuilding; Rear Admiral Wayne E. Meyer, AEGIS Shipbuilding Project Manager; Admiral Thomas B. Hayward, Chief of Naval Operations; The Honorable Trent Lott, U.S. Representative from Mississippi and House Minority Whip; The Honorable John F. Lehman, Jr., Secretary of the Navy; The Honorable John C. Stennis, U.S. Senator from Mississippi and member of the Senate Armed Services Committee; and Mr. Charles B. Thornton, Chairman of the Board, Litton Industries. The principal speaker was the Honorable Caspar W. Weinberger, Secretary of Defense.

In July, RCA began shipping the Combat System to Ingalls for installation and checkout on board ship. *Ticonderoga* is scheduled for commissioning in January 1983.

In a splash of champagne, Mrs. Reagan christens *Ticonderoga* in a special ceremony on Armed Forces Day, May 16, 1981.

the sea, he is faster, quieter, more numerous, and able to operate at longer ranges.

During this period, the concept of a new surface ship was forming in the minds of top Navy planners. Rear Admiral Wayne E. Meyer, writing in the *U.S. Naval Institute Proceedings,*[1] described it . . .

> A technical definition of the surface man-of-war's task to meet the challenge includes both an equal partnership with the manned interceptor to defeat the sophisticated and concentrated Soviet air threat to our task groups and a capability to defend commercial and naval ships against air threats where protection by carriers cannot be provided.
>
> To protect the ships under their care, surface forces must also be able to provide ASW [antisubmarine warfare] and ASUW [antisurface warfare] protection. The latter means they must be able to strike enemy surface forces, not so much singly, as in concert with other forces. As always, they must be able to perform in support of other naval forces.

This view is the surface warfare portion of the "Holloway Doctrine," named for Admiral James T. Holloway, III, former Chief of Naval Operations, who envisioned two new classes of surface warships — those that can function only as part of a larger task (or battle) group, and those that can function either in concert with other ships or independently. *Ticonderoga* - class ships are the latter.

Ticonderoga (CG 47) combat capability

Ticonderoga is the first of a new class of automated, high-firepower, guided-missile warships, whose multi-mission capability is made possible through quick reaction and highly effective firepower in the basic warfare modes — antiair warfare (AAW), antisubmarine warfare (ASW), and antisurface warfare (ASUW).

The mission of *Ticonderoga* is "to destroy enemy aircraft, missiles, submarines, and surface ships, in order to prohibit the employment of such forces against U.S. forces. CG 47 class ships will normally be assigned to carrier battle groups or surface action groups." To carry out her mission, *Ticonderoga* is armed with the AEGIS Ship Combat System, an integral part of the total ship design rather than the usual complement of commodity "add ons."

Equipment and computer programs from 25 individual detection, control, and engagement elements (Fig. 1) are

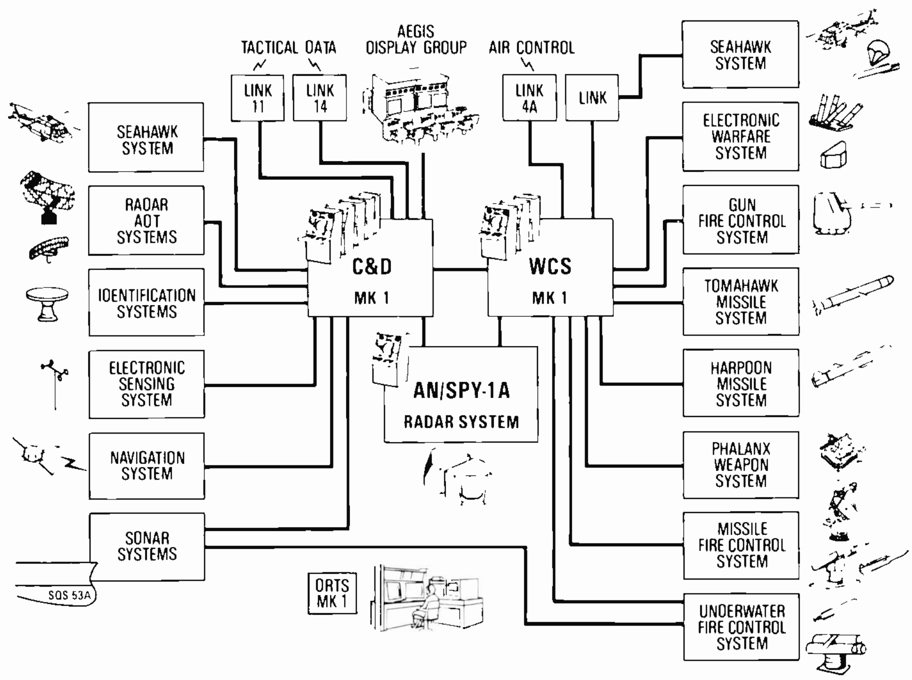


Fig. 1. The AEGIS Ship Combat System is a complex of 25 elements, with sensors integrated through the Command and Decision System, weapons integrated through the Weapons Control System, and off-ship information channeled through the communications links.

structured to form a combat system that is capable of responding to either a single threat or a coordinated multiple attack in adverse environments including electronic and mechanical countermeasures. The AEGIS Ship Combat System simultaneously and automatically processes data from these elements, directs tactical doctrine, coordinates assigned missions, determines modes of operation, and controls target engagements with the appropriate weapon elements.

The heart of the AEGIS Ship Combat System is the AEGIS Weapon System Mark 7, designed and developed by RCA and composed of nine computer-directed elements capable of standing as a fully automatic antiair and antisurface missile system. As part of the Combat System, the AEGIS Weapon System performs the principal air and surface defense functions. The control elements of this group provide track maintenance, threat evaluation, and weapon assignment and control for all warfare operations. It is the AEGIS Weapon System that furnishes direction, commands, and automation to the AEGIS Ship Combat System.

RCA's role

RCA's participation in major air defense systems began in the early 1950s as prime contractor for the Army's Land-Based TERRIER AAW system. (The Moorestown facility opened and Missile and Surface Radar became an independent operating unit at that time.) The mid-1950s featured the Land-Based TALOS Defense Unit, a Navy prime contract under which RCA was one of the first to introduce digital computer technology into antiair warfare missile systems.

The Navy's Surface Missile System Project invited RCA to participate in the Fleet "get well" program in the early 1960s, with an assignment to evaluate the TERRIER AAW and combat systems then deployed in Navy destroyers and destroyer leaders. RCA also participated in the development of reliability improvements to the ANSPG-55B fire control radar.

This era marked the beginning of RCA's experience in surface ship combat systems; experience in modern weapon systems began in 1963 with the award of one of the concept studies for the Advanced Surface Missile System (ASMS). This study, in turn, led to even greater participation in Navy systems in 1969 when MSR competed for and won the ASMS (now the AEGIS Weapon System) Engineering Development contract.[2]

RCA's ability to successfully conceive, specify, design, analyze, integrate, implement, and test a complex shipboard warfare system was demonstrated by superior first-time-at-sea performance of the AEGIS Weapon System in a special Navy test ship, *USS Norton Sound*. This performance, in turn, led to RCA's assignment to develop the total CG 47 Combat System. In the Combat System Engineering Development contract, awarded in 1976, RCA became responsible for synthesizing a complete combat system capable of simultaneously fighting in all three warfare areas while maintaining communications and command and control with other ships in the battle group.

Because of the uncertainties and alternatives in the Navy shipbuilding program, RCA and the Navy designed the combat system as a "superset" for use in a number of the proposed warships, from the largest strike cruiser to ships of decreasing displacement, such as smaller classes of cruisers and the new *Spruance*-class destroyer. When the *Spruance*-class hull was eventually selected as the first ship, the combat system design already existed for integration with the forthcoming design that is now known as *Ticonderoga* (CG 47) class.[3, 4]

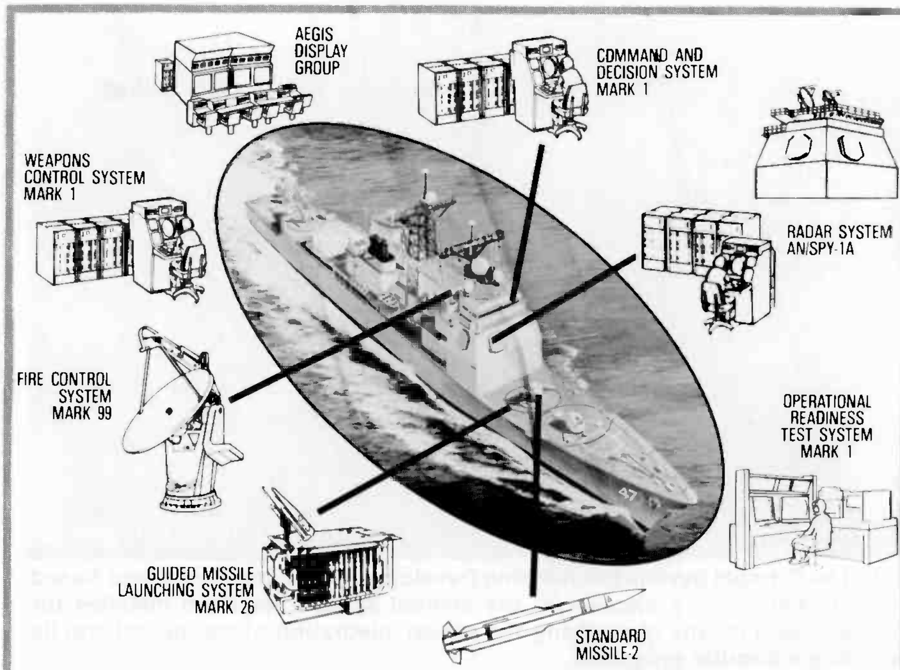
The integration task included the complete specification and documentation of the CG 47 Combat System, including all of its supporting elements. All digital, electrical, mechanical, and human interfaces were identified and defined through a series of interface control documents and interface design specifications. Detailed analysis of the combat system design involved use of functional flow and sequence/timing diagrams as well as simulations to establish performance against various combinations and types of threats in all environments.

This effort formed the basis for development of combat system computer programs that involved 760,000 core words for the tactical programs, 1.8 million words for the support programs (including those for the interface simulator systems), and 1.7 million words for Operational Readiness Test System data base.

This major software development effort included the detailed design, coding, and testing of all CG 47 Combat System computer programs at the Program Generation Center and Computer Program Test Site located at Computer Sciences Corporation's Moorestown facility. Based on the AEGIS-proven doctrine of "build a little, test a little," this effort advanced a step at a time through an Interface Simulator System and subsequently through the actual combat system elements at the Combat System Engineering Development (CSED) Site — the "cruiser in the cornfield" adjacent to the MSR Plant (Fig. 2).

The CSED Site serves as the focal point for the integration and extensive test and evaluation of all CG 47 Combat System elements with the tactical shipboard computer programs. Radars, weapon control equipment, computers, computer peripherals, displays, and communications equipment were successfully installed, checked out, integrated, and tested through a series of milestones that demonstrated increasing levels of combat system operational capability and compliance with performance specifications. Missiles, guns, and torpedoes were represented through simulators.

The Navy chose the CSED Site location on the basis of predefined site-selection criteria; RCA prepared the architectural and engineering data for the site and oversaw its construction. Then, RCA developed the installation and checkout procedures, designed and conducted the element and system-level tests, and performed operational analyses by reducing, evaluating, and documenting the results. In addition, RCA assisted the Navy in the development and conduct of training programs for Navy instruc-



The AEGIS Weapon System Mark 7 takes full advantage of modern technology to provide the most advanced antiair warfare system in existence today.

The AEGIS Weapon System Mark 7, as the core of the AEGIS Combat System, is the primary defense against air and missile attacks.

DETECTION of air targets is accomplished by the AN/SPY-1A Radar System. This unique radar searches a vast volume of space almost instantanously and, without interrupting surveillance, detects and tracks literally hundreds of targets simultaneously.

AN/SPY-1A was conceived and designed as a fully automatic radar. Driven by the AN/UYK-7 computer, the system responds to every scenario without the need for human action in the radar loop. Once the tactical doctrine is inserted by the radar controller (who communicates with the control computer by means of a standard shipboard console), no continuing human interaction is required, even in the complex high jamming environment for which the system was developed.

COMMAND is enhanced by the AEGIS Display System Mark 1, a series of computer-driven large screen displays and automated status boards. The ship's Captain, the Embarked Commander, and their respective Tactical Action Officers, positioned at this location, can assess all aspects of the battle situation and issue orders to on- and off-ship combat elements.

CONTROL is carried out by the Command and Decision System Mark 1 and the Weapons Control System Mark 1. These elements consist of a computer-display complex which forms the nucleus of CG 47's Combat Information Center and provides overall battle system direction and coordination. The Command and Decision System is the primary element through which battle doctrine is inserted.

ENGAGEMENT of air targets is conducted with the Fire Control System Mark 99, the Guided Missile Launching System Mark 26, and Standard Missile 2. These elements, in concert with the uplink midcourse command guidance function of the AN/SPY-1A Radar System, allow AEGIS to rapidly fire and control more missiles with greater accuracy than any other Navy system.

To keep this advanced system continuously available, AEGIS incorporates the Operational Readiness Test System Mark 1 which constantly monitors thousands of critical operating points, detects faults, and provides maintenance data for rapid correction or repair by the ship's crew.

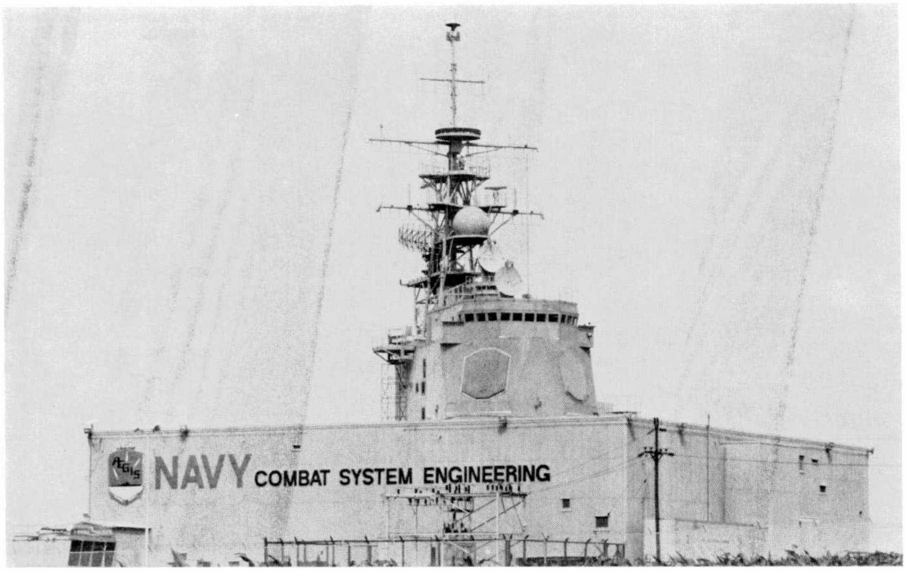


Fig. 2. The Combat System Engineering Development Site provides a land-based facility in which every element of the combat system has been installed (or simulated) as a means of verifying the actual integration of equipment and its controlling computer programs.

tors (who are now training CG 47 crew members at the CSED Site), in the evolution of provisioning criteria for the Combat System, and in a continuing program of logistics support for *USS Norton Sound* and site services and facilities support for the CSED Site.

Meanwhile, RCA worked with the Navy in writing specifications and the design contract for CG 47. In its role as Combat System design agent, RCA assisted in conducting the competitive runoff among potential shipbuilders (Bath Iron Works in Bath, Maine; General Dynamics, Quincy Division, in Quincy, Massachusetts; and Ingalls Shipbuilding Division of Litton Industries in Pascagoula, Mississippi). Ingalls was awarded the contract in 1978 for the detail design and construction of CG 47, and RCA has been working under a Navy contract to perform CG 47 class integration with Ingalls Shipbuilding since then.

Concurrently, RCA was awarded a contract to produce the AEGIS Weapon System Mark 7 Mod 3 for this new ship. RCA designed and built the Production Test Center (Fig. 3) to assemble and stage the Mark 7 Weapon System and selected combat system elements, with a specified set of shipboard cables to ensure that the weapon system would be operational before being landed in the ship.

In 1980, contracts were awarded to RCA and Ingalls for CG 48 Weapon System production and ship construction; RCA recently signed the contract for production of the third and fourth (CG 49 and CG 50) Weapon Systems and the purchase of long-lead components for CG 51.

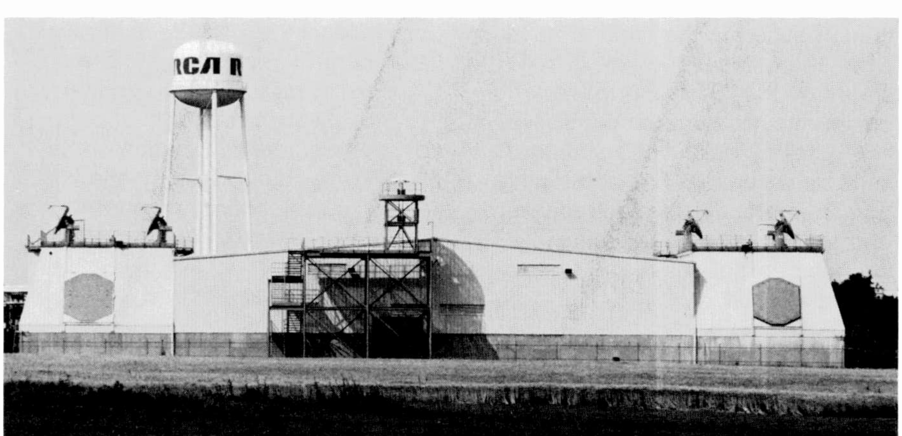


Fig. 3. The Production Test Center, built in 1979, provides a "proving ground" for assembly and system testing of the complete AEGIS Weapon System Mark 7. This capability enables validation of system performance with production equipment, cables, and computer programs before ship installation.

Shipbuilding

An important factor in the success of AEGIS was the decision to consolidate and integrate under a single command all responsibility for ship construction, combat system development, weapon system procurement, missile development and procurement, training, and provisioning. This command is called the AEGIS Shipbuilding Project (PMS-400), and its manager is Rear Admiral Wayne E. Meyer, U.S. Navy.

This consolidated responsibility within the Navy was a key factor in keeping the AEGIS Program active during an extended period of debate during the 1970s over selection of an AEGIS ship. It has always been clear that AEGIS must be put to sea; it is the only system with the capability to handle the types and kinds of saturation threats our potential enemies pose. But though the need has been clear, its development was slowed by the lack of a dedicated ship type. The tortuous path through the maze of potential ship classes finally resulted in two approved ship classes for AEGIS: a new nuclear-powered cruiser (CGN 42) and the gas turbine-powered destroyer, DDG 47, later reclassified as a cruiser, CG 47. CGN 42 was deferred in 1978, thereby leaving CG 47 (*Ticonderoga*) as the AEGIS survivor.

As mentioned earlier, three more AEGIS cruisers have been authorized, with authorization for an additional three ships anticipated in the fiscal year 1982 budget. The *Ticonderoga*-class fleet is projected to include between 18 and 24 ships at completion, the final number in great part dependent upon the number of battle groups in the fleet.

Summary

AEGIS has a long and checkered history, marked by a string of repeated successes. Brilliantly conceived, systematically developed, skillfully designed, and thoroughly tested, it nevertheless suffered low funding levels, partly because it had to compete with programs designed to cure the defects of previously developed systems and partly because of a lack of appreciation for the urgency of getting ships to sea to neutralize the increasing threat.

The struggle for an AEGIS ship throughout the 1970s characterizes U.S. Navy ship procurement of that period. That AEGIS survived it all is due not only to its technical excellence as a practical modern weapon system, but to the masterful management exercised by the AEGIS community — Navy, industry, and laboratories — led by the AEGIS Shipbuilding Project Manager.

By the time the last *Ticonderoga*-class ship is commissioned, her outward appearance may very well have changed considerably, but the concept of operation will remain the same. And *that* is truly the great contribution of AEGIS.

References

1. Meyer, W.E., "The Combat Systems of Surface Warships," *United States Naval Institute Proceedings*, Vol. 103, No. 891, pp. 110-123 (May 1977).
2. Goodwin, W.V., "The AEGIS Weapon System Acquisition," *RCA Engineer*, Vol. 18, No. 1, pp. 28-31 (June/July 1972).
3. Blades, T., "DDG-47: AEGIS on its Way to Sea," *United States Naval Institute Proceedings*, Vol. 195/1/911, pp. 101-105 (Jan. 1979).
4. Friedman, N., "AEGIS and its Platforms: DDG-47, CGN-42," *Marine Rundschau* (June 1980).

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Register immediately!

CEE to offer four live short courses in Fall 1981

Corporate Engineering Education (CEE) has contracted with Integrated Computer Systems of Santa Monica, California, to run four live short courses during the Fall.

The first two courses will be offered October 6-9, 1981.

- **Hands-On Microprocessor Troubleshooting** Teaches practical troubleshooting techniques reinforced by in-class, hands-on training with test equipment specifically intended for microprocessor applications.
- **Digital Filters and Spectral Analysis** Integrates the fundamental algorithms of digital filters and spectral analysis with advanced software techniques and hardware architectures.

Registration deadline for the above courses is September 4, 1981.

The second pair of courses will be offered December 15-18, 1981.

- **Microprocessor Software, Hardware and Interfacing** Hands-on course provides a broad foundation in the skills required for the design, programming, and real-world interfacing of microprocessor applications.
- **Structured Design and Programming** Presents the practical, systematic tools and techniques of structured programming as they apply to real-time engineering and scientific applications.

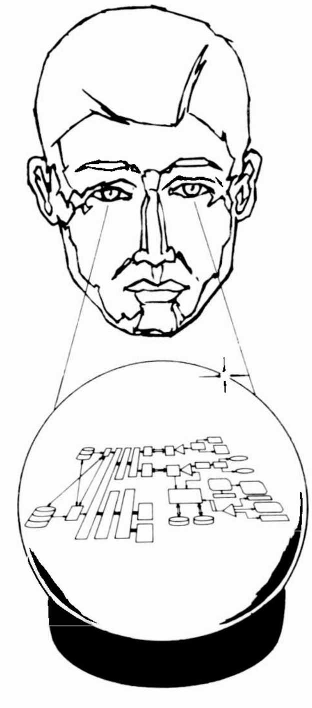
Registration deadline for these two courses is November 13, 1981.

Each course will be held at the Holiday Inn of Cherry Hill, New Jersey. Cost per participant will be in the range of $500-$650, depending upon the course and the number of participants. These fees represent a savings of 30-40 percent on the normal public offering price of these courses.

For detailed course outlines and registration information, please contact Margaret Gilfillan at CEE in Cherry Hill, TACNET: 222-5255.

O.T. Carver

A look at ATE in the 1990s



The most easily noticed changes in the '90s automatic test systems will be its role in such functions as training, real-time inventory control, and workload scheduling; equally noticeable may be some popular expectations that won't make it into the '90s.

Abstract: *Automatic test equipment in 1990 will provide many of the same functions as its 1980 predecessors. But the 1990 ATE will do more, and it will do it better. This paper describes trends in test requirements and technology advances in integrated ATE. It discusses the search for an alternative to manually developed application software, and suggests an expanded role for ATE in the maintenance shop. There is a projection of what will be new and different in the 1990s and some ATE developments that will not happen are discussed.*

ATE capability

Automatic test equipment (ATE) capability is forever destined to be chasing test requirements. Even as ATE engineers are completing the design of their newest next-generation tester, their fellow engineers are devising components whose test requirements exceed the new ATE capability. The growth of integrated circuits (Fig. 1) is an example. Steep positive slopes that relate some measure of capability to time are stereotypes in electronics. Figure 1 shows increase in active elements per integrated circuit chip plotted against time. In ten years, we have gone from about 1000 elements per chip to about 10,000 elements per chip, from the single-chip calculator to 16-bit microprocessors. The important point for ATE developers is that these complex devices spawn complex test requirements. ATE system capability must keep up, and engineers must adapt the high performance components to stimulus and measurement functions within the automated test system.

The government-financed Very-High-Speed Integrated Circuit (VHSIC) program will spur the growth of high-speed and large-scale integration. Speeds will be from 20 to 100 MHz, and there will be as many as 100,000 gates on a single chip. The ATE will have to interface with far more than the present 120 pins per device.

The ATE industry is driven by device technology, and it is at the device level that the electronics revolution is accelerating. Five-micron geometry, achievable by electron beam and optical direct processing on wafers, will be replaced by X-ray imaging to produce lines as narrow as 0.2 microns. Charge-coupled device memories of 256 kilobits and 1-megabit bubble memories will be available. Most ATE hardware still uses TTL and discrete devices, but new systems will use these newer components for greater speed and hardware reliability. The greatest stimulus to new system design is performance, and although unit cost is a competitive consideration, performance is what will sell new testers.

Similar advances are occurring in analog electronics, where information transmission and reception is being accomplished by radiated energy at higher and higher frequencies. As a result, devices for power and frequency measurement at 40 GHz are stock items for most RF component manufacturers.

An example of new analog test requirements is in the growth of millimeter-wave radar and communication equipment. Historically, the most popular part of the spectrum for radar operating frequency has been between 500 MHz and 35 GHz. Millimeter-wave applications above 35 GHz have not been supported adequately enough to develop components and systems, or to address and solve basic problems of propagation. In the last five years, however, there has been much activity in the 35- to 100-GHz region.

With increased application will

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come a greater variety of millimeter-wave components at lower cost. As systems begin to appear, so will the requirement for an ATE capability. The classic pattern is that new ATE requirements are first met by repackaged laboratory instruments similar to those used for engineering development testing. The special-purpose ATE will be followed by more generally applicable RF test stations with millimeter-wave stimulus and measurement capability. The ATE designer will draw from the same components available to the radar system designer.

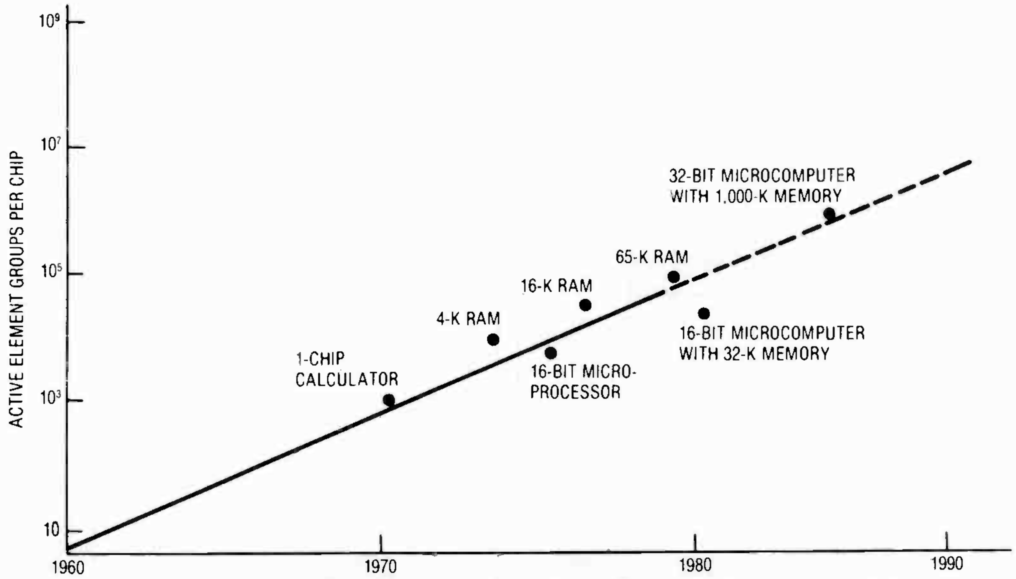


Fig. 1. Progress in integrated circuit logic devices. From AFCEA paper, C.G. Thornton, ERADCOM, Ft. Monmouth, N.J.

Architectural trends

The most fashionable architectural concept in ATE today is the distributed controller. Two recent developments have made the distributed control architecture commonplace. The first is a standard ATE interface bus, accepted by many instrument manufacturers so that bus-compatible measurement, stimulus, and switching devices are available off the shelf. The most common ATE bus is the IEEE-488, accepted widely enough to make it generally available to system integrators. The IEEE-488 bus has limitations; it has a 1 MHz maximum data rate, and it is usable for only short distances — about twenty meters. Another bus, the widely used RS-232C, is operable over greater distances, and compatible hardware is also generally available. Several companies offer plug-in cards that perform the functions of bus interfacing (IEEE-488, RS-232C, ASCII 8-bit parallel), digital-to-analog conversion, stimulus generators, measurement functions, switching and, of course, microprocessors and firmware.

The second development is the microprocessor — the computer-on-a-chip that can be embedded in the measurement device to take local control of processing tasks. Rather than the measurement subsystem sending sensed, digitized data to a system computer for RMS analysis, it can be done locally and only the final RMS value sent to the system computer. Meanwhile, the system computer is free to control stimulus devices, set up switching, or interface with the operator. A block diagram of a distributed-control ATE system is shown in Fig. 2. The availability of test functions at the card level makes it possible for the experienced ATE user to assemble his own system. Within limits, the user can tailor system capability to current needs and reassemble the building blocks for the next application.

Among larger ATE systems, there is a trend toward multi-port configurations. Most general-purpose ATE can handle one unit under test (UUT) at a time, although for any given test only a fraction of the total unit capability is in use. By sharing some functions and duplicating others, two or more test interfaces can be provided, and a UUT can be undergoing test concurrently at each interface. A 2-port configuration is shown in Fig. 3. A 2-port system won't quite double the throughput, because there will be some delay in using shared functions, but neither is the cost as great as it would be for two independent ATE systems. Shared-function ATE architecture is a compromise that attempts to gain throughput without equivalent increases in cost. The real cost in multiport ATE architectures is likely to be the system software complexity.

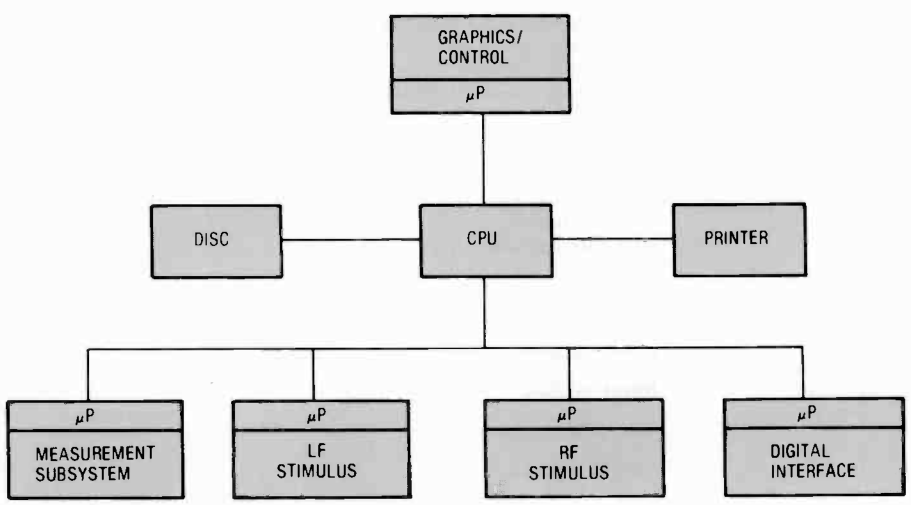


Fig. 2. Distributed ATE architecture.

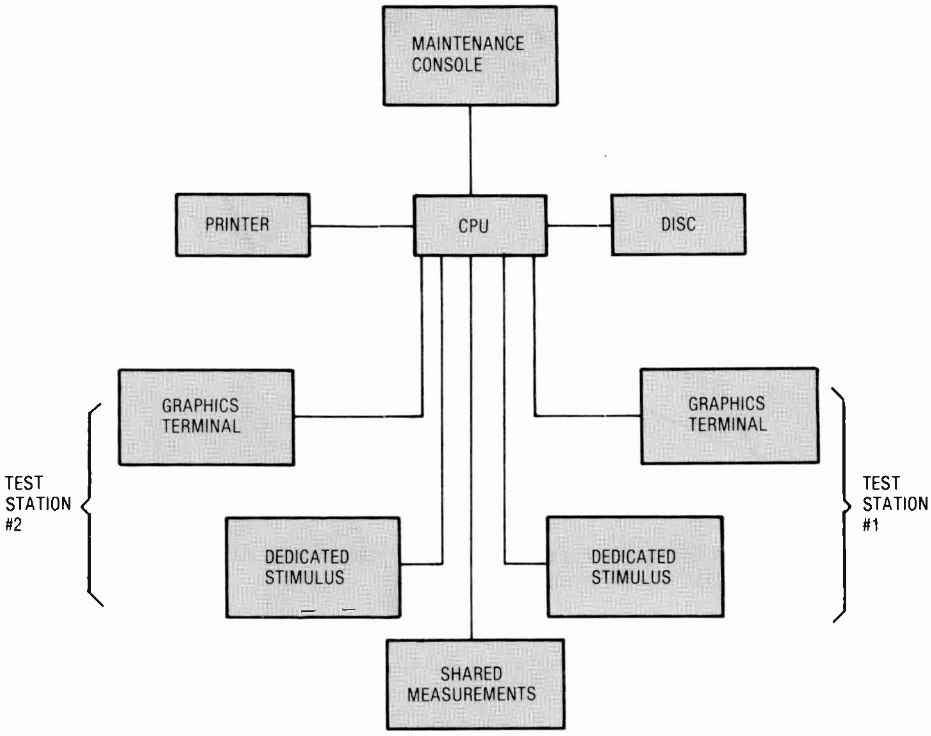


Fig. 3. Dual port ATE architecture.

ATE application software

In spite of the increase in technical capability of automatic test system hardware, preparation of the application software is still a unique development task for every new test item. Not only does this represent a never-ending development process, but the test software cost invariably turns out to be many times the test system cost. Is there a better way to develop ATE application software?

An automatic test system without application programs is like an expensive car without gasoline — it looks great in the garage, but it won't move. There is an important difference, however. Over the life of the car, the cost of gasoline will probably be no more than three-fourths the cost of the car. The cost of only *one* ATE application program could be greater than the unit cost of the test-system hardware. The application program cost is a "front end" cost; the investment has to be made before the user gets any productivity from the ATE. The cost (and the cost visibility) of software, and the ATE production dead time during software development, have prompted a search for a better way to develop application programs.

Application programs activate the tested circuit, inject electrical signals under program control, sense electrical reactions in the tested circuit, and make decisions about circuit condition. In concept, this is not too different from what the technician does with manual test instruments. Isn't there some dramatically different way of testing? Many exotic approaches have been tried, and some of these approaches are shown in Table I. The data in Table I was developed by the Princeton Laboratories. Here is a brief description of each approach.

Voltage Electrostatic Fields — An active electronic circuit creates an electrostatic field map that uniquely describes the state of voltage differential at all points in the circuit topography. Variations of this differential may be indicators of circuit health, or they may be diagnostic indicators. Because liquid crystals provide visible evidence of electrostatic fields, perhaps the unit under test could be made to be self diagnosing — a change in color could indicate that a component has failed.

Current Magnetic Fields — A current field map also exists for every active circuit. Perhaps this unique field map could be sensed and used to determine circuit condition. Because the field exists around, as well as on the unit under test, the circuit condition

Table I. Failure detection/isolation approaches.

	Voltage electrostatic fields	*Current magnetic fields*	*Power dissipation thermal radiation*	*Physical phenomena*
Access	Nodal voltages	Branch currents	Pad temperature	Direct component revelation
	Field maps	Field maps	Component temperature	
Measurement methods	Conventional stimulus-response	Edge connector	Thermocouple	Ultrasonic
		Current probes	Infrared scan	Optical
	Edge connectors	Hall effect		X-radiographic
	Direct probes			Absorption, interference, dispersion patterns
	Blunt probes			
	Steerable probes			
	Liquid crystal			
	Charge transfer			

could be sensed without using hard-contact test points.

Thermal Dissipation — The active circuit consumes power, dissipated as heat. This thermal radiation could provide a unique image of the circuit, and it could be compared with a 'perfect' circuit.

Physical Phenomena — This is a category for "all other approaches." These approaches derive from the hope that there may be some detectable physical difference between a good circuit and a faulty circuit. Perhaps the difference is detectable by some ultrasonic, optical, X-ray, or other technique. The appeal of these techniques is that no hard contact is required, and that there is a potential for automating the test procedure, dramatically cutting development time and cost.

Circuit Simulation — If the unit under test could be accurately modeled in a computer program, the user could exercise all possible failure modes and relate faults to measurable parameters at available test points. This approach works for purely digital circuits, but it is much more difficult to apply to analog or analog/digital devices.

A lot of time has been spent in search of a universal approach to test and diagnosis. Over the past fifteen years, probably $10 million and 150 man-years have been invested in test technique research. Voltage and current field maps are limited by component placement, irregular geometry, multilayer boards, and sensing device accuracy. Thermal techniques are subject to emissivity anomalies. Sonic techniques have questionable accuracy for small defects, and may even be destructive in application. Liquid crystals pose problems of board preparation and reliability.

The circuit simulation approach is a less exotic, more brute-force approach that requires detailed baseline information of component characteristics and circuit topography. But it just may be the best hope for the replacement of manually developed test programs. At least there are working techniques in limited use — limited by the size and complexity of the unit under test.

ATE in the 1990s

Additional ATE functions

History has shown that every general-purpose computer development will be followed by new applications after the original requirement has been met. With ATE there is a "third generation" system that uses the control computer for arbitrary waveform generation and for analysis of measured responses. What additional functions might ATE in the 1990s perform, other than test?

Operator/Maintenance Training — The ATE operator sees and touches only a small part of the total ATE system — generally a video display, a special keyboard, and a control panel. This interface, under stored program control, can simulate not only every testing situation, but also ATE self-maintenance scenarios. Training software that directs the system in an interactive mode can lead the inexperienced operator through simple simulated test operations. His response can be checked, his progress measured, and his on-the-job training tailored to his learning rate. The visual display will show ATE self-test progress by animated system block diagrams in color — not only providing status information, but teaching the ATE system to the operator as well.

Maintenance Management — The automatic test system is the first to know that a particular test item has failed and that the cause of failure is an integrated circuit on printed circuit board. This information is the basic data from which maintenance management decisions are made. The 1990's ATE will also:

- Accumulate and analyze test data from all test stations;
- Provide real-time inventory status information on all replacement parts, PCBs, subassemblies, and UUTs;
- Provide trend information to indicate potential problems as failures exceed prior experience;
- Project replacement usage rates for provisioning purposes;
- Indicate the effectiveness of field Engineering Changes or mod kits;
- Provide test station throughput information that can be used to efficiently schedule shop workload as a function of UUT test time, UUT population, functional test station load, and operator efficiency; and
- Provide failure data input to higher-level maintenance management systems by direct machine-to-machine interface. The data acquisition system will no longer depend on the technicians filling out forms by hand.

Adaptive Programming — Because UUT failure data will be accumulated locally, the individual test station can use this information to make the UUT application programs more efficient. The test designer generally develops the logic of the program to look for the most likely failure first. Since recent failure history will be available to the test system, perhaps the test sequence can be altered, on-line, to update the most likely failure.

Future requirements

Future requirements will demand faster clock rates, shorter rise times, and higher frequencies. The electronic world will never be all-digital, because the things we sense and control are analog. The digital part of the total system will grow functionally and become smaller physically. A-to-D and D-to-A conversion will move closer to the analog world outside the test system. Microprocessors will be in back of every interface pin, and will be a component of the hand-held probe. The probe will be literally a hand-held automatic test system able to stimulate, sense, range, threshold, evaluate, and process. It will be capable of every function but display, and that only because of the visual limitation of the human operator, not of the electronics.

Operator interface

The 1990 ATE will provide an "instrument panel" tuned to the young operator/technician. There will be two types of operator interfaces. The primary interface will be a color-graphics video display with animation and three-dimensional simulation to do more than merely present data. Using color and animation, the display will attract and direct operator attention, emphasize priority information, teach, and interact with the operator. During lunch breaks, the operator might even plug in a cassette and play a video game on his display.

The secondary interface will be a hand-held communicator that borrows freely from current electronic games. In size, shape, and operator control functions, it will look conceptually familiar. It will resemble an advanced electronic game, subtly encouraging its use and mastery by the youthful operator. It will show test progress, ask for operator responses, direct manual operations, recognize that the operator has done well or made a mistake. It will communicate with audio (peep, bleep, pip, buzz) as well as with video (alphanumerics, figures, symbols).

What **won't** *happen*

- An ATE system configuration often suggested is one where many test stations, geographically separated, are under real-time control of a remotely located large time-shared computer. The appeal of this configuration is controller economy through the shared central computer. Except for a few unique applications, this will not happen. System control is not a significant ATE cost. The cost/performance trade-off is moving toward distributed control, not centralized control.
- The analog automatic test program generation field continues to seek a universal stimulus — a single, exotic stimulus that can exercise all UUT functions and cause a UUT response uniquely identifying the failed component. White noise is one such stimulus. The problem is not in the universal stimulus, it is in translating theory to a practical test system, one with overwhelming requirements for measurement sensitivity in the presence of noise.
- With the projected efficiencies in ATE/operator interface, why doesn't the test system *talk* to the operator? Will a two-way voice interchange between man and machine be used?

ATE:
"I am now performing a gain test on the decoder preamp. Will you please set the UUT switch to position 4?"
Operator:
"Do you mean the LEVEL switch or the OUTPUT switch?"
ATE:
"The LEVEL switch, of course. The OUTPUT switch doesn't *have* a position 4."
Operator:
"Do it yourself, bubble brain; I'm going to have a cup of coffee."

Probably not. Visual communication is more direct, more objective, less susceptible to interpretation, less time-dependent, and devoid of sex and regional accent. Besides, try to imagine the enormous complexity of the software for such a system.

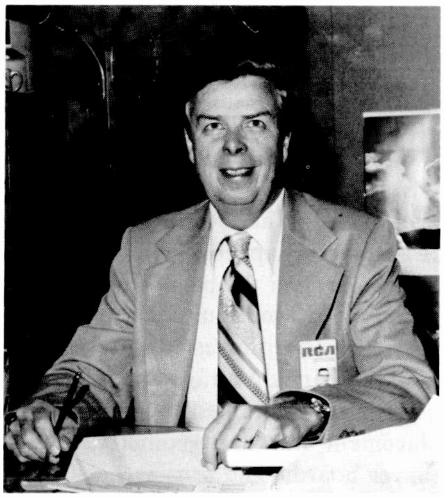
Summary

Automated test system developers will be pressed to produce ATE hardware and software equal to the testing needs of an exploding electronics field. Aside from such traditional electronics products as radar and communications, the electronic invasion will:

- Take over more control functions in automobiles, trucks, ships, and aircraft.
- Dominate medical instrumentation, provide preliminary diagnoses, and offer treatment alternatives.
- Provide the local pharmacist with a patient's medication history, potential drug interactions, and automatic third party billing.
- Replace electro-mechanical control devices in all home appliances (washers, driers, dishwashers, radar ovens, food processors) and provide energy management, home security systems, and electronic entertainment (for example, standard games such as Monopoly will be updated with microprocessor control for automated scoring and display.)

Most of the electronics on consumer products will be disposable on failure. The ATE role will be in factory test, as opposed to maintenance. For industrial electronics (medical, air traffic control, manufacturing process control), there will be a maintenance role as well as product assurance at the factory.

In the aerospace/military marketplace, the ATE requirements can only go one way — up. There were two characteristics in this area that reinforce the need for automated test: (1) prime systems will continue to grow in complexity and unit cost, and (2) the need for maintenance technicians will only become more critical.



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L.V. Hedlund

RCA's TR-800 helical VTR: A computer-based total-system design

An engineering team at RCA Broadcast Systems was given an enviable task — design and build a video tape recorder (VTR) with features and capabilities beyond anything presently on the market.

Abstract: *The RCA TR-800 helical-scan video tape recorder is more than a clever new piece of studio hardware. It's a sophisticated blend of technologies that may establish a new state-of-the-art in VTRs. The key to the TR-800 is distributed processing — several microprocessors communicating with one another to accomplish a common goal. A "central" processor handles the main functions of the VTR, and peripheral processors manage other functions such as variable speed control, time code generation and reading, and sophisticated editing.*

Engineers assigned to the new RCA TR-800 Video Tape Recorder (VTR) design project were presented with a cornucopia of opportunities and challenges.

With several Type C format VTRs already on the market, any new tape recorder developed must include innovative features and expanded capabilities to make it a strong contender in a very competitive market.

Technical performance specifications for the new VTR had to be superior. Ease of operation and serviceability were key considerations. Versatility became a prime factor in the design process: the new VTR had to include a range of built-in features to fit many application needs. Further, for extended operational sophistication and flexibility, a full complement of system accessory equipment had to be developed concurrently.

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Design objectives

With these and numerous other user-needs identified, our design goal became apparent. Simply stated, this goal was to design a complete helical-scan VTR system in the Type C format that would meet the needs of the discriminating user for high quality, high performance and operational flexibility in a variety of package configurations. Among the desired objectives were: improved editing capability; effective control of the variable play speed of the VTR by the editing system; expanded monitoring of the picture, waveform and audio; more remote control capability; improved reliability, and a significant reduction of non-productive editing time attributed to the VTR.

To meet this formidable challenge in a reasonable time, we had to rethink the classical methods used in the design of our previous video tape recorders. We preserved those that had served us well, and adopted promising new techniques as necessary to produce a technologically advanced VTR.

A microprocessor-based system

One of the time-tested designs that has given excellent service is the first microprocessor-based editing system for quadruplex VTRs — the AE-600 time code editing system. We chose to build on this approach in the design of the TR-800, taking maximum advantage of the innovative and highly flexible technology of the microprocessor.

In the TR-800 system, several microprocessors comprise

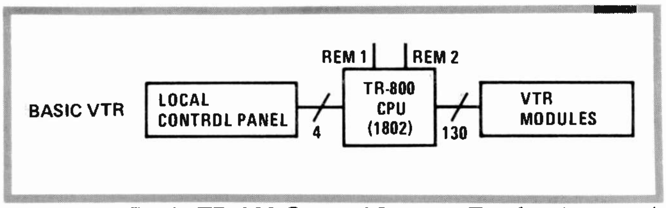


Fig. 1. The Basic TR-800 Control System. The fundamental building block of the control system.

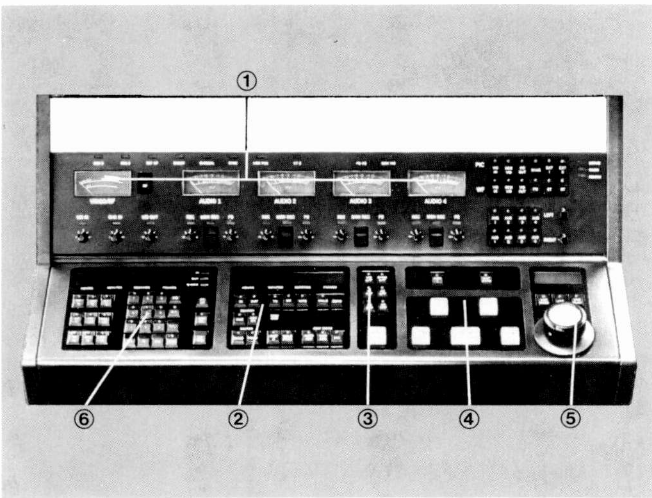


Fig. 2. The main TR-800 Control Panel. Mapping highlights the main functional areas.

a distributed processor system, with the main functions of the VTR being handled by a "central processor," while individual processors manage other functions such as variable speed broadcastable picture control, time code generation and reading, and sophisticated editing.

Distributed processing

A distributed processing system uses microprocessors, each a complete computer with a specific set of tasks to do.

Further, the system consists of a bus structure that connects all of the processors together and allows all of the processors to communicate with one another. The bus structure is generally divided into the address bus and the data bus. The type of device used at each processor doesn't really matter as long as a common protocol is obeyed for communication over the bus structure. Finally, one processor is designated the "master" central processing unit (CPU), with the primary responsibility of keeping order among the "slave" CPUs, and, of course, within itself.

Central processing unit

In the TR-800 design, the central processing unit is located in the main module nest of the VTR. Most of the feature expansion capability of our system is provided for through the use of distributed processing. The CPU is an RCA Cosmac CDP1802, and the software is stored in 4K x 8 EPROMs (erasable programmable read-only memory). The CPU is assigned the responsibility for handling the primary VTR interface with the operator at the main control panel and for control of the VTR itself (Fig. 1).

In its basic form, the control panel is partitioned into five major operational areas: 1. Video/Audio Monitoring; 2. Timer/Simple Editor Control; 3. Record Control; 4. Transport Control; and 5. Variable Speed Control. In the panel illustrated in Fig. 2, optional Time Code Generator and Super Search Editor controls have been added on the left (6).

In this configuration, there are 95 pushbutton switches, 114 LED (light emitting diode) or lamp indicators, and 18 seven-segment displays. Two standard ASCII keyboard encoders are used to encode the pushbutton data that is ultimately transmitted to the CPU. Illumination of the various LEDs and seven-segment displays is also controlled by the CPU via a random access memory (RAM) system located in the panel. The communication of the pushbutton and indicator data between the control panel and the CPU occurs at 2400 baud over two twisted pairs with a universal asynchronous receiver/transmitter, known as a UART, at each end. The RCA CDP1854 is used in the TR-800 system.

The main software includes a built-in basic editor. The Tape Time of the Edit In and Out points can be stored either on the fly or in still scan. The Edit can also be previewed before it is made.

The second level of editing, called the Super Search Editor (SSE), is available as an accessory. It is implemented by adding more software to the memory of the CPU via additional EPROMs, and by adding a keyboard and overlay to the VTR control panel. The SSE is programmed to edit to either Tape Time or Time Code. The Edit In and Out points can be entered as described above for the basic editor, or they can be keyed in via the keyboard and transferred to the In and Out memories. We also have programmed the SSE to store up to nine cue points that can be used for either the Search-to-Cue function or as a temporary memory for future Edit points.

Remote control provisions

The remote-control capability of the TR-800 is available in three forms: Remote 1, Remote 2, and Edit. The CPU memory is programmed to accommodate each of these modes.

Remote 1 employs a simple remote panel containing five pushbutton-indicators for the Stop, Play, Record, Wind and Rewind modes of the VTR. Delegation to this panel is via the Remote 1 pushbutton on the main control panel.

It should be noted here that neither an ASCII keyboard encoder nor a full microprocessor is needed at the remote location just to get the VTR to listen and respond to five simple commands. All five functions are obtained by simple contact closures via a 24-wire cable connected to the Remote 1 I/O at the rear of the VTR (Fig. 3).

Remote 2 is the full VTR mode remote, and involves the

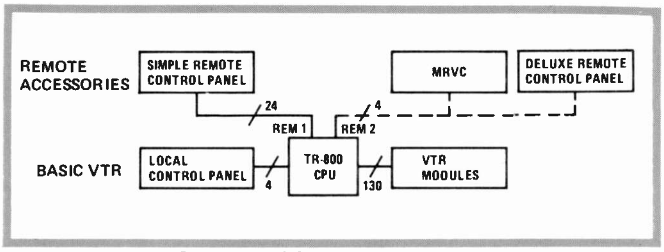


Fig. 3. Control System with remote accessories. Expanding on the basic control system.

first phase of our Distributed Processing system. This is a two-twisted-pair I/O port with delegation selected via the Remote 2 pushbutton under the flip-up cover at the top of Fig. 2. Two uses of this port are as a deluxe remote control panel, or as a major tape system accessory unit that we have designated as MRVC (Multi-Rate Video Controller).

The Edit mode remote provides for complete Time Code Edit control.

Major system components

While the main thrust of this article is on the application of microcomputers to the design of the TR-800, several other key elements of the total video tape system need to be introduced. These items, which are the keys to executing the many VTR-related tasks that can be accomplished with the amazing flexibility of microprocessor technology, include:

- Tape Reeling Servo
- Capstan Servo
- Super Track Servo
- Digital Time Base Corrector
- Multi-Rate Video Controller*
- Time Code Accessory Modules*
- AE-800 Time Code Editing Systems*

Asterisked items use individual microprocessors as part of the TR-800 distributed processor system.

Tape Reeling Servo

The TR-800 incorporates a sophisticated tape tension and tape velocity servo system. The Tape Reeling Servo is depicted here in a simplified block diagram (Fig. 4). The mode and speed commands come from the CPU. In the shuttle mode, the tape tension is measured by two tension arms and the velocity is measured by a tachometer engaged with the tape. Control of these parameters is through DC amplifiers driving permanent magnet DC motors used for the supply and take-up drive elements. In the Record, Play, Variable Play and Variable Wind (speeds below 4 x Play) modes, the tension is measured and controlled as in the shuttle mode, but the tape velocity is controlled by the capstan.

The system has two tachometers — one at each end of the tape path — and the CPU selects the one nearest the reel taking up the tape. Since take-up tension is precisely servo-controlled, the stretch in the tape at the tachometer in use is the same regardless of the direction of wind. This assures

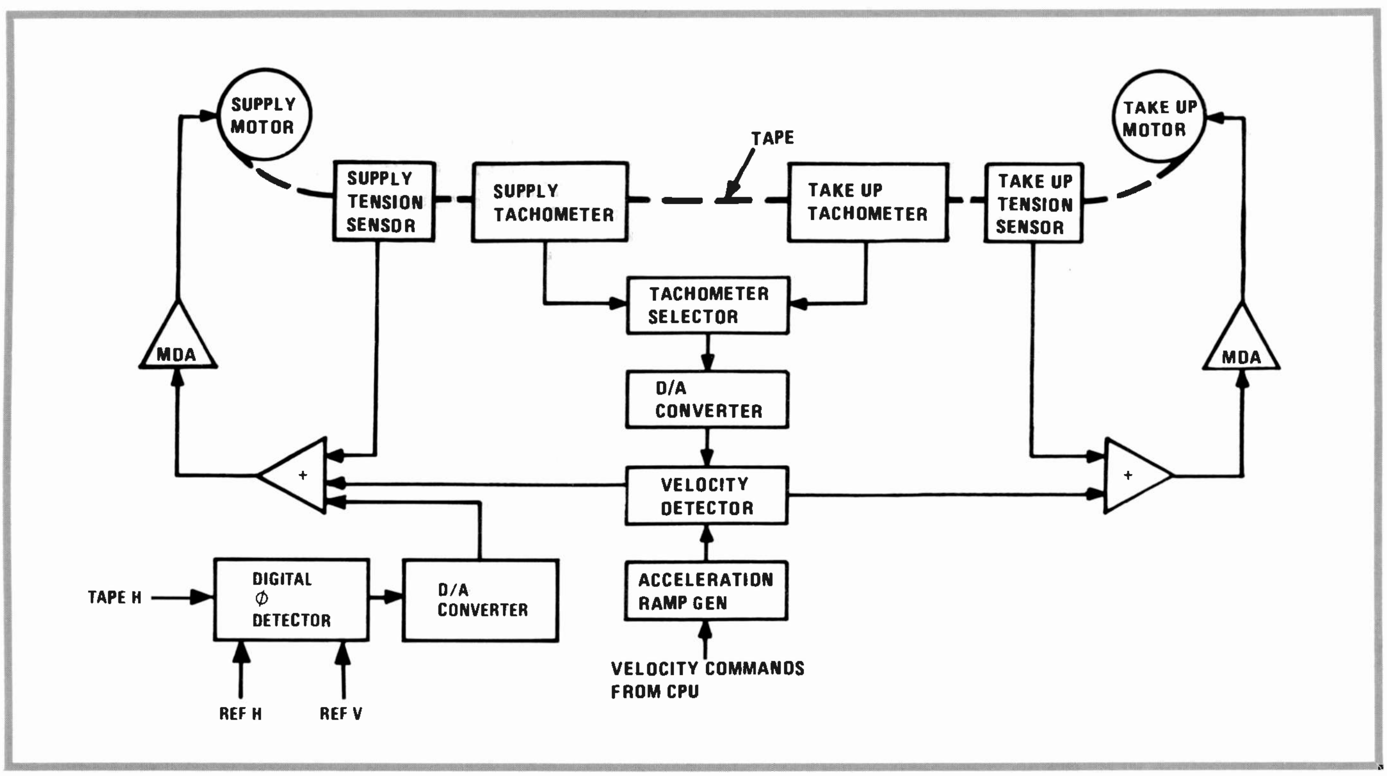


Fig. 4. Tape Reeling Servo. The primary servo responsible for moving the tape from reel to reel.

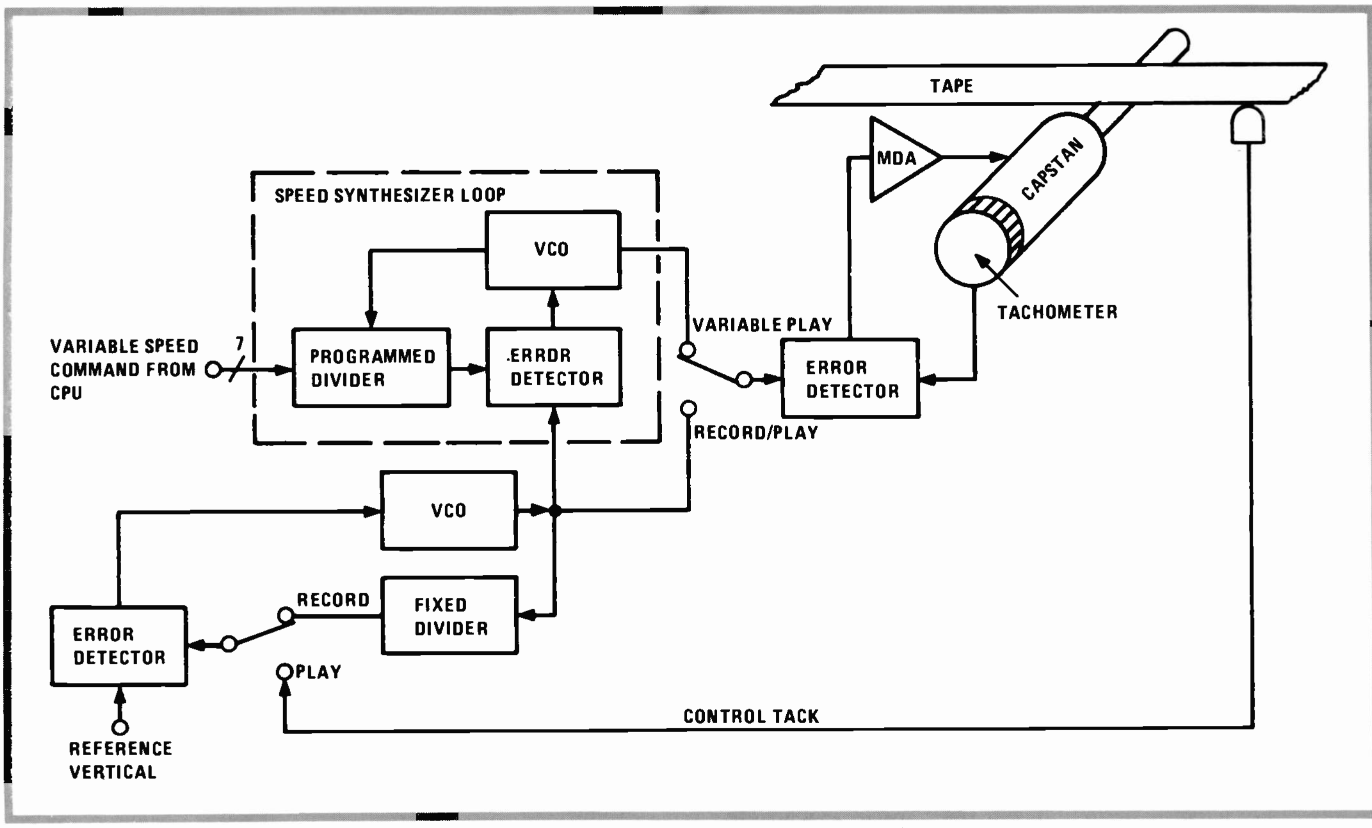


Fig. 5. Capstan Servo. Precision control of the tape speed in Record, Play and Variable Play Modes.

that the best measurement possible is made of tape length, or tape time, as it is usually called. The same selected tachometer is used by the velocity section of the servo to control the speed at which the tape is transported from one reel to the other in the shuttle mode.

As shown in Fig. 4, the tachometer output is converted to a DC level that represents the velocity of the tape. This DC level is then sent to the velocity detector, where the velocity error signal is developed. There are two fundamental aspects of velocity that are of interest: steady-state velocity and rate-of-change of velocity. Rate-of-change of velocity is, of course, acceleration or deceleration. This velocity detector controls these important parameters. Whenever the CPU commands a new velocity via an 8-bit digital to analog (D/A) converter, located in the Computer module, it does so as a step function from the original to the new value. Inside the reel servo module, this signal passes through a ramping circuit that determines the rate of change of the input signal to the reference side of the velocity detector and, hence, the acceleration/deceleration characteristic of the tape reeling servo.

Capstan Servo

There is a unique feature of the Capstan Servo that makes it a key building block in the complete system approach taken in the design of the TR-800. That feature is variable speed control of the capstan in both forward and reverse

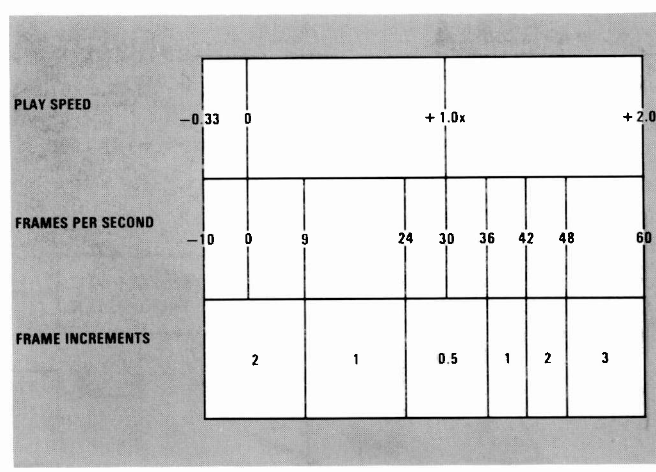


Fig. 6. Capstan variable speeds. Chart showing tape speed and increments in the Variable Play Mode.

directions in incremental rate differences as small as one field per second.

As shown in Fig. 5, the heart of the Capstan Servo system is the speed synthesizer that is used to control the capstan speed in the Variable Play mode. The divider in this loop determines the frequency of the Voltage Controlled Oscillator (VCO), which in turn determines the speed of the Capstan via the Motor Loop. The division ratio of the divider is stored as a look-up table in a programmable read-only memory (PROM), and is selected by the speed-request command from the CPU.

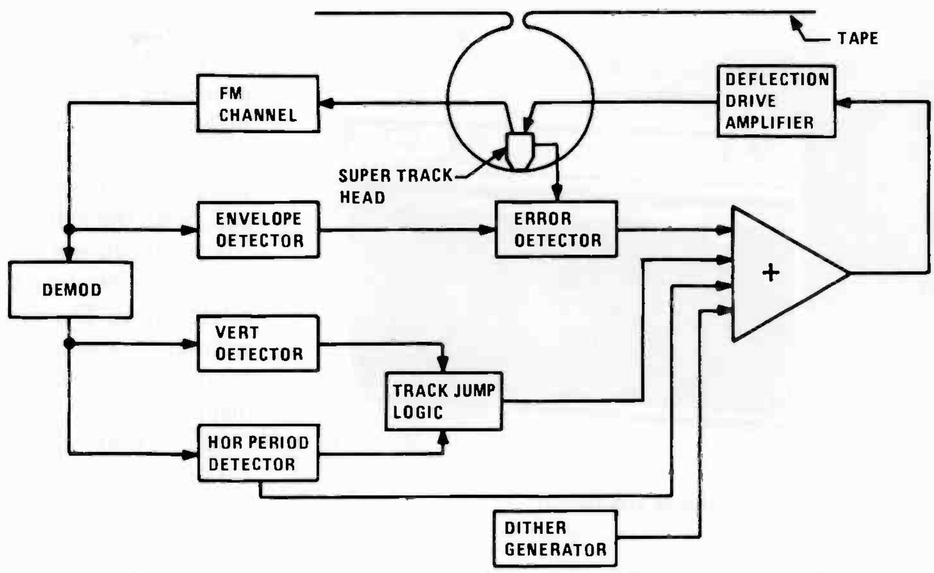


Fig. 7. SuperTrak Servo. The servo responsible for keeping the playback video head on the recorded track in all Play and Variable Play Modes.

By making this a digitally-controlled system, the operator is offered a large choice of variable repeatable playback speeds. The increments of speed have been programmed in a unique fashion (Fig. 6). Note in particular the increments around normal play speed, and you can see that one-field resolution is provided between 24 and 36 frames-per-second. The significance of this resolution and the capability of programming the speed will be explained later.

SuperTrack Servo

The SuperTrack accessory for the TR-800 provides for broadcastable color playback from reverse motion through still frame to fast motion. Total control of this facility is integral to the TR-800, permitting on-line control as well as pre-programming capability.

The SuperTrack Servo System (Fig. 7) is responsible for keeping the ST video playback head on the recorded track in the Play and Variable Play modes. It employs a video head mounted on a sandwiched piezoelectric structure that can be driven in a direction perpendicular to the recorded track. The well known scheme of dithering the head and measuring the FM amplitude in a synchronous detector is employed to develop the servo error signal.

Digital Time Base Converter

Several unique design features make this unit more than just another Digital TBC — not the least of which is the fact that it was designed from the ground up to continue the full microcomputer-controlled system concept of the TR-800 program.

As shown in the block diagram (Fig. 8), the TBC-8000 contains all of the usual TBC items, including Drop Out Compensator (DOC) and Velocity Error Corrector (VEC). However, Time Base Correctors for Type C helical scan

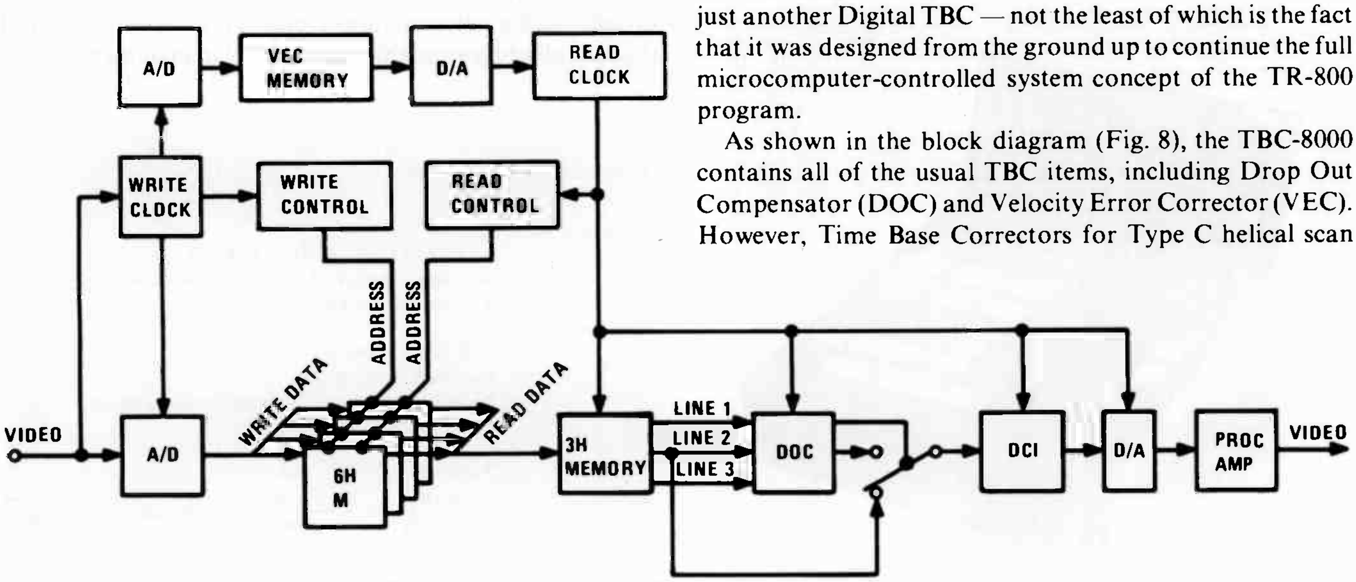


Fig. 8. Block diagram, TBC-8000. A complete Digital Time Base Error Corrector with up to 24 T.V. Lines of correction.

TBC-8000 Digital Time Base Corrector.

VTRs need another capability — reconstruction of the NTSC four-field color sequence from any one, but only one of the four fields. There are many ways to do this, but they all involve separating the chroma from the luminance and then recombining these signals in a manner to effectively produce the NTSC four-field color sequence.

In the TBC-8000, this function is performed in the digital domain for enhanced performance and long-term stability. The process involves chroma inversion; hence, we refer to this subsystem as the Digital Chroma Inverter (DCI). With the DCI, color rendition is possible at tape speeds up to ten times play speed.

Multi-Rate Video Controller

With the MRVC, variable speed replays in forward or reverse are easily handled by the TR-800. This facility handles instant replays and slow motion operations in sports, and is useful in production for special effects and time compression or expansion.

The MRVC contains another CDP1802 microprocessor with about 12K of software and a power supply, making it a completely self-contained microcomputer. Communication with the TR-800 CPU is over two twisted pairs via the Remote 1 I/O and a CDP1854 UART at each end. With the MRVC, the VTR operator can store up to 12 cue points during each recording. The record time and cue points are displayed on two linear bar graphs to depict relative time. The bar graph is designed to display either 60 seconds or 6 minutes of elapsed record time. Selection of the desired time display is by a range switch to the left of the displays.

The MRVC also allows the operator to command the TR-800 to return to the beginning of the recording with the push of only one button. Other cue points can also be easily selected. The MRVC will also control the TR-800 in the Play or Variable Play modes. The operator can select any of the preset playback speeds using one pushbutton, or control the VTR over its entire range of playback speeds by means of a linear slider mechanism. A "Time Remaining" display provides a constant update of time to the end of the recorded section regardless of speed selected during playback.

Multi-Rate Video Controller (MRVC).

Putting it together

Before proceeding, let's briefly recap a few important TR-800 system components that have been covered so far: a Distributed Processing System; a Multi-Rate Video Controller; a tension-and-velocity-controlled Tape Reeling Servo; a wide range variable-speed controlled capstan; a SuperTrack video head deflection servo; and a wide range Digital TBC.

By putting all of these elements together, we have broadcastable color pictures from −⅓ to +2.0x play speed that are all programmable via the CPU in incremental rates

TAPE LENGTH = RATE x TIME

$L = RT$

ORIGINAL TIME

L_1 = TAPE LENGTH TO BE PLAYED

R_1 = 30 FRAMES PER SECOND NORMAL PLAY SPEED

T_1 = 32 SECOND PROGRAM SEGMENT

NEW TIME

L_2 = TAPE LENGTH TO BE PLAYED

R_2 = NEW PLAY SPEED

T_2 = 30 SECOND PROGRAM SLOT AVAILABLE

$$L_2 = L_1$$

$$R_2 T_2 = R_1 T_1$$

$$\boxed{R_2} = \frac{R_1 T_1}{T_2} = \frac{(30\ f/s)\ (32s)}{(30s)} = \boxed{\text{32 FRAMES PER SECOND}}$$

Fig. 9. Program time alteration. A sample calculation for program time alteration.

as small as one field per second. Not only will the system do the standard tasks of an instant replay device for sports, but it will do some special tricks such as time compression and time expansion of program material.

Let's say, for instance, that you have a 32-second tape or dub for later play to air, but the final time slot available is only 30 seconds. Solution: Dial 32 into the variable play speed control of the TR-800. In this mode, that number represents 32 frames-per-second, and the 32-second tape will be played in 30 seconds, as shown by the calculation in Fig. 9.

Not only could this save a lot of time for people who may have had to do some fancy editing of the video, but the same advantages may accrue with the audio.

If the magnitude of the time change is small, the resulting pitch change in the audio may not be objectional and it would be possible to dub the time-altered audio at the same time as the video.

Time Code Accessory modules

Thus far, only the basic editing facilities of the TR-800 have been mentioned. Now we are about to return to the world of microprocessors and a description of their function in the sophisticated Time Code Editing capability developed for this new VTR.

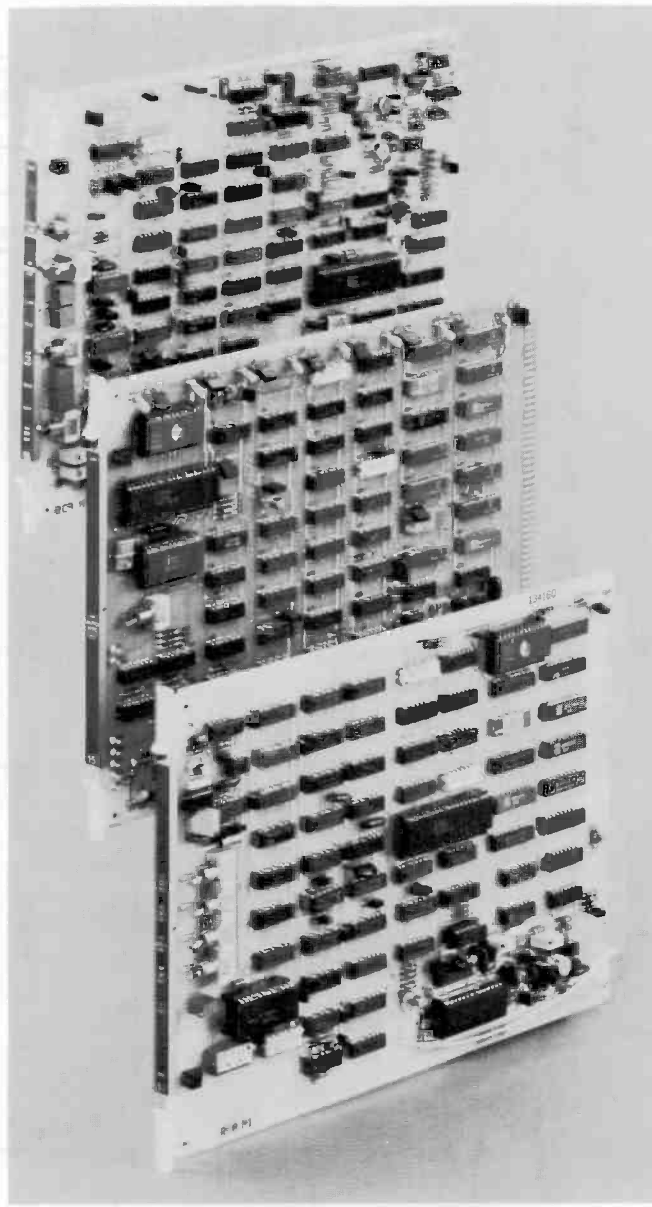
The three accessory Time Code modules for the TR-800 — Time Code Generator, longitudinal Time Code Reader, and the Video Time Code Processor — are all housed in the main module nest of the VTR. Each of these modules includes a full microprocessor as part of the TR-800 Distributed Processing system.

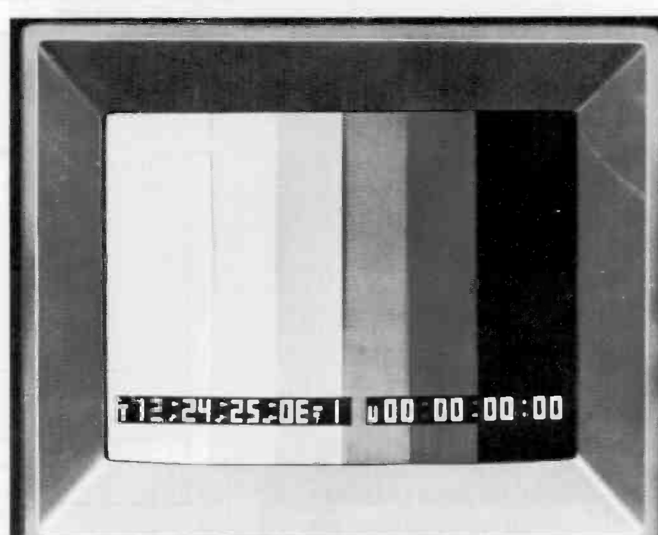
The TR-800 CPU communicates with these modules over the TR Bus and requests a specific module to process a particular function (Fig. 10). The responsible processor performs its task and when finished, communicates an appropriate status back to the CPU.

An 8035 microprocessor is used in all three modules because it is smaller than either the 1802 or 8085, and it contains an internal RAM. This is an important consideration in minimizing the use of valuable space in the VTR. This factor, together with the fact that we have used a microprocessor for each module function, allowed us to get all of these functions on just three modules.

Figure 11 is a simplified block diagram of the Time Code Generator module. Other than the fact that a microprocessor is used as part of a Distributed Processor system, the important thing to note is that this TC Generator is designed to provide Vertical Interval Time Code (VIT Code) in addition to the standard longitudinal Society of Motion Picture and Television Engineers' (SMPTE) Time Code.

The main task of the second Time Code accessory module, the Time Code Reader (Fig. 12), is to read the longitudinal code (LT Code). Its secondary task is to pass on the VIT Code obtained from the third module to the TR-800 and the editing system at the appropriate time. The





Time Code Accessory Modules for TR-800.

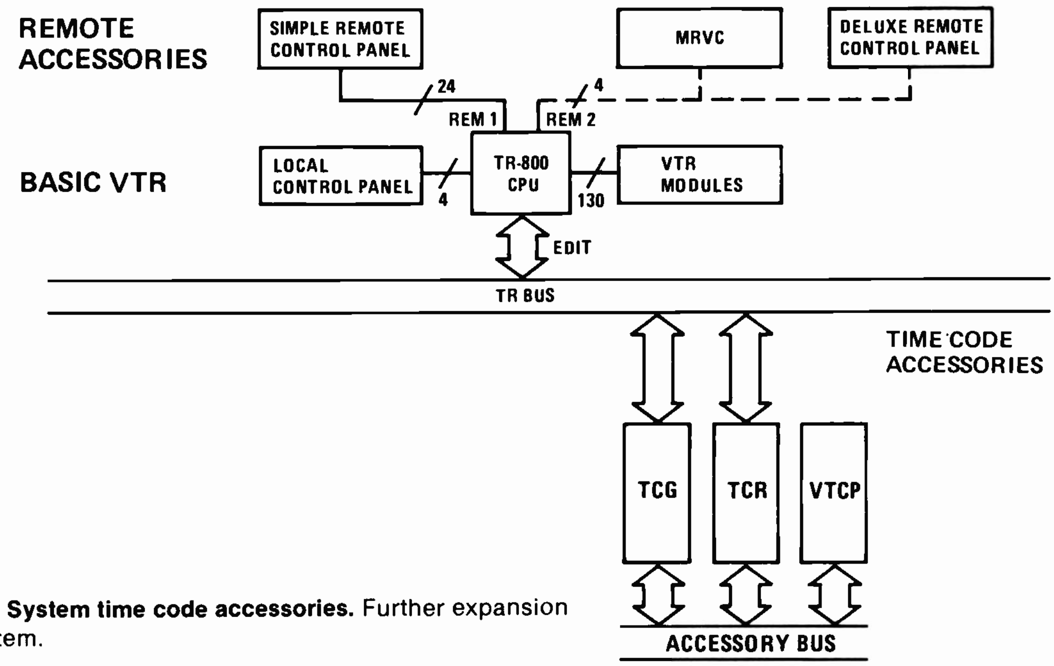


Fig. 10. TR-800 Control System time code accessories. Further expansion of the basic control system.

front end of this module is a proven design that has served us well in the AE-600 editing system. As in all such systems, it does, however, have a lower limit in tape speed at which it will no longer read the longitudinal code successfully. This is where VIT Code comes in and leads us to the third and final Time Code Accessory module.

In addition to extracting the VIT Code from the video signal, the Video Time Code Processor module (Fig. 13) has two other major functions to perform. The first function is to decode the VIT Code and send the data over the Accessory I/O Bus to the Time Code Reader module, where it is automatically or manually selected and sent on for display on the various seven-segment displays of the system. The automatic selection of VIT Code occurs at speeds below which the LT Code can be successfully read. The second function is to format the two codes for display on a standard TV monitor. The characters are white and are inserted into the video either with or without a black

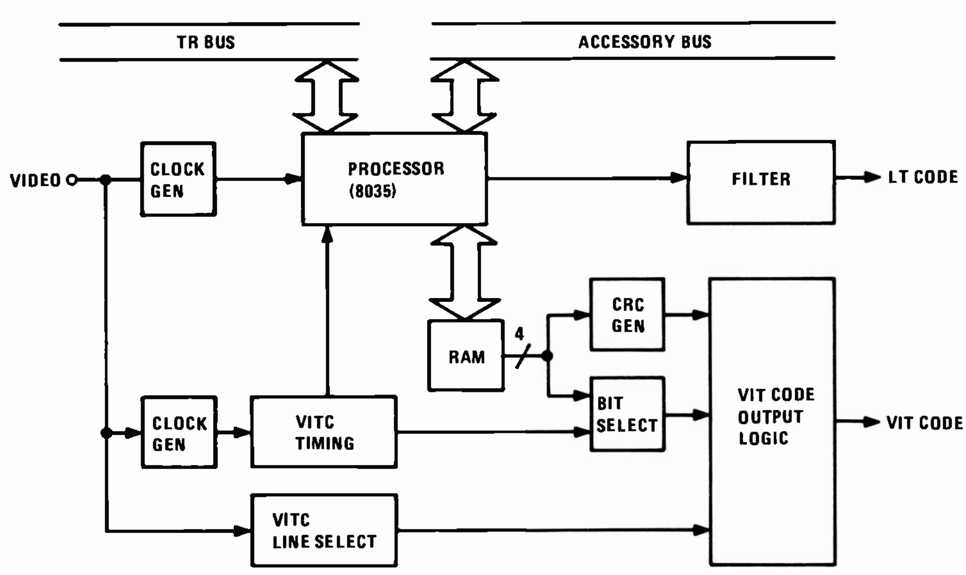
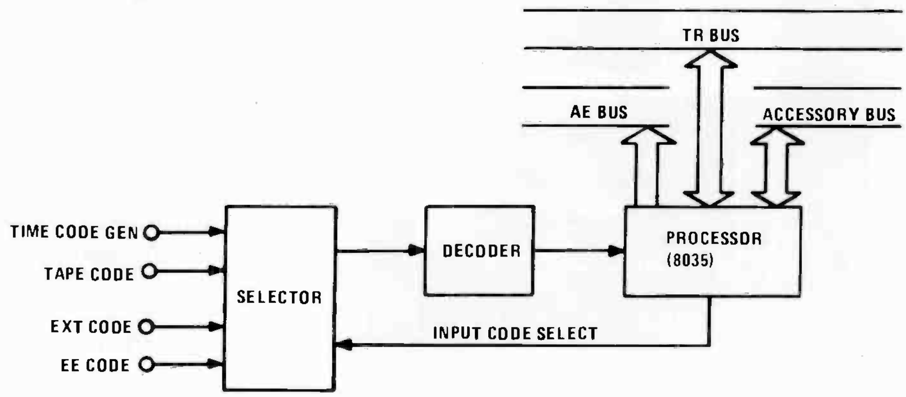


Fig. 11. Block diagram, Time Code Generator module. A single module generates both Longitudinal and Vertical Interval Time Code.

Fig. 12. **Time Code Reader module.** Processes the playback Longitudinal Time Code for distribution to the VTR and the Editing System.



surrounding box, depending on the choice of the user. The character height and position is also variable. A choice of either 28 or 42 raster line high characters is provided, and they can be positioned anywhere on the raster. Although the three accessory modules are totally self sufficient when housed in the TR-800 main frame, there is a further use for them — operation with a full Time Code Editing system.

AE-800 Time Code Editing System

The final and most significant element of the TR-800's Distributed Processing System is the AE-800 Time Code Editing System. The expanded Distributed Processing System depicted in Fig. 14 shows the complete system.

An 8085 in the AE-800 communicates with the CPU in the TR-800 over the TR Bus via Edit I/O port, the last of our remote ports. It also communicates with the three Time Code accessory modules through the Time Code Generator modules and the Accessory Bus. The TR-800 CPU independently communicates with these modules over the TR Bus. In addition, another 8085 is housed in the CRT/Printer interface to allow timely display of Edit decision data on the CRT built into the TR-800 studio console, and for logging the desired data on any standard hard-copy printer. Operator control of the AE-800 is through either the local control panel for simple standup style editing, or from the AE-800 remote-control panel for more sophisticated three-machine editing. The final microprocessor of our system, an 8085, is located in the AE-800 remote control panel.

A major feature included in the design of this editing

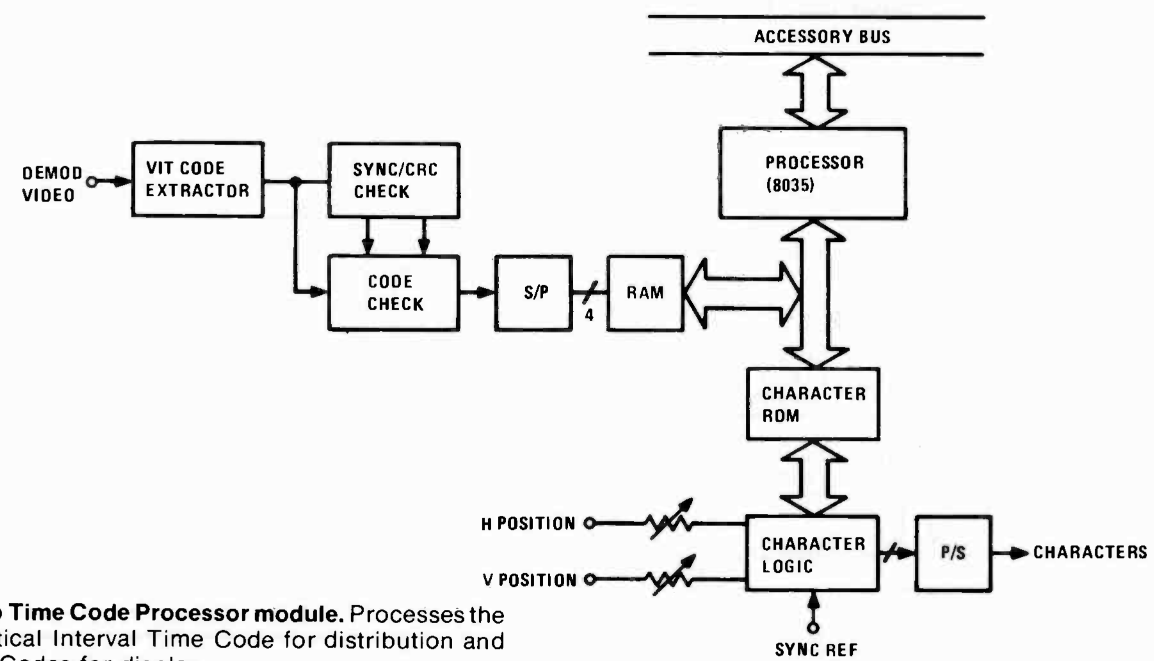


Fig. 13. Video Time Code Processor module. Processes the playback Vertical Interval Time Code for distribution and formats both Codes for display.

TR-800 Type C One-Inch VTR.

system is complete control of the Variable Play mode of our VTR. This means that an operator can request a particular play speed from the source machine to fill an available time slot in a master tape on the record machine.

LOCATION	CPU TYPE	PROGRAM SIZE
TR-800 CPU	1802	30K
MULTI-RATE VIDEO CONTROLLER	1802	12K
ACCESSORY MODULES		
TIME CODE GENERATOR	8035	2K
TIME CODE READER	8035	2K
VIDEO TIME CODE PROCESSOR	8035	2K
AE-800 CPU	8085	20K
CRT/PRINTER INTERFACE	8085	5K
REMOTE CONTROL PANEL	8085	5K
	TOTAL PROGRAM	78K

Fig. 15. Microprocessor Summary, TR-800 System. A list of microprocessor bypes, their function and the corresponding program size.

The system will calculate the required cue point for the source machine, based upon its play speed, and automatically cue the VTR to this point.

Summary

In this article, no attempt has been made to cover the total design of the TR-800 VTR in any detail. There has been no discussion of the design as it relates to picture, waveform, and monitor selection, beginning and end-of-tape sensing and warning indicators, and so on. And the AE-800 editing system was touched on only briefly in terms of its use of microprocessors, and not at all in terms of its extensive editing capability and flexibility.

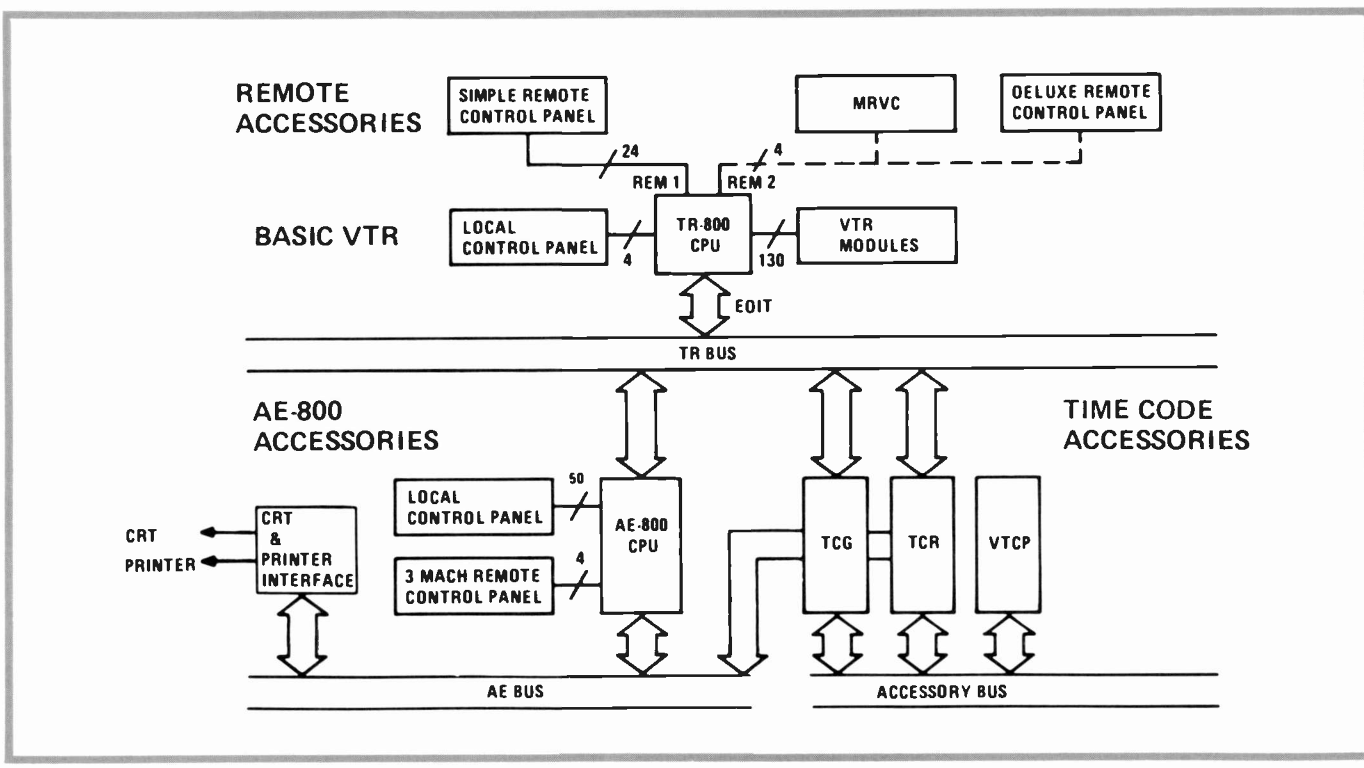


Fig. 14. TR-800 Control System — full distributed processing system. The final expansion of the basic control system.

As noted earlier, the main thrust of this article has been to describe the use of microprocessors in the TR-800 and its system accessories. Figure 15 shows the distribution of microprocessors in the TR-800 system and their primary tasks, with an indication of the program size for each. The full system contains eight individual microprocessors and a total of about 78K of program.

The use of microprocessor technology has allowed as to pack a host of valuable features in a very compact package. If we were to implement this design in hardware without microprocessors, the complete distributed processing control system alone would occupy the space equivalent to two and one-half control systems of a TCR-100 Video Cart Machine, or ten IDA/ADA Video Cassette identification systems, or the control system of ten basic Quad VTRs.

There is no question that the microprocessor will have a significant impact in the 1980s on the people who make and use quality broadcast equipment. It already has.

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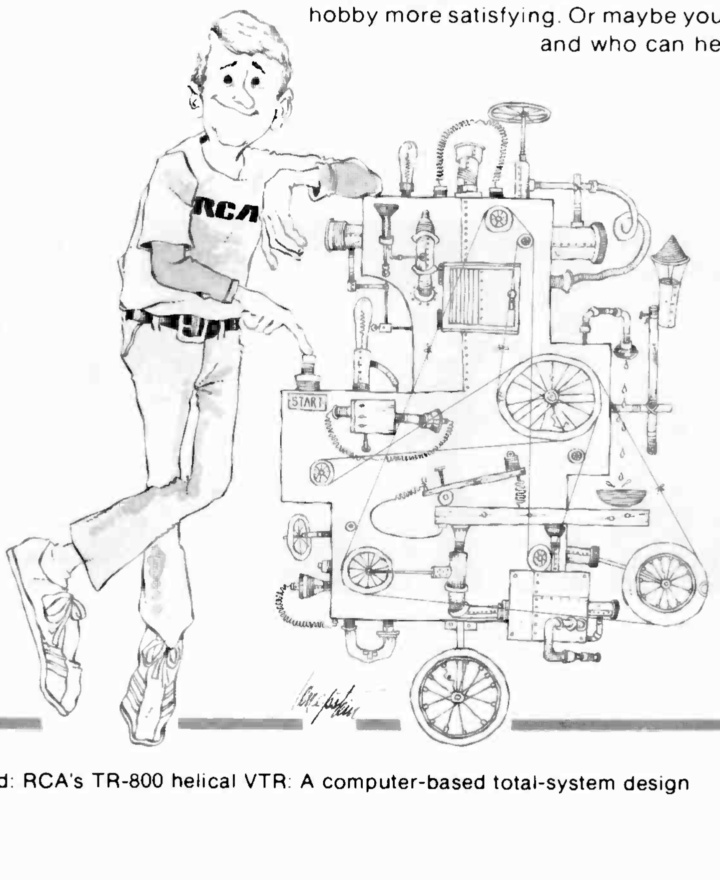
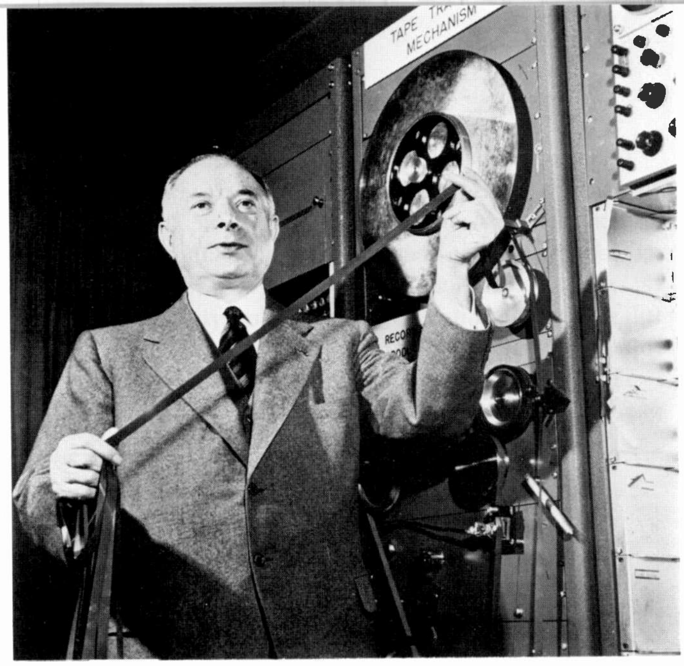


R.F. Muller|J.A. Haggart

The art of videotape editing

Follow the 25-year history of videotape editing — a blend of technology and art — from the Jack Paar Show, *through the* The Flip Wilson Show, *to today.*



The late General David Sarnoff with an experimental half-inch videotape developed in 1955 by 3M. It was a forerunner of the tape in today's home videocassette — not even dreamed possible a quarter century ago. (Courtesy 3M)

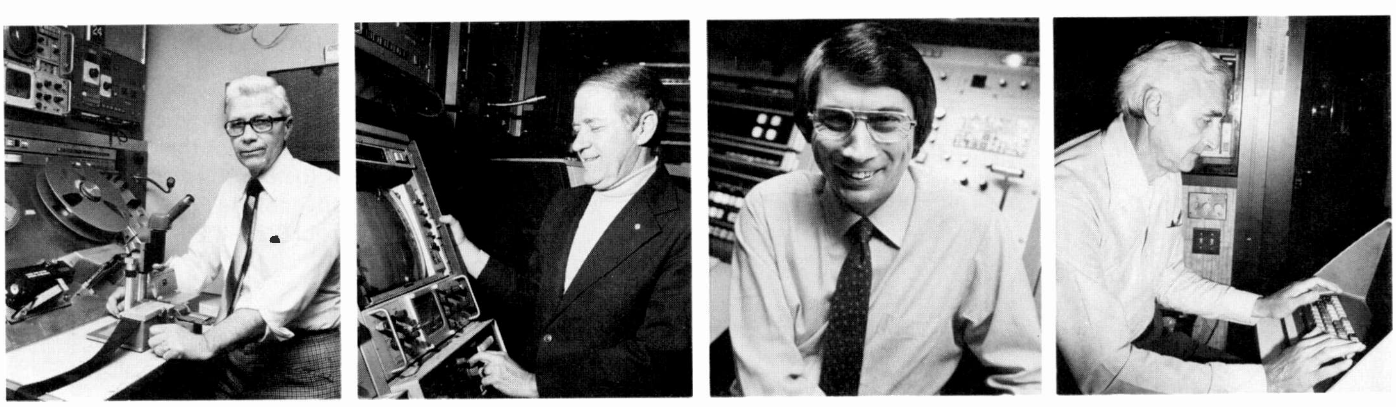
Abstract: *"What you see is what you get" as scenarios intersperse the exposition, and the authors follow the technology of videotape editing from manual splicing through computer-controlled editing. The future of videotape editing will encompass various new technologies that will continue to change the television landscape.*

Of razor blades and splicing tape

Charles "Buddy" Shadel peered into the microscope lens atop his Smith and Smith splicer as he completed the physical alignment. He reached for an Allen wrench to make a minor but necessary correction in order to slice precisely in the middle of the 5-mil guardband that separated the 10-mil-wide tracks of video information. A successful splice required Buddy to cut in the proper area and to be lucky enough to match an odd with an even field. "Someone must find a way to identify the proper place for me to cut," Buddy mused. "It would make being a videotape editor so much easier."

The first challenge

In March 1956, Ampex introduced videotape recording. Almost immediately, producers were anxious to rearrange the scenes they had recorded on this new "magical medium." Prior to this date, the only practical way to record an electronically generated television signal was to aim a film camera at a monitor, a crude process known as kinescope recording. Videotape eliminated the need for an optical transfer by recording the electronic signals directly on a two-inch-wide magnetic tape.



Meet the editors. Left to right, Charles "Buddy" Shadel, Walter Balderson (both now supervisórs at the NBC New York videotape desk), Rex Bagwell (Manager of Post-Production, Burbank) and John Olszewski (senior CMX editor in New York).

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The design engineer's first challenge was to record a wideband signal equivalent to 18 octaves of frequency, while maintaining a reasonable linear tape speed. After much experimentation, four heads were placed 90° apart on a drum that rotated perpendicularly to the surface of the tape. By modulating the video on an FM carrier, the required bandwidth was compressed to four octaves. The frequency response required to record this signal was obtained by moving the tape at 15 inches per second (ips) and rotating the video head drum at 240 revolutions per second, producing an equivalent head-to-tape velocity of 1,560 ips. These heads, plus stationary audio, cue, and control track heads, produced a magnetic footprint which is illustrated in Fig. 1.

Originally, the only way to accomplish the requested rearrangement of program segments was physically to cut the tape. The simple quarter-inch audio editing block was enlarged to a two-inch width to accommodate the wider videotape. This method was imprecise, it generally did not allow for a synchronous edit and caused a severe disturbance in the picture, and it sufficed for only a short while. The production team's demand for an undisturbed edit led designers to seek a system that would allow editors like Buddy Shadel to make a synchronous splice.

For years researchers had used a medium in which carbonyl iron filings were suspended to "develop" audio tape for the purpose of checking track alignment and spacing. When this solution, called Visimag (RCA) or Edivue (Ampex), was applied to the tape and allowed to dry, a pattern like that shown in Fig. 2 would emerge. Using the solution, the editor was able to develop the tape, peer through a hand-held jeweler's loupe, and find the edit point. See edit sequence, Fig. 3a-f.

During the late 1950s, several improvements were introduced that speeded up the physical editing process. These included a means of running the splicing foil under the tape, the addition of a guillotine device for more accurate cuts, and the addition of a microscope with a graticule to assist in finding the edit point (Fig. 4a-b).

Still the editor had only a 50/50 chance that his cut would make a proper edit. To work around this problem, many editors included a few additional frames of video in the first cut. If the splice matched two similar fields (even to even or odd to odd), the edit would bobble and break up. He would then recut the splice, take out the required number of fields to get back in sync, but be careful not to trim to the point that the program no longer made sense. All this made a difficult process even more tedious.

At the April 1958 Society of Motion Picture and Television Engineers (SMPTE) Conference in Los Angeles, Jerome Grever of RCA described an RCA design that used a 30-Hz edit pulse to replace the 60-Hz field pulse. He stated, "We have a slightly different system... Every half an inch there (is) one frame pulse, this being slightly different from the Ampex system which has pulses every quarter inch, every field." This new pulse would finally provide an accurate indication of the point at which an editor could be certain of making a synchronized splice. This "frame pulse" later underwent minor modifications, but formed the basis for an edit standard when it was incorporated in the Ampex machines and adopted by SMPTE (Figs. 2 and 5).

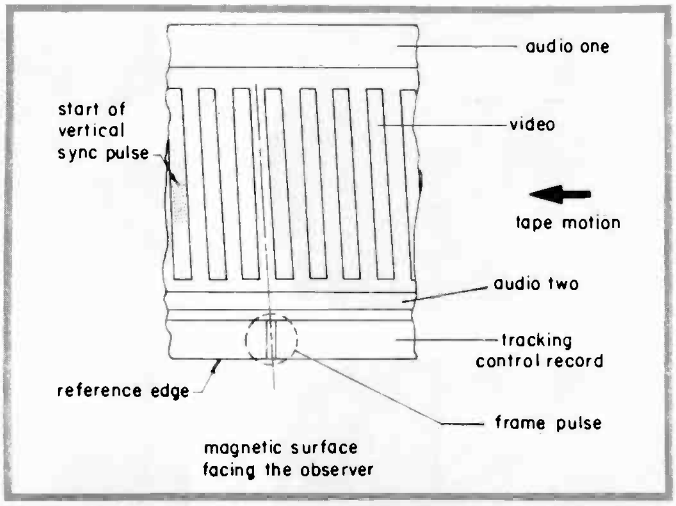


Fig. 1. Magnetic "footprint" of a 2-in. Quadruplex videotape recording. The audio, cue (audio two) and control signal are longitudinal tracks recorded by fixed heads. The video information is contained in the transverse tracks inscribed by the four rotating heads. (courtesy SMPTE)

Five minutes a splice

Buddy was about two-thirds of the way through editing this week's Jack Paar Show. *It was 1:20 p.m.*

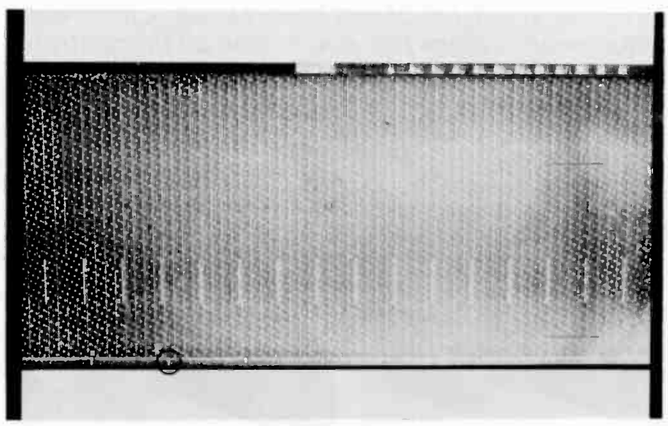


Fig. 2. "Developed" piece of videotape. The *frame* pulse contained in the control track is circled. This 30 Hz signal improved the odds of a correct edit by marking the frames, instead of each field.

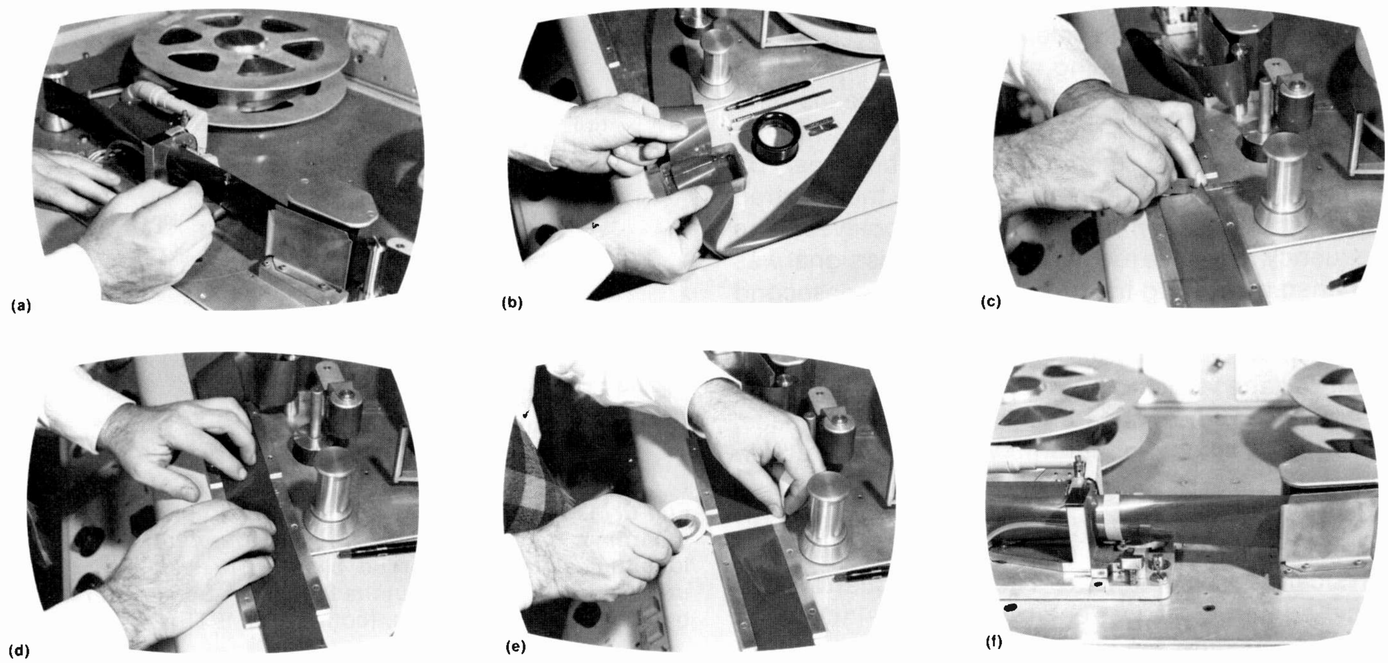


Fig. 3. Editing sequence with an early splicing block. (a) Editor marks the desired edit point, **(b)** the tape is dipped in a suspension containing carbonyl iron filings to "develop" the tracks; **(c)** after the proper place is located with the aid of a magnifying lens (bottom of photo), the cut is made using a straight edge as a guide; **(d)** tape must be flipped and repositioned in order to **(e)** apply the splicing tape to the backing; **(f)** the splice must be played back to determine if it is acceptable. (Courtesy Ampex Corp.)

Surrounding his work area were the tools of a videotape editor: splicer, marking pen, razor blade, roller, even white gloves. Except for the Smith and Smith splicer itself, these tools very much resembled those used for cutting film (Fig. 6).

Buddy marked the start of an off-color joke by Buddy Hackett, which the NBC "censor" said had to come out. He then played the tape to just beyond the audience laughter, stopped the VTR, and marked the out point. The "pregnant pause" left by Hackett provided enough space to make a good edit without any lip-flap. With both sides of the edit marked, Buddy used scissors to cut out the large segment that separated them. After shaking the glass jar to re-mix the carbonyl iron filings and Edivue diluent, he used a cotton swab to place this suspension on the control-track edge of the tape. Within seconds, a pattern of white "hash marks" appeared. He placed them under the microscope and closed the top left side of the jig.

Under the microscope, the developed pulses could be seen clearly. Turning the knob on the splicer, Buddy positioned the edit pulse under the center stripe of the graticule. He moved the tape three tracks to the right, centered the guardband, and made his cut with the built-in guillotine. He performed the identical routine on the right-hand segment.

Buddy then pulled out a clean section of ultra-thin

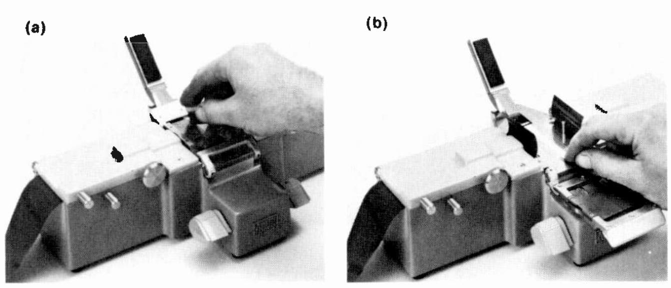


Fig. 4. The improved splicer. (a) The improved Ampex splicer included a clear plastic guide for the razor blade, and **(b)** lifting pins to allow the application of splicing tape without flipping the videotape over. (Courtesy Ampex)

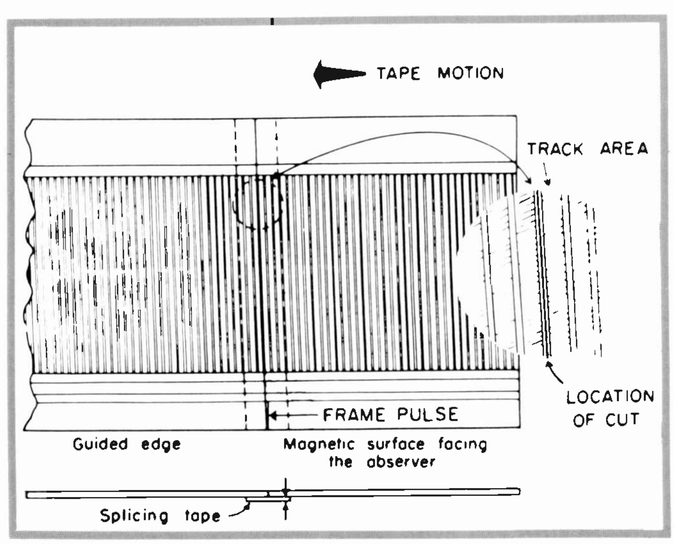


Fig. 5. Diagram noting the proper location for a cut, and the application of splicing tape. Editors often moved the cut several guardbands over from the one above the frame pulse. (Courtesy SMPTE)

foil tape. This splicing material had to be very strong to withstand the punishment of the headwheel, while adding very little to the thickness of the videotape itself. After positioning the foil under the cut, Buddy allowed first one end and then the other to contact the adhesive. To insure a good bond, he "ironed out" the tape with a rubber roller. As he finished trimming the excess splicing foil, Buddy noticed the time — 1:25. Five minutes a splice was a good pace!

But major obstacles still existed. Years before, film had perfected a double system for editing picture and sound individually. Videotape's format did not allow for separate cutting. The 9.25-inch distance (Fig. 7) between the audio and its corresponding video signal made physical splicing all the more difficult. As he lit his pipe for the twelfth time today, Buddy muttered, "There has to be a better way."

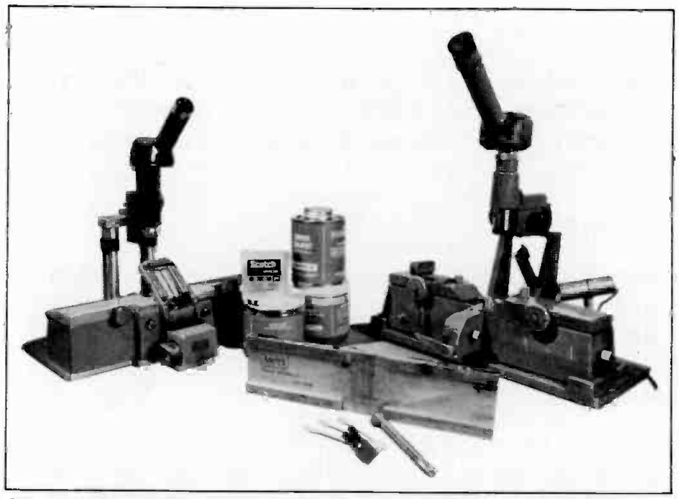


Fig. 6. The editor's tools. Background, left to right: Ampex splicer with "home brew" microscope added; splicing tape and Edivue diluent; the S&S splicer. Foreground: original edit block with rubber roller, swabs and, most important, the razor blade.

The better way

Walter Balderson struggled with the cart that contained all the Flesh and Blood master reels as he made the turn into VTR 15 and 16.

It was August, 1967, and he was about to be the first NBC-New York editor to splice a show electronically using the Editec™ system. The noted director Arthur Penn (Bonnie & Clyde, Alice's Restaurant, and Missouri Breaks) had completed the teleplay called Flesh and Blood at NBC's Brooklyn Studios. Even though most of the special effects had been recorded in the studio, Baldy needed about three weeks to assemble the correct scenes, make internal edits, and put the finishing touches on this 90-minute production. "Editec™," said Baldy, "opens a whole new era of editing. Now I can preview a scene, make adjustments, move the cue point, and not bother the original tape." As he completed timing the editor and making a trial edit, Unit Manager, Bruce Bassett, entered the room. It was now time for Baldy to make his first electronic splice.

The second challenge

Several years before, in the early 1960s, RCA and Ampex, the two major VTR manufacturers, were locked in a battle to market the first electronic splicer. To design such a system, engineers had to address problems at the edit point such as double recording, phase differentials, and servomechanical disturbances.

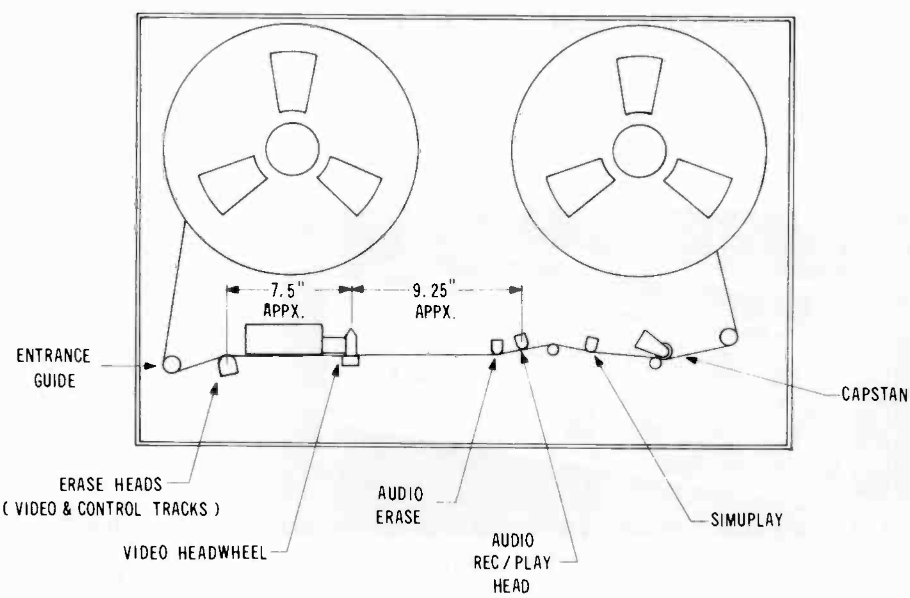


Fig. 7. Simplified tape path of a TR-70 indicating the offset of the erase, video, and audio heads. Ampex located the position of the VR-2000's erase stack closer to the entrance guide, adding approximately 1.5 inches to its separation from the video head.

OFF-LINE

A term used to describe a low-cost edit system that uses an inexpensive tape format (like ¾-inch cassette) to prepare a "workprint" and generate an Edit Decision List (EDL).

ON-LINE

Refers to a system that employs high quality equipment to produce a final edited master, and where edit decisions are made in real-time.

AUTO-ASSEMBLY

A process where the EDL produced in an off-line session is loaded into an on-line system, for computer controlled execution of the edits in either sequential (A mode) or checkerboard (B mode) patterns.

Double recording was a physical problem precipitated by the location of the erase head with respect to the video head (Fig. 7). The erase head had been placed just inside the entrance guide, a full nine inches in front of the video head. If the erase bias and video record current were applied simultaneously, approximately 18 frames of tape would contain both the old and new information, until the newly-erased section was reached. The design team changed the machine's control logic to use the video synchronizing pulses as counters which would turn on the video record head 18 frames after energizing the erase head. An identical approach was used to solve the out-splice problem.

A servo system locked to the same source during the transition from playback to record solved the servo-mechanical problems and made assemble edits possible. In the assemble mode, the editor adds program material to the previously recorded segment and builds his production piece by piece. This mode allowed the producer to build his show sequentially, but did not provide the means to place one segment within another as required for a video-only cut away. Out of this need came the "insert" edit system, that used the previously recorded control track as the locking source for the capstan.

With only minor changes, the editor was given the ability to select between the audio/video, or video-only modes. Finally, the producer had the flexibility to rearrange picture and sound in a fashion he had used in film.

Fig. 8. Early model of the Editec programmer. Later versions included a video only mode, animation controls, and secondary cue provisions. (Courtesy Ampex Corp.)

"That's a buy . . . we'll fix it in editing"

Bruce Bassett was joined in the edit room by Joan King, the production assistant, and Hal Venho, the associate director on Flesh and Blood. *Today's edit sequence involved Edmund O'Brien slapping his daughter, played by Kim Darby. Besides the basic switched master, isolated wild shots of this scene had been recorded which Baldy would use to edit a montage that would increase the dramatic impact of the scene. The use of videotape editing for such a purpose was, in itself, novel.*

After transferring the basic shot onto the master tape, Baldy hit the CUE button at an appropriate point. A distinct "chirp" was heard as it was recorded on the cue track. A second cue was put on the tape to mark the out-splice or end of the edit. By using the one-frame cue shift function in conjunction with the preview capability, Baldy could place the insert exactly where he wanted it. The flip of a switch allowed him to change from an "audio/video" to a "video-only" edit (Fig. 8).

Once Hal was satisfied with the preview, Baldy re-racked the tape to the proper pre-roll point, rolled the VTRs, and "armed" the editor. From here on, Editec™ was the shining star. The controller read the in-cue, and started the countdown to the electronic splice. Moments later, the second cue began the count-down toward the out-splice. After a series of these preview and record operations, Baldy had created a sequence of time expansion which heightened the dramatic turn of events that the slapping had precipitated.

Electronic splicing helped videotape rise above mundane assembling of scenes to the creation of artistic, dramatic moments. Although complex servo and timing circuits were used to make it a reality, the editor's control panel was fairly straightforward. Once the cue points were determined and previewed, an edit could be made in little more than the actual record time. This system of electronic splicing was limited only by the inaccuracy of normal cueing and the inability to provide perfect parking and start up of the playback machines. Tape editors needed the electronic equivalent of the "edge numbers" used for years as an index in film.

"Down for the count"

Rex Bagwell was busy at VTR 18/20 preparing for a 10 a.m. session to edit this Thursday's Flip Wilson Show.

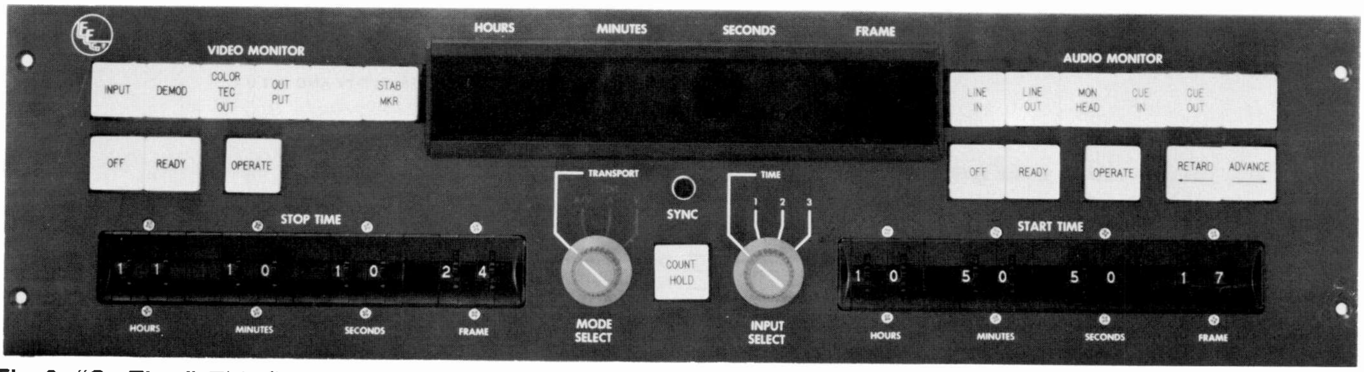


Fig. 9. "On Time". This first timecode editor was designed to work with the VR-2000. (Courtesy EECO)

Monday he had logged the time code from the master segment reels and now had a list of preferred takes. After loading the reel, Rex dialed in the eight digit number for the first location and put the VTR into FAST FORWARD. Within moments Bob Henry's production team would be ready to start work.

The third challenge

During videotape's infancy, while electronic editors were being created on the lab bench, the United States entered the Space Age. To index space flight telemetry on data tapes, NASA and other agencies developed a variety of coding systems.

In early 1964, Richard Hill of CBS-Hollywood proposed that one such code, the AMR (Atlantic Missile Range) C-1 code, be adopted for use in videotape editing. In a paper, Hill later enumerated the videotape applications of this time code: timing of tapes; footage measurement in time; rapid location of recorded material; remote indication of footage for cueing purposes; automatic cueing of tapes; automatic starting of playback machines; synchronizing machines during overlap playback; automatic exact synchronization of machines (for double system recording); and electronic editor control with automatic starting of playback machines during transfer editing. The introduction of time code ushered in videotape's second decade and became an integral part of it.

Hill worked closely with Electronic Engineering Company of California (EECO) on the design of the first television timecode editing system, called ON-TIME™, which was introduced in March 1967 (Fig. 9). Timecode was on its way toward slaying the monster called videotape editing. No longer did the editor have to mark "on the fly" and settle for an edit point that was "close enough." If he was unhappy with a preview, he could adjust the time code as required; he was also freed from the inaccuracies caused by imprecisely cued machines. However, in the early days of timecode editing, synchronization between two machines was possible only if the code on each tape matched exactly.

Just as government agencies developed different numbering systems, VTR manufacturers came up with incompatible codes. In early 1969, SMPTE attempted to reduce the chaos by establishing a committee to develop a standard code that would insure interchangeability (Fig. 10). This standard, known as SMPTE code, assigned an 80-bit data stream to each television frame, which defined it by hours, minutes, seconds and frame count (30 frames per second). Some experimentation was done on a system that would have modulated the control track with the timecode, but this was later dropped in favor of placing it on the cue track.

In mid 1970, RCA joined with EECO to develop and market an all new Electronic Editing System (EES)

> "...time coding became a tremendous value because...that allowed you to take notes out in the field and when a person got to a point in a speech where he said something that you know you wanted — you jotted down that time, brought it back and could go right to that time again."
>
> ...*Joseph Angotti,* Producer, NBC News

NON-DROP FRAME

A format of continuous timecode (also called "Color Time") based upon the color rate of 29.97 frames per second. Timecode generated at this rate is 108 frames ahead of clock time at the end of each hour. A one-hour program timed, using Non-Drop Frame as a reference, would be 3.6 seconds (108 frames) too long.

DROP FRAME

A format (also called "Clock Time") that discards two frame counts at the beginning of each minute, with the exception of every tenth minute. No actual video frames are lost, only their numerical designations are shifted in order to keep the count in-sync with actual clock time.

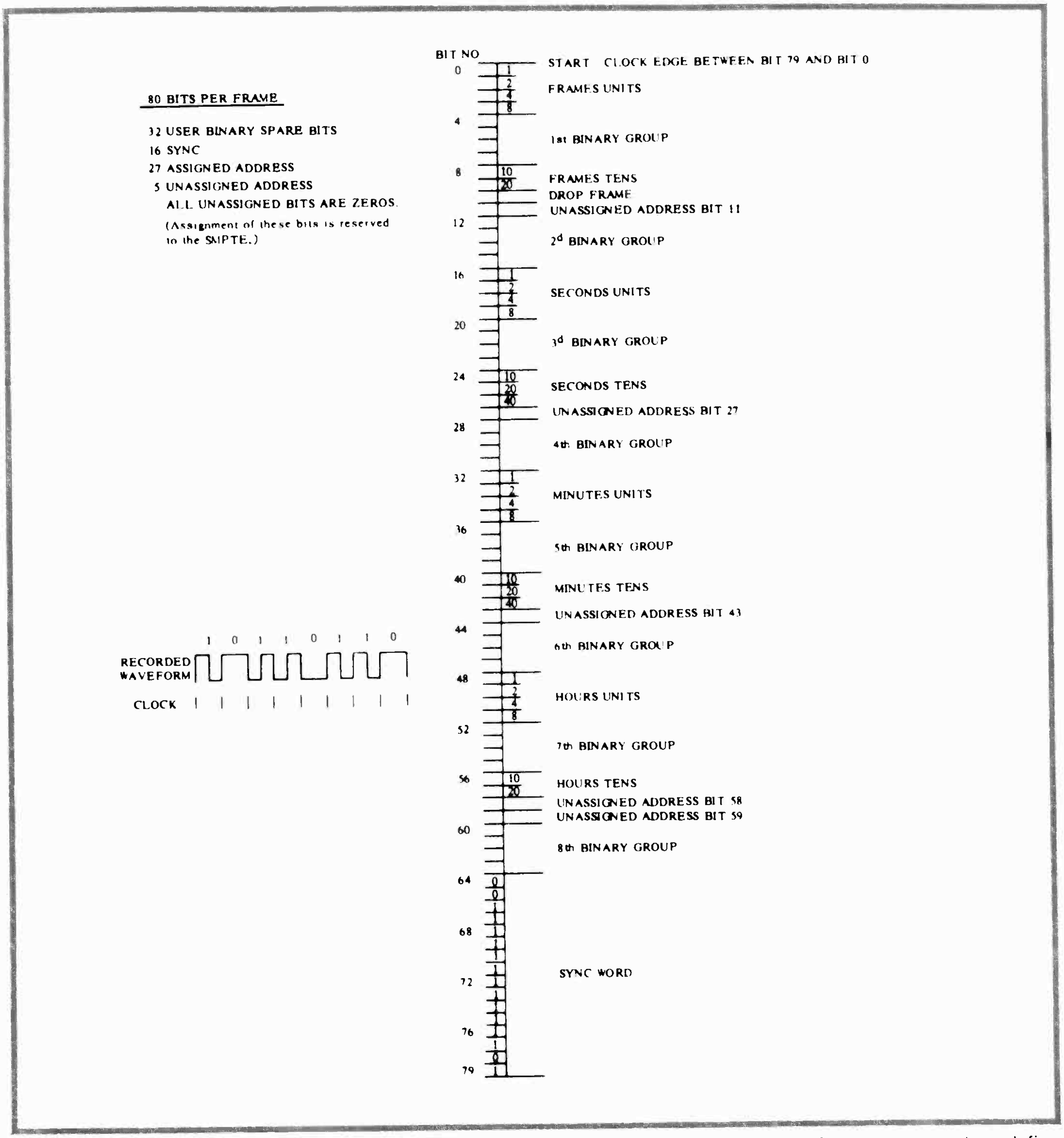


Fig. 10. Data stream of the 80-bit SMPTE videotape time code. Besides the eight digit address or "edge number," the code has provisions for user-defined information, drop frame indication, direction of tape movement, and five unassigned bits for future use. (Courtesy SMPTE)

based on timecode. This system had operator-oriented improvements such as the entry of edit points into memory, edit preview, higher speed search to an edit point, and single-glide cueing. Direct data entry from a keypad and the TCE-100's centralized transport controls formed an early edit cockpit (Figs. 11 & 12).

"What you see... is what you get!"

Rex Bagwell had completed the picture and sound edits for the first two segments of The Flip Wilson Show. *After re-recording a one-minute and two-second slug for commercial position two, he was ready to insert the segment featuring Flip's popular*

Fig. 11. TCE-100 edit controller. This system included three code read-outs; edit controls on the main input panel, including a keypad for timecode entry; and a transport control panel.

character, Geraldine. Rex loaded his next start and stop points into the record machine controller, and placed the VTR in the correct shuttle direction to locate the new point.

Consulting the time code log, he found the "buy take" for the Geraldine skit started at 21:07:52:00. He wound the tape to that area and viewed the scene for an exact "in-point," allowing a good amount of time for the wolf whistles, screams, and applause that greeted Geraldine's entrance. Geraldine's first line was a sassy, "What you see . . . is what you get!" *To add impact to that line, the director edited in a facial close-up which had been isolated to a separate reel of tape. By noting the IN and OUT points for the line and loading the isolated camera reel, Rex made a video-only edit that was in exact sync with the audio and the switched master.*

Since all the VTRs (Program and Isolated) were fed a common timecode while recording, it was easy to drop in a special shot from the iso-reel with precision. This new timecode system would allow Rex to transfer the edited sound, along with the code, onto an audio multi-track machine. Laughs and applause could then be added to ease-over edits that might otherwise sound jarring.

That first step in 1964 was a giant leap toward assuring the director that "what he wanted *was what he* got." *What remained now was for the design engineers to simplify the manipulation of time code points, develop frame accuracy to its ultimate degree, and make the system more responsive to the creative needs of Rex and other editors.*

Timecode GOes east

John Olszewski was about to start editing Drag Race, *an episode of the* GO! *show's second season.*

The first year had been difficult for the editors on GO! *because the complete CMX system had not yet been installed at NBC-New York. An off-line System 400, employing non-broadcast one-inch VTRs, was*

Fig. 12. An edit bay at NBC, Burbank, California. To the right of the edit system is a video switcher with dissolve-and-wipe capability, and a small audio mixer. These added devices expanded the signal manipulation capabilities in parallel with the increased sophistication of the editor. (Courtesy EECO)

used to pre-edit the shows. The editing or "conforming" of the two-inch broadcast master, however, had required the editor to re-type each record IN and OUT point, as well as the playback IN point on a Datatron 5000 system. "The first year I often went to sleep to the tune of 8-digit time code numbers," said Johnny O. "Our new system will be a big operational improvement."

The fourth challenge

If EECO and RCA had provided a "cockpit" for editing, then CMX introduced the equivalent of "Mission Control." In 1970 a joint experiment between CBS and Memorex (CMX) produced a super-sophisticated editor called the CMX 600 (Fig. 13).

There had been a great desire to get away from the concept of an individual programmer for each machine, and to interface all functions into one unit. With a Digital Equipment Corporation mini-computer as its "heart," the CMX system used an array of computer-oriented peripherals to put the editor in control.

The pictures and editing menus appeared on dual CRTs directly in front of the editor. A light pen, connected to the console, allowed him to make his selection, and to control the picture motion on both screens. In the 600, pictures and sound were stored with their time code as analog signals on magnetic disk packs. Only six systems were sold due to the high initial cost (about $300,000). The limited storage of source material in black and white made it practical only for pre-edit of short segments such as commercials.

Two years later the CMX System 300 became available for on-line editing and auto-assembly of pre-edited shows. By using a computer to manipulate standard VTRs, a system was developed that allowed the editor to control the record and playback machines, as well as the switcher, from a typewriter-like keyboard. This frame-accurate editor, with its off-line system 400 counterpart, became a success. The editor was freed from the drudgery of arithmetic calculations, manual entry, and record keeping. The producer was able to preview and execute edits that included dissolves, wipes, and other effects in a manner that was repeatable. The computerization allowed the editor to concentrate less on the hardware and more on the creative aspects of his task.

A punched paper tape record was generated with all the time code IN and OUT marks, as well as the edit types. It was then possible to re-load this edit decision list (EDL) into the computer memory for auto-assembly (Fig. 14). Soon other manufacturers picked up this edit systems concept, and videotape editing became a sophisticated art.

Fig. 13. The CMX 600 console. The sleek design included two monitors which could display the exit and entrance points simultaneously, or the edit "menu" as pictured. The light pen on the desk top was used to select options from the menu and control picture motion. (Courtesy CMX Corp.)

Fig. 14. Sample Edit Decision List print-out and punch paper tape. Among the information included is the edit number, reel number or source, audio/video mode, type of transition (and duration if applicable), Record IN and OUT times and Playback IN and OUT times.

Going with *GO!*

For the last several days in May 1974, John Olszewski and Rift Fournier, a GO! *director, had pre-edited a work copy of the show from the six hours of material shot last month at The Grand Nationals in Quebec, Canada. Besides showing plenty of dramatic races, Rift had written a story around Jack Hart, safety director for the National Hot Rod Association. As he loaded the edit list into the PDP 11/05 computer, Johnny O. explained that Jack Hart's inspection of each race vehicle served to emphasize the importance of safety to* GO!'s *young audience.*

Just then the computer reported "186 EVENTS LOADED" on the CRT screen. Johnny O. told Don Reilly, his playback man, to load the first 3 reels. The documentary style of GO! *required a "B" mode or checkerboard assembly. In this way the computer scanned down the list of edits and executed all the events for which the proper reels were loaded. To keep pace with the computer, Don checked off each edit as it was recorded, and Johnny O. adjusted the video levels during pre-roll. The computer stopped the VTRs and reported "EDIT 27 REQUIRES REELS 01 and 14." Johnny O. checked his notes and realized that edit 27 was a dissolve from the intro of* DRAG RACE *host Don Imus, to the* GO! *montage and opening theme. Once Reilly had loaded reel 14, the assembly was resumed.*

"This computer program is not very easy to manipulate." thought Johnny O. "But, thank goodness, it does save me from retyping the more than 6,100 numbers and spaces needed to define these edits."

The GO! *show schedule called for Johnny O. and the audio mixer to edit music, sound effects, and Imus' narration to fit the completed video master. They would then lay the audio segs onto a multi-track audio tape that had the VTR natural sound and corresponding timecode already on two of the 8 tracks. "After a day of mixing the audio elements," Johnny O. mentioned, "we then re-lay the mixed track onto the two-inch video master. Then it's time to start the cycle over with another director and a new episode."*

The cycle that John Olszewski followed was held together by the common element of time code, the digital "genie" that, in conjunction with the computer, produced accurate edits, lenghly automatic assemblies, and absolute synchronization heretofore possible only with the use of *sprocket holes!* It was indeed a turning point for videotape editing.

The cycle continues

Technology has improved vastly in the seven years since that *GO!* edit session. CMX introduced the 340 expandable system that, along with the Sony 7000, uses distributive processing to perform simultaneous functions and machine interface. With improved 340X programs, it became just a matter of a few key strokes to transfer edit times from one machine to another, or from one segment of the EDL to another. The enhancements include the storage of all edit decisions in memory, expanded list management, and auto-assembly within the main operating program.

The future challenge

Throughout the 25-year history of videotape editing, the most effective and useful improvements have been made when the technical design team, the tape editors, and the production team communicate effectively with each other. The future of videotape editing may encompass a variety of new technologies still on the drawing board (e.g., digital recording and solid state storage), but in any case, the direction it must take is clear:

1. Make the device more responsive to the editor. One way could be instant scene access via "bubble memory" storage of source material.
2. Create a "transparent" system that allows the editor flexibility without getting in his way. A new CRT that allows the user simply to point at information he wants to retrieve or modify may be a step in the right direction.
3. Increase the edit accuracy. Audio edits, especially music cuts, require greater resolution than 1/30 of a second.

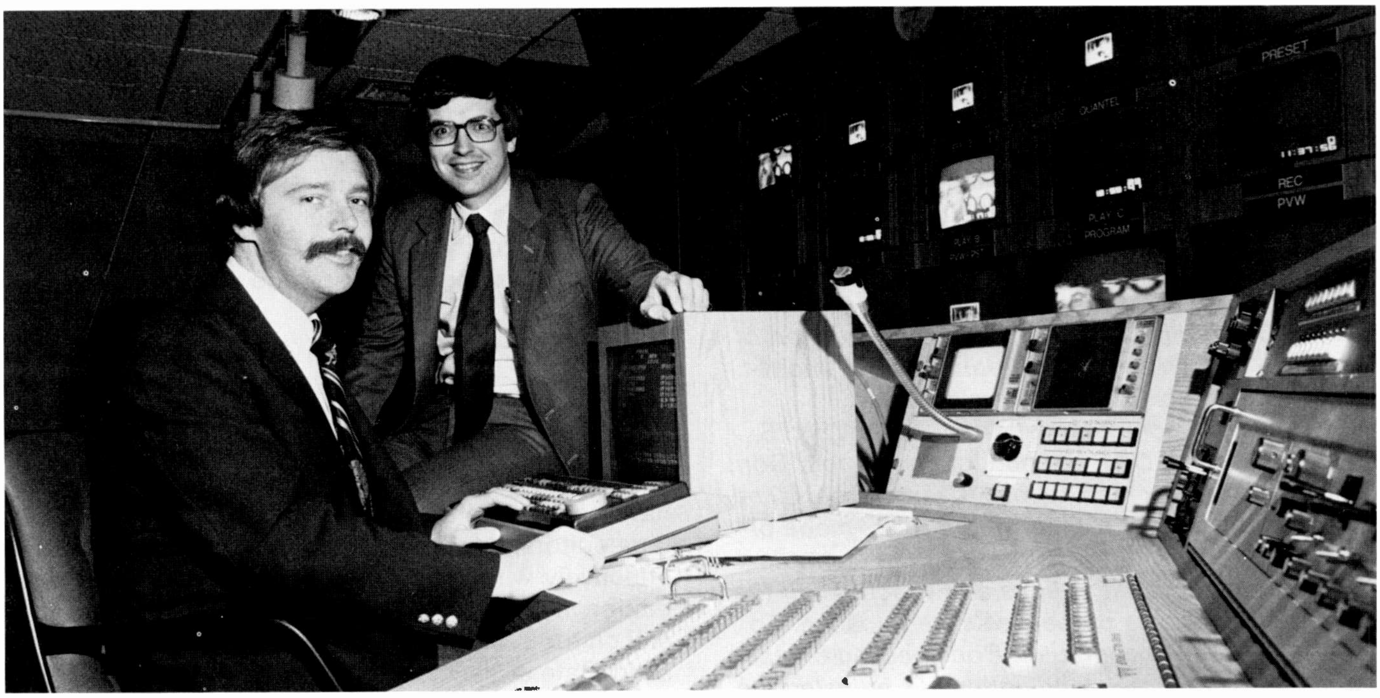
From the production point-of-view, a *good edit* is one that you don't notice. A *good edit system* is one that does the job without overshadowing the tape editor's aesthetic and creative goals.

Acknowledgments

NBC — Stan Bashen, Craig Curtis, Robert Daniels, Charles Weller, Shel Hoffman, Joseph Kolb, Robert Levy, David Wilson, and Dorothy Aviles. RCA — Sid Cycs, Jerome Grever, Tony Lind, William Trippel. SMPTE — Alex Alden, Al Conte. Ampex — Charles Anderson, Charles Ginsburg, Peter Hammar, Robert Wheller. CMX — Joseph Rooney. EECO — Ruth Ferry, George Sweatland, Gary Ware. 3M — Richard Ziff. Universal Studios — Richard Hill.

Bibliography

1. Annual Report of the EECO (Electronic Engineering Company of California) for 1967.
2. "Discussions on Videotape Recording," *Journal of the SMPTE* (Nov. 1958).
3. "Electronic Film/tape Post-Production Handbook," 1973 Edition.
4. "Operation Manual for Smith Television Magnetic Tape Splicer," S&S Manufacturing Company, Alto Loma, Calif.
5. "TV Tape Splicer," *RCA Broadcast News* (March 1960)
6. Bonney, R.B., Kloba, T.J., and Pargee, R., "A Proposed Standard Time and Control Code for Videotape Editing," *Journal of SMPTE*, (March 1970).
7. Ennes, H.E., *Television Broadcasting Tape Recording Systems*. Howard W. Sams & Company, Inc., Indianapolis, Ind. 1973 and 1979 editions.
8. Hill, R.E., "Digital Time Code Systems for Television Broadcast Operations," (Feb. 1966).
9. Macheim, K.R., "Techniques in Editing and Splicing Videotape recordings," *Journal of the SMPTE* (Nov. 1959).
10. Rozien, J., "Electronic Marking and Control for Rapid Location of Vertical Blanking Area for Videotape Recordings," *Journal of the SMPTE* (Nov. 1958).
11. Weller, C., "Splicing Videotape Without Edit Pulses," Internal NBC Instruction Manual, not published (1960).



Jerome Haggart, Senior Videotape Editor and **Robert Muller,** Director of Video Recording Operations, at the CMX 340X keyboard in Edit Room 5, NBC, New York's newest post-production facility.

Jerome Haggart, a Senior CMX Videotape Editor, began his career at NBC-New York in 1970 when he joined the videotape staff as vacation-relief operator. Since becoming a permanent editor in 1972, he has been recognized for his contributions to the Peabody Award-winning children's series *GO!*, and also received several Emmy nominations and Certificates of Achievement from the National Academy of TV Arts and Sciences. In 1977, Mr. Haggart was honored for his work on *NBC's Sportsworld* with an Emmy for "Outstanding Individual Achievement in Videotape Editing." He most recently won The Creative Excellence Award in the U.S. TV Commercial Competition for a 60-second NBC Football promo. He has taught videotape editing seminars, and is currently working on a variety of shows, network advertising and promotion, and sports projects.

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Robert Muller is Director, Video Recording Operations, at NBC-New York with overall responsibility for Videotape Production Recording, Editing and Post-Production Audio. He worked as a Studio and Tape Engineer at NBC-Cleveland during various periods between 1967 and 1972. From 1974 to 1977 he worked for Cathedral Teleproductions, the TV production arm of the Rex Humbard Ministry, as Operations Manager for Videotape and Studios. The Cleveland Chapter of National Academy of Arts and Sciences awarded him an Emmy in 1975 for a *Good News* special broadcast. He rejoined NBC in Chicago as a Technical Supervisor in 1977 and transferred to New York the following year. Mr. Muller served as a Manager in Studio Operations before taking over the Videotape Department last December.

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T.L. Credelle

Large-screen flat-panel television: A new approach

Several approaches to large-screen flat-panel television are being studied, but the guided-beam method seems to hold the most promise.

Abstract: *A number of display systems have been investigated that could lead to the realization of large-screen flat-panel television. The requirements of size, brightness, color, and power efficiency have eliminated some new technologies such as liquid crystals and electroluminescence. But a new guided-beam approach, based on cathodoluminescence, looks promising. Electron beam guides distribute modulated current over the display area, producing a high-brightness, full-color, large-area display that operates at reasonable power levels.*

Ever since television sets started appearing in people's homes, there has been an interest in large-screen, flat-panel television. For years, science fiction writers have been predicting that hang-on-the-wall television will be an integral part of the home of the future. The rising sales of wall-projection TV units indicate a growing consumer interest in large-screen television. The realization of large-screen wall TV is, therefore, a goal that continues to generate interest at RCA and other television laboratories. Of particular interest to RCA has been the development of a 75-cm x 100-cm, thin, full color, consumer television with operating characteristics matching or exceeding those of today's best receivers.[1-4] The requirements of size, high brightness, color, and power efficiency have suggested new approaches to large-screen television that are based on cathodoluminescence — that is, a display where electrons in a vacuum strike color phosphors to create a picture. This is the concept used in all standard color receivers today.

Several different techniques for flat-panel displays have been pursued by RCA and others. In the next section, some of these efforts — in both electron beam and non-electron beam displays — are reviewed and compared with the display requirements for large-screen color TV. Following that is a description of the design considerations for large-screen displays in general, and for RCA's newly developed guided-beam flat display in particular. The operating characteristics of the guided-beam display, which uses electron beam guides to distribute video-modulated current over a display area, are then discussed.

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Display requirements

The design goals for a large screen display are listed in Table I. The market being addressed is 100- to 150-cm (diagonal) consumer television, roughly 2.5 to 5 times the viewable area of today's largest sets. The picture element (pixel) size, brightness, and contrast are those required to produce a high-quality NTSC broadcast picture (somewhat smaller spot sizes would be required for European standards). The panel size, particularly its thickness, means that, for the first time, a hang-on-the-wall TV might be possible. In this regard, weight is an important consideration and has implications in the structural design of the display. Power consumption is another important constraint for any new product. The goal is to limit the power to no more than four times the power consumption of today's large sets (the proposed display has four times the display area). This means that the luminous efficiency of the display system should be greater than 2 lumens/watt.

Several candidate technologies exist for flat displays; in fact, several are on the market today. A comparison of the characteristics of several flat panels operated in a television format is shown in Table II. As a reference, the CRT

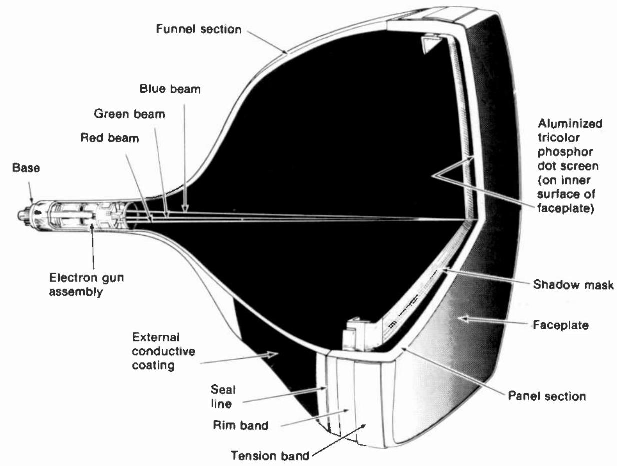
Table I. Design goals for a large screen display.

Screen size	75 cm x 100 cm (30-in. x 40-in.)
Thickness	⩽10 cm (4-in.)
Pixel size	1.5 mm (0.060 in.)
Brightness	350 cd/m^2 (100 fL) peak, full color
Contrast	50 : 1
Power	<300 W
Weight	<50 kg (110 lb)

Guided-Beam Display Tube vs.the CRT: Similarities and Differences

The display component of all color televisions today is the shadowmask cathode ray tube, or CRT, which is shown here in cross section. The main components are the electron gun assembly, located at the back of the tube, the faceplate, which is coated with light-emitting phosphor material, and the shadowmask, which separates the three electron beams into three colors on the screen. Another essential component, not shown here, is the magnetic deflection yoke, which scans the electron beams across the phosphor screen to "paint" a picture. The CRT is enclosed in a glass envelope consisting of a funnel section and panel or faceplate section. The larger the CRT, the thicker the glass that is required to withstand the forces of atmospheric pressure.

The guided-beam display tube, shown in Fig. 1, has some of the same components, but they are arranged in a new format. First of all, the new tube is flat and comparatively thin. The electron sources are, therefore, arranged along one edge of the display and the electron beams are guided to the appropriate phosphor dots. Beam deflection is accomplished by switching voltages on electrodes deposited on the backplate, eliminating the magnetic yoke. Because of the large display size, internal supporting structures are added for support against atmospheric pressure. This contrasts with the open structure of the CRT. The phosphor screen and shadowmask, as shown in Fig. 6, are essentially the same as in a color CRT; the main difference is that in the guided-beam tube, the screen and mask are flat.



Cross-sectional view of color tube showing targets. From B.Z. Littlefield article, *RCA Engineer,* Vol. 25-2 (Aug./Sept. 1979).

The operation of the conventional CRT is relatively simple; three video signals are fed to the three electron sources — one for each color. The beams, focused by the electron gun, are scanned across the mask and screen through the action of the magnetic yoke. A complete picture is created in 1/30th of a second. In the guided-beam display, the video signals are stored in a memory and displayed one line at a time. Here there may be as many as 500 electron guns — one for each column of picture elements. As with the CRT, a picture is created in 1/30th of a second.

operating characteristics are also shown. The flat CRT† performance is that of RCA's guided-beam display; other flat CRTs have achieved resolutions in excess of 3.1 lines/mm. The limitations of the non-electron-beam flat panels are apparent from this table. Both AC and DC plasma and electroluminescence (EL) suffer from lack of brightness, limited color range, or low luminous efficiency. Liquid-crystal displays are low power, but color is difficult and they are, therefore, better suited for portable, monochrome TVs. The display life is still a question for some of these technologies.

Flat CRTs, on the other hand, appear to offer the possibility of meeting the stated goals for large-screen color television. There have been several proposals for flat picture tubes, and they can be categorized by the type of electron source and the modulation technique they use.

The first flat CRTs developed used a modulated point source of electrons at the edge of the display to reduce tube depth.[6,7] Poor color, limited size, and high manufacturing costs were major problems since these were designed to compete with regular CRTs. Another type of flat CRT employs an area source of electrons and modulation/addressing electrodes at each picture element. Area sources investigated include thermionic emitters,[8,9] field emitters,[10] and electron multipliers.[11-13] A third type, described in detail in this article, includes a localized source of electrons (point or line) and electron beam-guides to distribute modulated current to each picture element. The beam guide, which is analogous to a fiber-optic light guide, must have high transmission efficiency to maintain a uniform display.

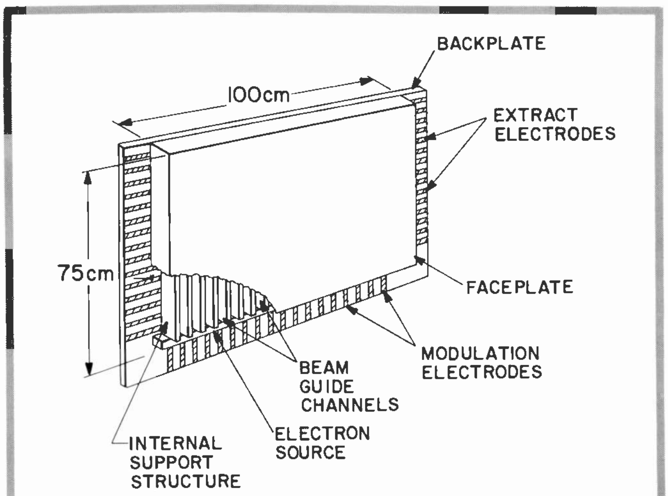


Fig. 1. Schematic view of 1.27-m (50-in.) diagonal guided-beam, flat-panel television. Electrons from the electron sources travel up vertical beam guides and are then deflected toward the phosphor-coated faceplate. Tube thickness is approximately 10 cm (4-in.).

† For the purpose of this paper, a flat CRT is defined as a display device where light is created by electrons striking a phosphor and where the depth is significantly less than the diagonal.

Table II. Comparison of flat panel and and CRT TV capability[5].

	CRT	AC Plasma*	DC Plasma	AC EL	LCD	Flat CRT† (RCA Guided Beam)
Size	63 cm diag	22 cm x 22 cm	25 cm diag.	15 cm diag.	5 cm diag.	12.5 cm x 25 cm
Number of lines or cells	480 lines	480	384x95	240x320	220x240	80x160
Resolution	400 TV lines (0.8 l/mm)	2.4 l/mm	2.0 l/mm (H) 0.63 l/mm (V)	2.7 l/mm	7.4 l/mm	0.63 l/mm
Efficiency, lumens/watt (including drivers)	5-7	0.1-0.3	0.07	1.0	—	5-7
Area luminance, cd/M^2	700	35	35	100	Reflective	350
Color	R,G,B	Orange	R,G,B	Orange-yellow	White reflective	White
Life	>10^4 hours	>10^4	Not reported	Not reported	Not reported	>10^4 hours

* Larger displays (up to 43 cm x 43 cm) have been developed for computer graphics applications.

† Quoted results are from experimental prototype. System capabilities include full color. Resolution suitable for 127-cm diagonal TV.

System description and design considerations

The basic configuration of a guided-beam, flat-panel television is shown in Fig. 1. The tube is made up of two flat pieces of glass and four side walls. The back of the tube is patterned with electrodes, and the faceplate (viewing side) is coated with color phosphors. Inside the box are electron sources, electron beam guides, and an internal support structure. The electron sources and modulators are typically located along the bottom of the tube and inject current into vertical beam-guide channels. The internal structure is necessary for support against atmospheric pressure, which is over eight tons per side! With this support, the glass thickness can be less than 6 mm (25-in. kinescope faceplates are approximately 12 mm thick).

The design of a large-screen, flat display involves several system tradeoffs. For a guided-beam display, these design considerations are affected by current source and beam-guide current limitations, color requirements, structural support designs, and circuit complexity.

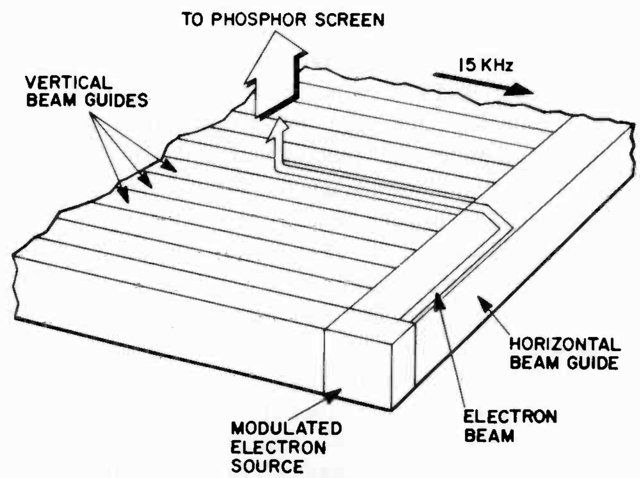


Fig. 2. Element-at-a-time addressing can be used with a single electron gun in the corner of the tube and a single horizontal electron beam guide.

Current source and modulation

Conceptually, the simplest way to distribute current to the display area is to use a single modulated point-source of electrons, and a single horizontal beam-guide at the edge of the display, which sequentially directs electrons into an array of vertical beam guides (Fig. 2). Information is then displayed one element at a time. The disadvantages for large television displays are the necessarily high switching speeds (10 MHz) and high peak currents (>1 mA). A preferable technique, illustrated in Fig. 3, is to use multiple electron sources with a discrete modulation point for each vertical beam guide. Peak beam currents are reduced by 500 times and information can be displayed line-at-a-time. The penalty, of course, is an increased number of interconnections and increased circuit complexity.

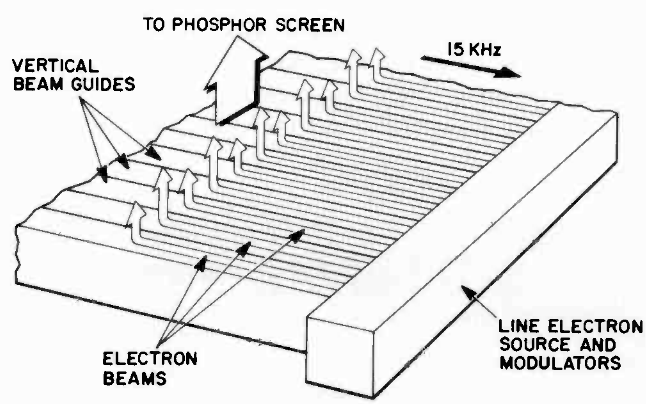


Fig. 3. Line-at-a-time addressing is used in conjunction with a line electron source. In this approach, each beam guide has its own modulated source of current.

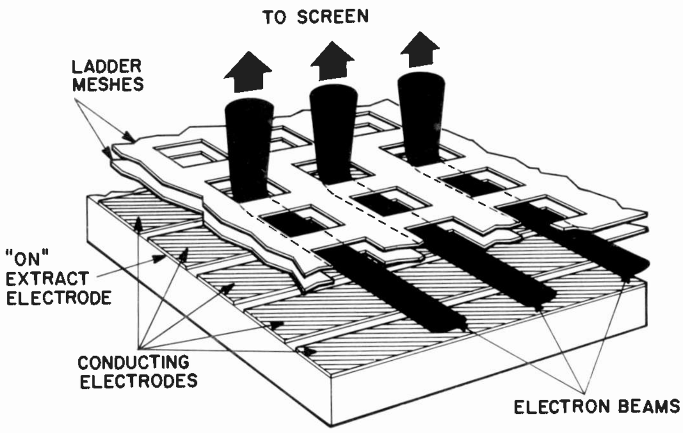


Fig. 4. The ladder beam guide is an example of a periodically-focused beam guide with extraction. The electron beams are "transmitted" down the guide until they reach an energized extract electrode. A negative voltage on this electrode causes a 90° beam deflection out of the guide toward the phosphor screen.

Electron beam guide

The electron beam guide, first developed for use in traveling wave tube amplifiers, is a device that can transmit a low voltage (~100 V) electron beam over long distances (up to 1 m) at high efficiency (>99 percent). In addition, it must be possible to deflect the beam from the guide at any point along its length. The structures examined satisfy these requirements and can be constructed with a metallized backplate and precisely etched flat metallic meshes arranged in a simple layered arrangement.

One example of a beam guide, which is called the ladder guide, is shown in Fig. 4. The central elements of the structure are two parallel, mutually aligned, low-voltage (40-80V) meshes spaced between a phosphor screen and a glass plate coated with rows of conducting electrodes located under and relatively near the apertures. These electrodes perform the dual function of beam focusing or extraction, depending on the applied voltage. In the transmission mode, approximately 350 volts is applied to the rows of electrodes on the lower plate. The motion of the electrons is confined by periodic electrostatic fields produced between the low-voltage meshes and the high voltage on the screen and the lower plate. Beam extraction is provided by application of a negative voltage (−60 to −180 volts) to one of the electrodes on the lower plate. Ladder guides up to 76-cm long have been experimentally tested. Transmission efficiencies up to 99.9 percent have been achieved at beam currents sufficient for a display brightness of 350 cd/m^2 (100 fL). A photo of an experimental 76-cm ladder guide is shown in Fig. 5.

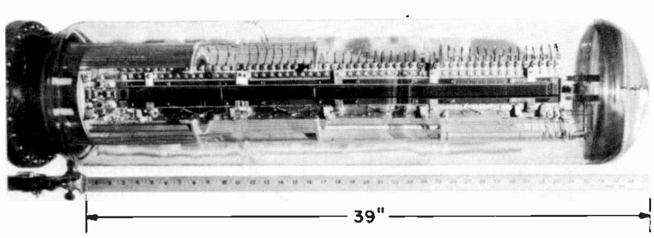


Fig. 5. Experimental ladder beam guides up to 76 cm (30 in.) long have been built and tested. Transfer efficiencies of over 99 percent have been achieved in such devices.

Resolution and color

Resolution and color requirements are largely determined by display size and performance. For the proposed 127-cm diagonal color television, the pixel size is 1.5 mm^2. In the simplest system configuration, this implies a guide width of 1.5 mm, with extract electrodes on 1.5-mm centers. For higher-resolution systems, some multiplexing may be used; that is, one beam guide may address several columns of pixels. The modular guided-beam display uses this approach. To obtain color, several choices exist: (1) the number of guides can be tripled, (2) the number of extract electrodes can be tripled, (3) three-position scanning can be introduced between the guide and the color screen, or (4) a shadowmask can be used. The first three techniques require accurate control of beam position and spot size at the screen. A shadowmask relaxes beam position tolerance, but it requires an additional high tolerance part and it reduces power efficiency.

Structural support

The internal structure in a large-area flat display must support atmospheric pressure while remaining invisible to the observer. This structure, which can consist of thin (1 mm) glass vanes, can play an active role in guiding and focusing electron beams. Two principal choices exist for the support: (1) one vane per column of pixels, and (2) one vane per several columns of pixels. In the first approach, the vanes can be used as part of the beam guide, and because there are as many vanes as horizontal pixels, the supports are easily made invisible. The second approach, which is modular, results in a lighter tube with fewer parts. However, a potential problem with module boundary visibility is introduced.

Circuitry

A form of addressing in which a complete horizontal line of video is displayed (line-at-a-time addressing) is proposed for most guided-beam flat-display systems. Separate color signals can be displayed either sequentially or simultaneously. Modulation can be either analog or digital — pulse width modulation is best suited to systems with one guide per pixel column. An important system tradeoff with respect to modulation is the amount of multiplexing used. Single modulation points may address several pixel columns, thus reducing the number of modulators.

System example and display characteristics

Several experimental guided-beam tubes have been constructed to determine the characteristics of this type of

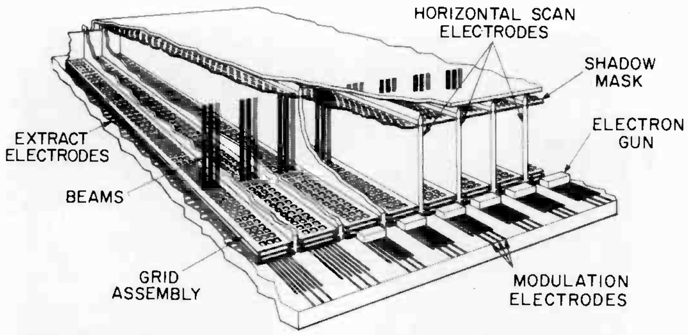


Fig. 6. Cutaway view of the modular guided-beam flat-panel television. The display is divided into a number of vertical modules; within each module are electron guns, beam guides, a shadowmask and phosphor screen. Thus, a portion (e.g., 1/40th) of the picture is displayed in each module.

display. A section of a modular flat display with ladder beam guides is shown in Fig. 6. Contained within each 2.5-cm module are three modulators, three ladder-mesh beam guides (one for each color), focus electrodes, a shadow-mask, and a color phosphor screen. Operation is as follows: For each color, a line of video is stored and then divided into 40 sections (for a 100-cm-wide display). During the next line time (53.5 μs), each section of video is clocked out in parallel (but at a slower rate) to the separate modulators. The modulated beam currents are distributed to the pixels within each module by scanning the extracted beams across the module. The principal circuit components are shown in Fig. 7. The proposed system makes extensive use of digital processing. RGB video is first digitized in 6-bit/color 12-MHz A/D converters (e.g., RCA CA3300). This sampling rate corresponds to 640 horizontal samples. Data is clocked out of the secondary registers in parallel and at one fortieth the sampling rate (300 kHz.) The gain uniformity control circuit includes a random access memory that stores the I-V characteristics for each of the electron sources. This information is used to correct for non-uniformities between sources. The ability to correct for brightness errors in this manner is unique to guided-beam displays; it does, however, rely on high beam-guide transmission efficiency. Vertical line selection is achieved via the 15-kHz commutator, which is an array of high-voltage switches. Horizontal scanning within each module is electrostatic and is provided by a high-voltage oscillator.

The characteristics of the proposed modular guided-beam flat CRT are compared to present day CRTs in Table III. Note that, although the brightness capability of the proposed system is lower than that of present CRTs, its performance is superior in several areas. Notably, the resolution of the new display is not degraded at high

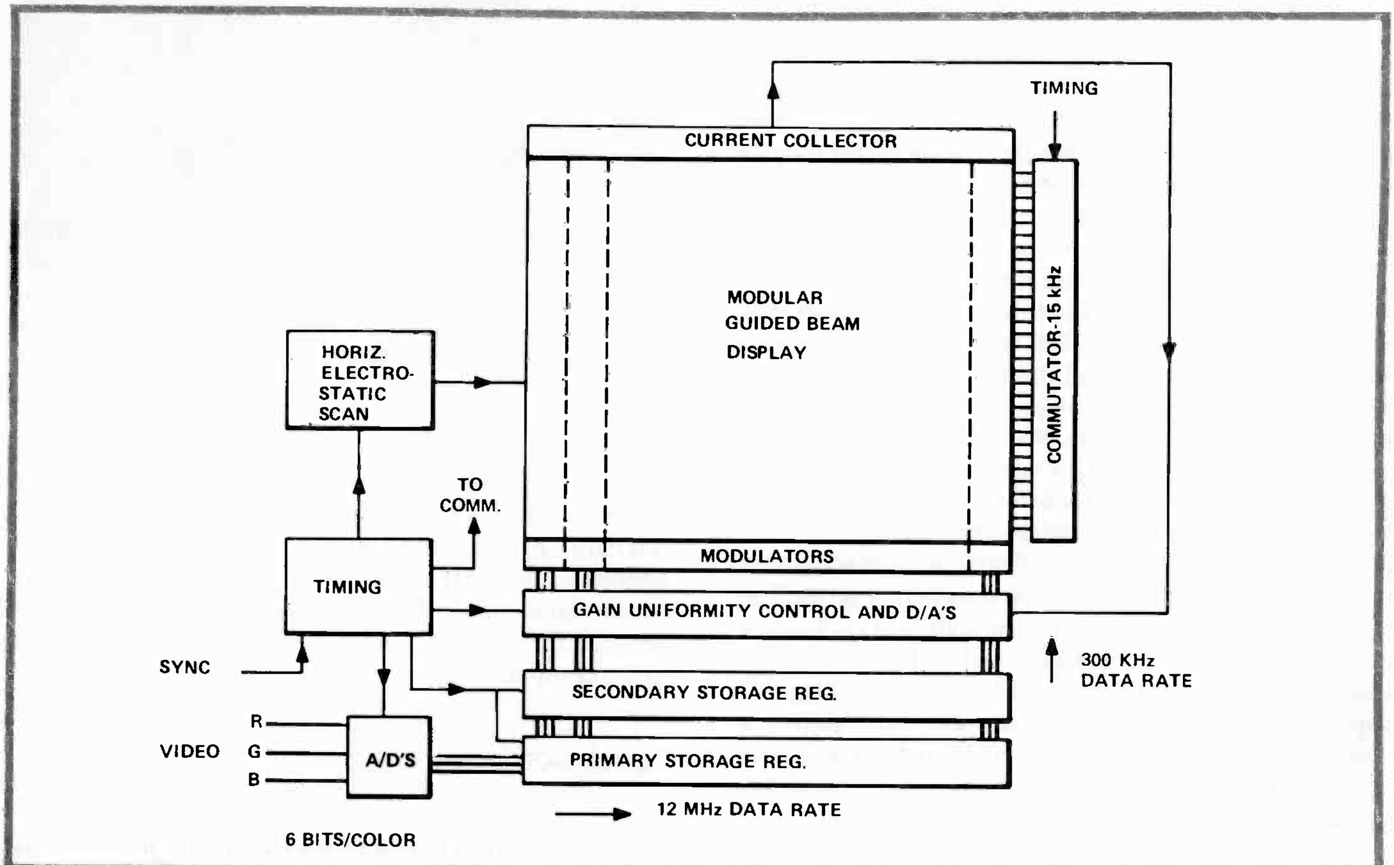


Fig. 7. Circuit block diagram for the modular guided-beam display. Extensive use of digital processing of the video signal is made to format the information for this display.

Table III. Display characteristics of proposed 127-cm guided-beam television and 63-cm color CRT.

	Guided Beam Display	*Color CRT*
Screen size	75 cm x 100 cm	37 cm x 50 cm
Tube thickness	10 cm	~40 cm
Weight	~50 kg	~25 kg
Power	300 W	75 W
Number electrical connections	~400	9
Peak brightness	350 cd/m^2	1000 cd/m^2
Average brightness	100 cd/m^2	300 cd/m^2
Resolution		
Low brightness	400-500 lines	400-500 lines
High brightness	400-500 lines	150-200 lines
Contrast	50:1	Limited by ambient
Small area non-uniformity	1 percent	1 percent
Center-to-edge non-uniformity	1 percent	50 percent
Non-linearity	Perfect	7-10 percent
Color misconvergence	<0.2 mm	<1 mm
Overscan	None	~10 percent

brightness, nor does it change from center to edge of the display. The brightness, linearity, and color misconvergence are also uniform across the display. The system is designed to have adequate resolution for today's broadcast standards; high resolution can be achieved with some system changes. One of the main limitations to higher resolution is the design of the shadowmask/internal support system. The glass vanes must contact the phosphor screen without being seen, and this limits the tri-phosphor stripe pitch to ~1 mm, or 1000 lines, across the display. Brightness may be reduced in this case because of reduced shadowmask efficiency. The number of scan lines in the proposed system is set for NTSC standards. Vertical resolution can be changed by increasing the number of horizontal extraction electrodes or by employing limited vertical scanning with the existing electrodes.

An example of the "white field" performance of a modular guided-beam display is shown in Fig. 8. The experimental tube consists of one module 2.54 cm wide by 30 cm long by 10 cm thick. Contained within the module, which is built to a scale required for a 127-cm diagonal display, are three electron sources and three guides, a focusing system between beam guide and screen, electrostatic horizontal scan, and a monochrome phosphor screen. Area brightness of this test was 100 cd/m^2.

To test video performance of a modular guided-beam display, a five-module device (13 cm wide by 25 cm high by 10 cm thick) was constructed. Dimensions and spot size are consistent with a 127-cm diagonal display size, so only a portion of a picture can be viewed. Typical performance is

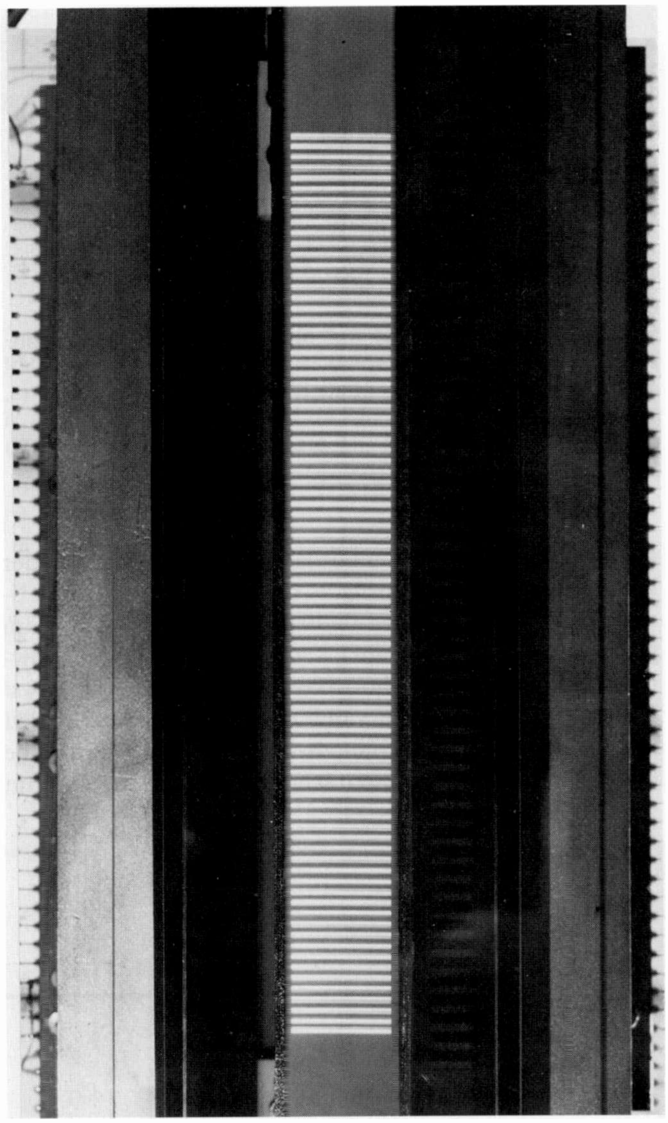


Fig. 8. Black-and-white "white field" performance of a 2.5-cm x 30-cm single module. Vertical line spacing is 3.1 mm (0.124 in.); the horizontal spot size is approximately 1.8 mm (0.070 in.).

shown in Fig. 9, where off-the-air video is displayed at 150 cd/m^2 area brightness. Full vertical resolution of 0.63 lines/mm is achieved with 2:1 field interlace. Horizontal resolution is limited by the video bandwidth of 4 MHz. The vertical black lines make up half of the black matrix required for a color display, and they conceal the contact points between the faceplate and internal support vanes.

Conclusion

The electron beam-guide display could lead to the realization of large-screen flat-panel television. This new device is capable of producing a high-brightness, full-color, thin, large-area display that operates at reasonable power levels. It is, therefore, one of the leading contenders to meeting the goal of hang-on-the-wall home television.

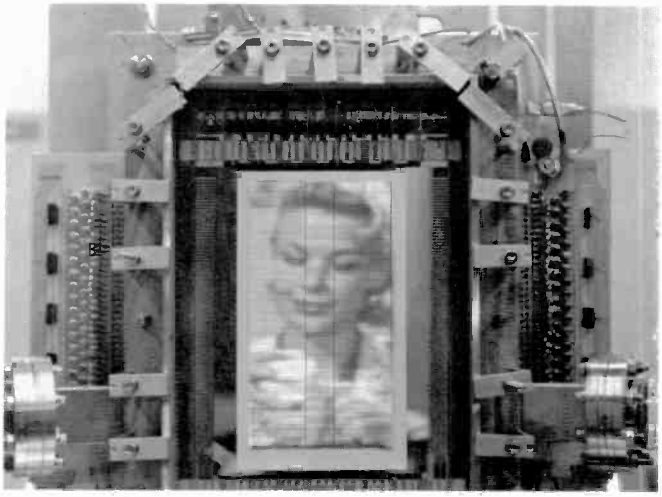


Fig. 9 (a). Off-the-air video displayed on a 12.5-cm x 25-cm (5 in. x 10 in.) black-and-white modular guided-beam display. The displayed image is only 1/25th of the total picture for a 1.27 m (50 in.) diagonal TV.

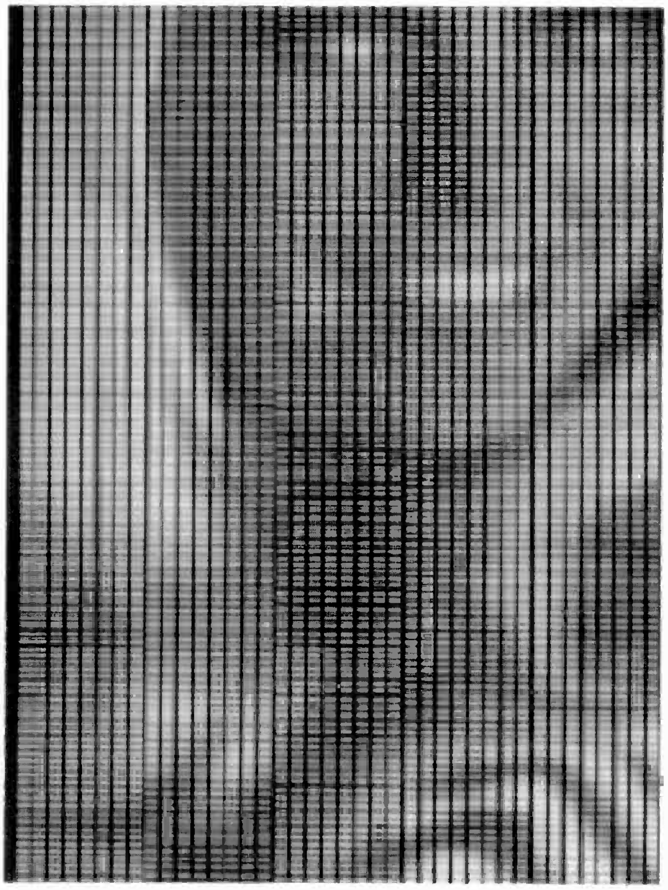


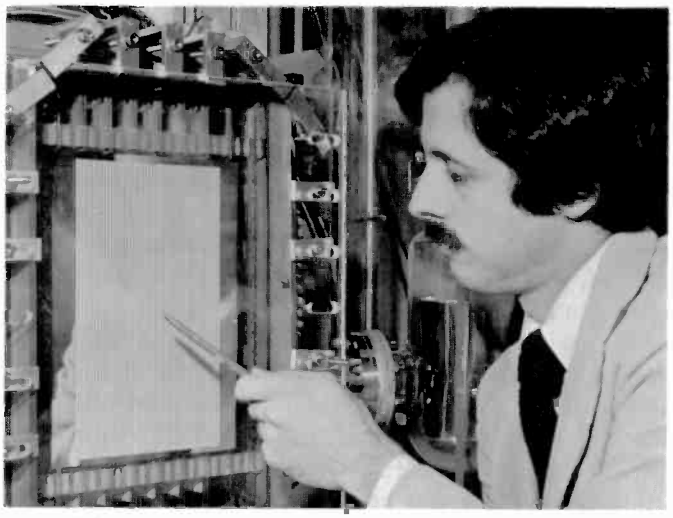
Fig. 9 (b). Close-up view of the 12.5-cm x 25-cm display with simulated black matrix lines. In the actual color display, vertical black lines at twice this density are added to improve resolution and contrast.

Acknowledgments

The work reported here is the result of a large group effort at RCA Laboratories. The author would like to acknowledge T. Stanley, J. van Raalte, and J. Russell for early direction of this project; C. Anderson, J. Fields, S. Bloom, C. Catanese, R. Gange, W. Stewart, W. Siekanowicz, and F. Vaccaro for electron optic analyses and experimentation; F. Marlowe, L. Johnston, and J. Fischer for circuit development; and L. Cosentino, C. Carroll, R. Hedel, G. Stockdale, and V. Christiano for design and construction of experimental devices.

References

1. Anderson, C., *et al.*, "Electron Guides with Extraction. A Potentially Useful New Class of Electron Devices," *IEDM Technical Digest*, pp. 264-267 (1978).
2. Siekanowicz, W., *et al.*, "Ladder Mesh and Slalom Electron Guides for Flat Cathodoluminescent Displays," *SID Digest*, pp. 24-25 (1980).
3. Credelle, T., *et al.*, "Cathodoluminescent Flat Panel TV Using Electron Beam Guides," *SID Digest*, pp. 26-27 (1980).
4. Credelle, T., "Large Screen, Flat Panel Television: A New Approach," *Electro/81 Technical Digest*, (April 1981).
5. Tannas, L., and Goede, W., "Flat-Panel Displays: A Critique," *IEEE Spectrum*, pp. 26-32 (July 1978).
6. Aiken, W.R., "A Thin Cathode-Ray Tube," *Proceedings of the IRE*, pp. 1599-1604 (Dec. 1957).
7. Gabor, D., *et al.*, "A Fully Electrostatic, Flat, Thin Television Tube," *Proceedings of the IEEE*, Vol. 115, No. 4, pp. 467-478 (April 1968).
8. Goede, W., "A Digitally-Addressed Flat Panel CRT," *IEEE Electron Devices Transactions*, pp. 1052-1061 (Nov. 1973).
9. Scott, W.C., *et al.*, "Flat Cathode Ray Tube Display," *SID Digest*, pp. 88-89 (1978).
10. Spindt, C.A., "Development Program on a Cold Cathode Electron Gun," Final Report NASA CR 159570, May 1979, NASA Contract No. NAS 3-20096, SRI Project 5413.
11. Schulman, R. and Schwartz, J., "A Novel Cathodoluminescent Flat Panel TV Display," *SID Digest*, pp. 134-135 (May 1976).
12. Catanese, C. and Endriz, J., "The Multiplier-Assisted Discharge: A New Type of Cold Cathode," *J. Appl Phys.*, Vol. 50, No. 2, pp. 731-745 (Feb. 1979).
13. Endriz, J., *et al.*, "Feedback Multiplier Flat-Panel Television," *IEEE Electron Devices Transactions*, Vol. ED-26, No. 9, pp. 1324-1358 (Sept. 1979).



Tom Credelle is currently Group Head, Advanced Display Systems Research, at RCA Laboratories. Since joining RCA in 1970, he has been involved in photoconductivity research, holographic recording, and, since 1973, flat-panel television. He received an RCA Laboratories Outstanding Achievement Award in 1974. Mr. Credelle presently directs the program to develop large-screen television.

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J.M. Ratay

The quality and cost attitude in production

Quality and Cost are very delicately balanced factors that are dealt with every day in the manufacturing system. It takes all the skills of a dedicated management team to make the proper decisions and to avoid imbalances that could lead an operation into problems.

Abstract: *The author uses examples to illustrate various maxims followed by the management at the Marion plant of RCA Picture Tube Division, including: "the customer must be satisfied!"; "almost every operator failure can be improved with a process change"; and other principles pertaining to tolerances, redundancy, repeatability and uniformity.*

Quality can be defined as the degree of excellence that a thing possesses. Traditionally, quality persons have defined quality in terms of how well it meets the standards specifications; however, in our manufacturing operation, the degree of quality in the product is determined by the extent to which the customer is satisfied. So the perception by management of quality, to a large extent, is formed by customer feedback. Hence, it is very difficult to compare the quality of different types of product, if one does not have a working knowledge of the producer-customer relationship. As an example, if a customer is easily satisfied, the perceived quality would be considered excellent. In Fig. 1, I show this relationship in picture tubes for the past fifteen years. Product quality that would have been considered excellent in 1965 would be considered lacking today. The quality actually produced today is substantially improved compared with 1965. However, customer demands have increased at a faster pace than producer improvements have been introduced.

In 1981, we are at a pivotal time in domestic picture tube manufacturing. We must meet the quality and reliability demands with a cost-effective approach if we are to stay competitive on a worldwide basis.

It is very important to construct a system that will have built-in quality. The approach, "build it right the first time," is the most cost-effective way to achieve our goal. In Fig. 2, you will note several factors which affect system quality (S_Q): product design, parts, process, equipment, and people. If each of the factors used are 95 percent effective, system quality is 77.4 percent effective. It is apparent, then, that to achieve system quality approaching 100 percent is a major task and a team undertaking.

Many times in manufacturing, we must decide if a forced quality improvement (FQI) has to be employed, or if time will permit a planned quality improvement (PQI). This is a very critical cost decision. In Fig. 3, we show the time-cost relationships that can exist in each circumstance. In Fig. 4, we show the time-quality relationships which can exist with the method of approach to the problem.

In a forced quality system, an attempt is made through extra product testing and higher shrinkage levels to bring about a quality improvement. As can be seen, a very large increase in tube-cost is incurred. The initial cost of the

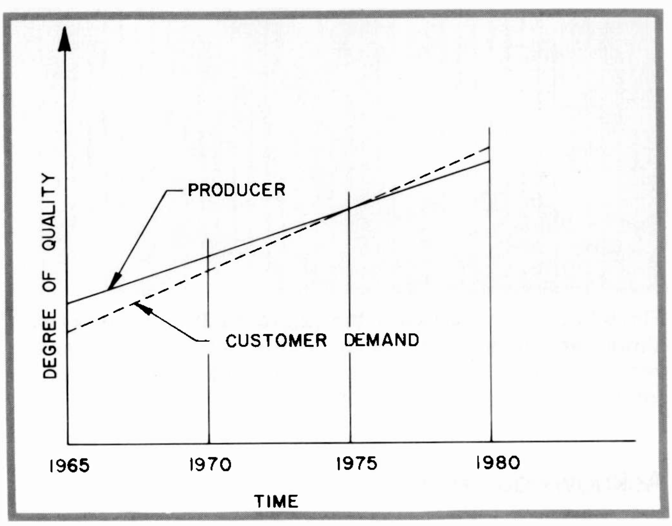

Fig. 1. Customer demands have exceeded producer improvements.

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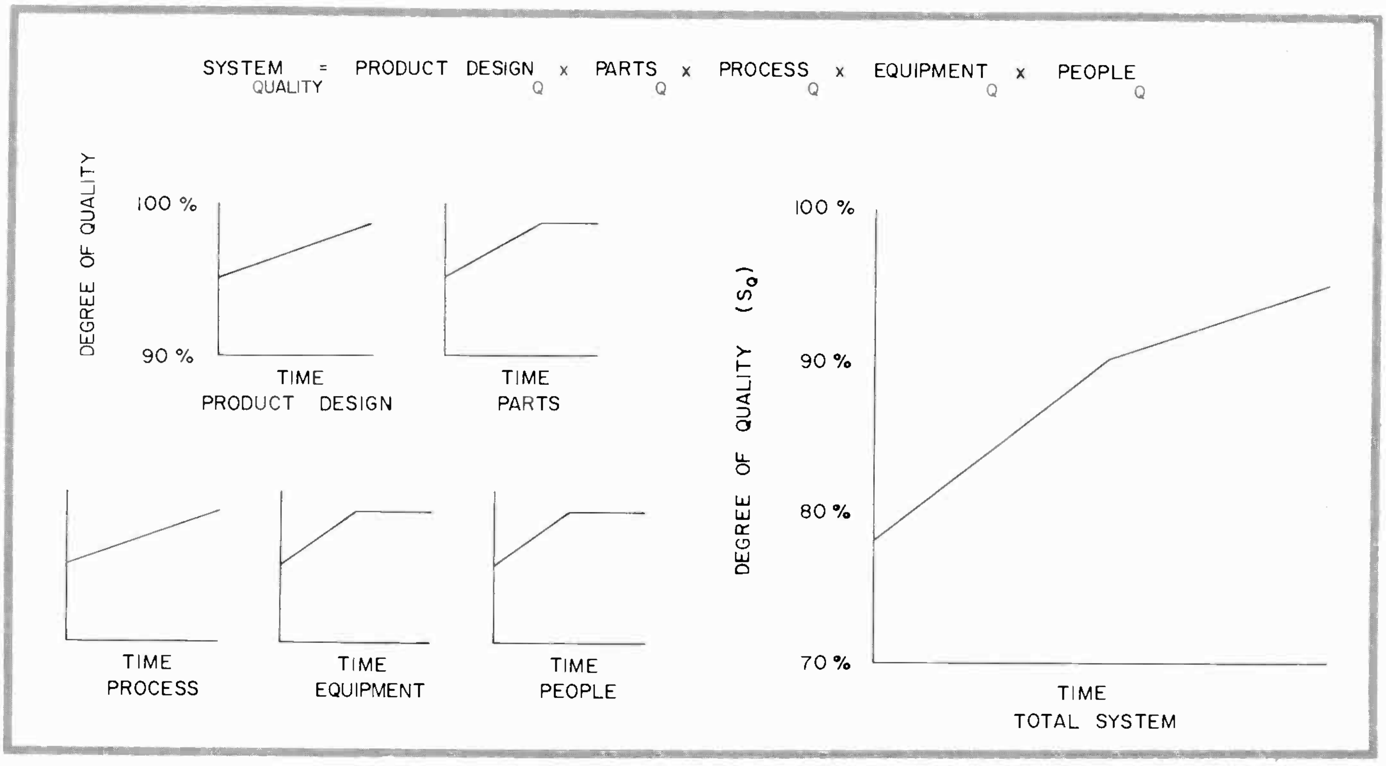

Fig. 2. Factors that affect system quality. System quality as a whole can be mediocre, even if each part of the system has high quality.

forced quality curve improves only if built-in problem fixes eventually take place. The curve shown depicts this happening. Figures 3 and 4 show an optimistic conclusion for the forced approach. This method always has very high early costs because no new tools are brought to bear to solve the built-in problems.

A planned quality system is an effort that recognizes both cost and quality objectives. Projects and systems are aimed at built-in quality, productivity, and cost improvements. The quality improvement is achieved without incurring the high cost of the forced system. Figure 5 shows the quality-cost relationship of the two methods of

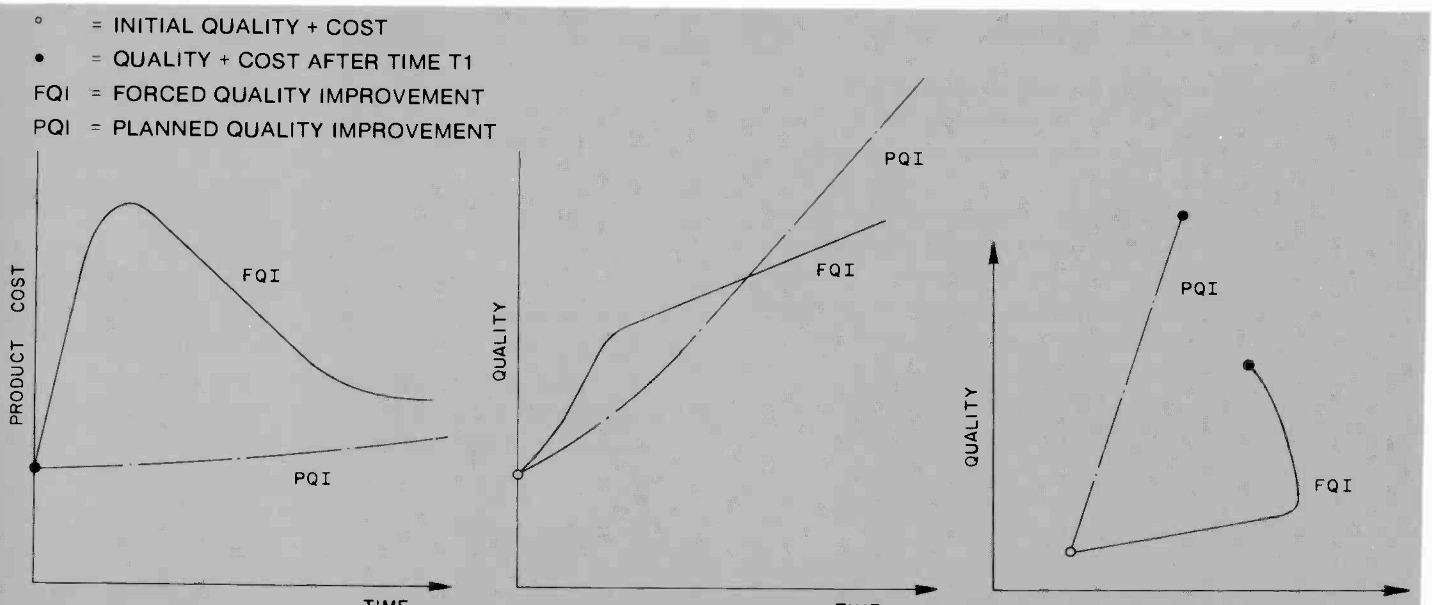

Fig. 3. Time-cost relationships for forced quality improvements and planned quality improvements in manufacturing.

Fig. 4. Time-quality relationships in manufacturing.

Fig. 5. Quality-cost relationships in manufacturing.

operation. Why use FQI at all? Because of the need of a "quick fix" for the customer. (In essence, we select the better product while the PQI is underway.)

The customer must be satisfied (at once)!

A manufacturing operation's attitude and philosophy are key features in the battle for low cost and high quality. At the Marion location, we have several maxims with which we operate. Perhaps the most important is: "The customer must be satisfied." This will happen regardless of how seemingly demanding or extreme a short-term fix must be until a permanent solution is found. Here are some examples:

- Added inefficient labor. Where people must be added to retest product or do 100 percent inspection of certain items instead of sample inspection.
- Extra process. Perhaps an off-line added high voltage stability process requiring extra equipment and labor.
- People at the customer site. If our product is not running as smoothly as "brand X" in a customer's environment, we send technical people to the customer's site to demonstrate proper set-up of our product in their system.

This attitude is necessary if we are to keep and increase our market penetration to keep our plants fully loaded. A plant that is not operating at capacity quickly loses its cost-effectiveness.

Successes and failures are shared experiences. We believe that when this is a reality of operation, real teamwork exists. We must always recognize that everyone is valuable, and use their expertise and foster their contributions.

Monitoring and controlling quality

We are improving the repeatability and uniformity of our product in many areas. In an effort to monitor our product quality, we introduced engineering indexes in 25 elements of manufacture.

We have several indexes aimed at the control of particles in picture tubes. Some of these are: an index for cracked, punctured and crazed electron gun beads; a test for the integrity of anode coating stripe and panel stud coating stripe; and fiber counts on the electron gun and in the panel shadow mask assemblies.

Other indexes determine what percentage of the product is free of defects. This data is useful for evaluating the effects of changes in the process. Finally, we have indexes to determine how much product goes straight through the operations with no rework or extra handling.

The items monitored are primarily aimed at control of customer problems. This effort is superimposed and additive to the regular checks in the existing quality system. If performance deteriorates from the acceptable level, all responsible parties are notified and effective action takes place.

Redundancy improves the quality level

We have introduced operations, even if it seems to be a duplication or an additional effort, to accomplish the same end as previous operations. The shadow-mask wash process illustrates this principle the best. We tried for several years to keep masks free of particles through all operations. We could do it for short periods of time, but because of the many people and processes involved, a failure inevitably occurred. With the mask-wash system, which is the final panel/mask prep operation, we overcome the loss of control and its deleterious effect.

Tolerances tightened

We are tightening tolerances in our operations and in our vendors' operations.

From the glass component, electron gun, and shadow mask vendors, we have requested improvement of tolerances in areas that will increase our process latitude and improve performance. This is being done in an orderly manner to prevent long-term financial hardship to the vendor.

Internally, we are attempting to achieve a 30- to 50-percent tightening in tolerances. The picture tube manufacturing areas have approximately 19 departmental areas. Manufacturing engineers continually attempt to tighten one departmental process/product standard per calendar quarter. We are working in areas we feel are important to tube performance and process latitude in downstream in-plant operations. This program also will allow us to introduce production mechanization improvements with a minimum of difficulty.

If the total systems' tolerances can be reduced, it will be easier to assemble the product, and uniformity and repeatability will be improved.

Operator proficiency

Another maxim of operation is "Almost every operator failure can be improved with a process change." Many persistent operator handling problems were virtually eliminated when we instituted a change in the system in which the operator was working.

With this philosophy and attitude, the Marion organization has made dramatic improvements internally as well as at our customers' sites. Today, customers can still be gained or lost because of the cost-or-quality issue.

Acknowledgment

The Quality group does an excellent job today. The problem at hand, however, is immense in size and complexity. It requires all the manpower and expertise in the organization to meet the demanding goals.

The Manufacturing groups have done an excellent job

with cost and productivity. Continued gains in these areas are needed to stay competitive. Excellent help from all support groups has been an important factor to continued performance improvement.

In summary, the quality, cost, competitive system which exists today requires a tremendously effective team effort. It is everyone's responsibility to make a dedicated contribution in all these areas to continue our business success.

John Ratay is Manager, Process and Production Engineering at RCA Picture Tube Division, Marion, Indiana. He earned a B.S. degree in Mechanical Engineering by attending evening classes while holding a full-time position as a Designer for the Varityper Corporation in Newark, New Jersey. The Varityper Corporation manufactures business composing machines. His responsibilities were in the design and follow-up of precision mechanism through the prototype, tool model, and into the trouble shooting of the manufacturing stage.

Mr. Ratay joined the RCA Corporation as an Associate Engineer in Production Engineering at Scranton, Pennsylvania, in 1966. He worked as an engineer in the Bulb Recovery, Matrix and Screening areas of tube manufacturing. He was later promoted to Manager, Production Engineering at RCA Scranton. On August 19, 1974, he transferred to RCA Marion as the Manager, Process and Production Engineering.

In addition to his duties as Manager, Process and Production Engineering at Marion, he has served as Acting Plant Manager since March, 1981.

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RCA Review's *special issue:*

New manufacturing technology for PC boards

The June 1981 issue of *RCA Review* is devoted to the new porcelainized-steel PC boards developed at RCA Laboratories. The new materials overcome previous shortcomings of porcelain boards — they do not contain any sodium or potassium (no "brown plague" phenomenon), are almost entirely bubble free, can withstand multiple refirings at temperatures in excess of 900°C, and have a high voltage-breakdown strength (>5kV). The issue also contains papers describing a family of compatible base-metal thick-film inks, manufacturing processing steps, interconnect devices, and design rules.

- "Introduction," L.S. Onyshkevych
- "Manufacturing Steps in Production of Porcelain-Enameled PC Boards," L.S. Onyshkevych, W.H. Tsien, T.T. Hitch, and P.R. Smith
- "High-Temperature Porcelain-Enamel Substrates — Compositions and Interface Studies," K.W. Hang and J. Andrus
- "Electrophoretic Deposition Coatings from Isopropanol/Glass Slurries," A. Sussman and T. Ward
- "Electrical Properties of RCA Porcelain-Enameled PC Boards," B.J. Thaler, J.H. McCusker, and J.P. Honore, III
- "Mechanical Properties of RCA Porcelain-Enameled PC Boards," J.H. McCusker, W.H. Tsien, and B.J. Thaler
- "Optimization of RCA Porcelain Composition for Compatibility with Thick Films," A.N. Prabhu, K.W. Hang, E.J. Conlon, and S.M. Boardman
- "Characterization of RCA Thick-Film Compositions on RCA Porcelain-Coated-Steel Substrates," A.N. Prabhu, K.W. Hang, E.J. Conlon, T.T. Hitch, and A. Kusenko
- "Fabrication of Large-Area Thick-Film Hybrid Circuits Using RCA Porcelain-Coated-Steel Substrates," A.N. Prabhu, E.J. Conlon, A.Z. Miller, J.H. McCusker, and T.T. Hitch
- "Finite-Element Analysis of Stresses and Thermal Flow in Porcelain-Enamel PC Boards," J.H. McCusker
- "The Design of Electronic Circuits on Porcelain-Enameled PC Boards and Hybrids," D.P. Dorsey, W.H. Tsien, and P.R. Smith

J.A.Haik | J.N. Bloeser | M.O. Calvert
D.A. Courter | N.W. Strinkowski | R.G. Tracy

Intracorporate Support Services: Worldwide support to Government Systems

This small, interdisciplinary group performs a highly specialized function.

Abstract: *This paper provides a description of each of the groups comprising Intracorporate Support Services (ICSS). These groups support the Government Systems Division in serving the Department of Defense and NASA. Their teams travel worldwide to supply field maintenance, installation, operation and maintenance, planning, training, and documentation services.*

A small but vital organization within the Government Services Department of RCA Service Company is a group known as Intracorporate Support Services (ICSS), which exists to provide field support for systems produced by RCA for the Government. This group is perhaps unique in that, while performing a highly specialized function within the corporate scheme, it represents a wide range of occupational skills and disciplines.

As an organizational entity, ICSS, managed by Charles A. Lane, exists within that segment of Government Services Field Operations which is under the executive direction of William F. Given, Division Vice-President. ICSS today has a field staff roughly four times the size of the approximately 100-man force RCA fielded through a massive, emergency recruitment program in the middle of World War Two to support RCA-produced military hardware. The basic types of services now provided by ICSS, and the share of effort represented by each type, are indicated by the graph in Fig. 1. Operations elements within ICSS are dedicated either to a specific type of hardware, a specific division of RCA, or a major category of service. All elements are committed primarily to support the Government Systems Division in serving the Department of Defense and NASA. This paper is devoted to descriptions of the major services furnished by each of these elements.

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AEGIS

Intracorporate Support Services has furnished support to the AEGIS program since the contract definition phase some ten years ago. A wide range of engineering and technical functions constitute this effort: training, documentation, operation and maintenance, field testing, and maintenance engineering. The AEGIS group of ICSS worked with Missile and Surface Radar on the engineering development models, the land-based test site, the test ship, and the production test center, thereby developing in-depth skills in those field services supporting the heart of AEGIS' hardware system: the computer-controlled, phased-array radar system designed by RCA Missile and Surface Radar (Fig. 2).

A test team, well-seasoned by participation in land-based test site operations, contributed significantly to highly successful test operations aboard the test ship U.S.S. Norton Sound operating from a home base at Port

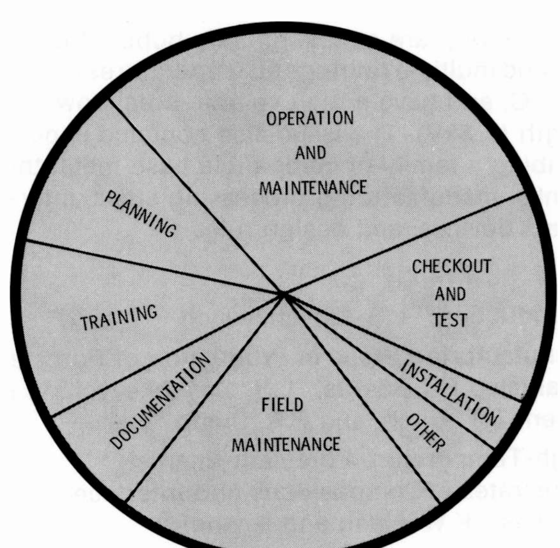

Fig. 1. Shares of Intracorporate Support Services' (ICSS) effort among major categories of service.

Fig. 2. Lawrence Schulman, Test Specialist with the AEGIS group of ICSS, mans the test monitor central console of the Operational Readiness Test System. Under computer program control, the system provides status assessment, maintenance control, and testing of radar, fire control, and other elements of AEGIS.

Hueneme, California. A team now aboard the U.S.S. Norton Sound is engaged in test support of advanced launch systems that are to be fitted into future ships of the Ticonderoga (CG-47) class. Other members of the original test team are engaged in support of the production test center, combat system engineering development site, and computer program test site activities. This group is to accompany the first AEGIS production system to Ingalls Shipyard at Pascagoula, Mississippi, for approximately a year of testing prior to Fleet acceptance.

The AEGIS training contingent, which is staffed with analysts, instructors, and clerical personnel, has furnished continuous support to the program and is presently engaged in training CG-47 personnel after having defined CG-47 combat system manning and training requirements and having prepared course materials for 15 courses satisfying those requirements. A publications facility operated by the AEGIS Support Group produces system-level maintenance and operations documentation.

The AEGIS group is prepared for sustained activity throughout the coming decade, based on plans of the U.S. Navy, which indicate a need for 24 AEGIS-equipped cruisers to be delivered in the 1980s. The capability to continuously furnish seasoned test support teams for all AEGIS-equipped ships is being developed through a "Rota System," whereby test team members are "recycled" through engineering development and production test facilities, providing each new ship team with a nucleus of experienced members who are knowledgeable in equipment updates for each ship. Use of a grooming site has proved to be an efficient means of alleviating dockside problems and reducing the time needed for installation and test leading to acceptance. During the next two years, training will be completed for CG-47 personnel and Navy instructors, and training efforts beyond that period will be devoted to teams on future ships. The AEGIS documentation activity will provide documentation update support to future ships programs.

Satellite and space systems

Many of RCA's contributions to space exploration and allied fields are reflected in the support provided to RCA-produced space hardware by the Satellite and Space Systems group of Intracorporate Support Services. For example, in support of NASA's Space Shuttle program, the group furnishes field engineering support to closed-circuit television equipment produced by RCA Astro-Electronics and to Extravehicular Activity (EVA) radio systems produced by RCA Government Communications Systems. Another team supports integration and testing of spacecraft built by RCA for the TIROS (Television Infrared Observation Satellite), Dynamics Explorer, Satcom, Nova Navigation Satellite, and Defense Meteorological Satellite programs. Another provides orbital operations support to the RCA-built Atmosphere Explorer Satellite, while still another furnishes similar services to the MAGSAT (Magnetic Field Satellite), ISEE (International Sun-Earth Explorer), and the Solar Maximum Mission satellites.

Typical of the tasks conducted by the satellite and Space Systems group at RCA plants are pre-integration testing of spacecraft black-box components, installation of components in the spacecraft, and spacecraft testing during and after integration, including thermal-vacuum and other environmental testing. ICSS personnel frequently follow the spacecraft to the launch pad for final prelaunch checkout. Related functions entail maintenance of ground support equipment used in testing the spacecraft and manning spacecraft control systems at remote tracking stations during early orbits. As for postlaunch support, ICSS teams commence operation of the spacecraft, exercise of subsystems, and related operational activities moments after launch. They continue these services throughout the life of the spacecraft, which may be several years.

Most of the support provided by the group is to payloads or complete systems produced by RCA Astro-Electronics. The unique experience which ICSS technicians and engineers bring to these programs is usually traceable to their participation in earlier intracorporate support to aerospace programs and other RCA Service Company projects, such as NASA's Space Tracking and Data Acquisition Network, the Eastern Test Range, and the Atlas missile weapon system. Since the early days of the TIROS weather satellite program, intracorporate support teams have provided planning and evaluation services to that series of spacecraft, first for NASA and now for the National Oceanic and Atmospheric Administration

(NOAA). More recently, support has expanded to encompass maintenance of spacecraft software. The TIROS orbital support team operates from NOAA's National Environmental Satellite Service Control Center in Suitland, Maryland, although its responsibilities frequently take it to Goddard Space Flight Center, to the RCA Space Center in Hightstown, and to other locations.

At NASA's Johnson Space Center in Houston, Texas, a team provides field engineering support to the Space Shuttle CCTV and EVA radio systems. There, ICSS personnel conduct pre-installation acceptance testing, integration, and checkout of these systems and provide training and instruction to Shuttle crew members in operation and emergency maintenance of the EVA and CCTV systems. The team is frequently called upon to travel to launch sites, vendor plants, and subcontractor operations locations throughout the United States and Canada, and one engineer is resident at Kennedy Space Center, Florida, where the first several Space Shuttles are being launched.

ICSS has provided orbital operations support to the Atmosphere Explorer at Goddard since launch of the first RCA-built satellite of this series in 1973. Two more of these satellites followed in 1975, and two similar Dynamics Explorer payloads will be launched in 1981. The Goddard team plans and conducts around-the-clock operation of the orbiting spacecraft, evaluates performance, and provides comprehensive mission planning for future spacecraft. Support of a similar nature has been provided for the MAGSAT, ISEE, and Solar Maximum Mission programs and to the Air Force at Offutt Air Force Base, Omaha, Nebraska, for the Defense Meteorological Satellite.

Some of the programs now supported by the Satellite and Space Systems group will continue for several years. Others, such as the Space Shuttle and TIROS efforts, may run to the end of the decade and beyond. Effort on some of these programs is still expanding, and new programs continue to surface. Consequently, ICSS involvement in aerospace-related programs probably will continue far into the foreseeable future.

Radar and digital systems

The Radar and Digital Systems Support group provides field support services for instrumentation, surveillance, and fire-control radar and digital communications equipment designed and produced by Missile and Surface Radar and Government Communications Systems of the Government Systems Division. Staffing of these support efforts ranges from a single individual on the HR-76 program in Taiwan to 75 persons on the KREMS (Kiernan Reentry Measurements Site) program on the Kwajalein Missile Range. Most efforts require staffs of from 2 to 12 persons and include such tasks as installation, modification, operation and maintenance, field test, and depot-level maintenance.

This group's largest single effort entails operation and maintenance of the TRADEX (Target Resolution and Discrimination Experiment), ALCOR (ARPA-Lincoln C-Band Observables Radar), and MMS (Multistatic Measurement System) radar systems at the KREMS installation on Kwajalein Atoll in the South Pacific. This is a long-term, Army-sponsored program whose purpose is to obtain radar metric and signature data on reentry objects and space vehicles. These data returns are used by many agencies, for ballistic missile and anti-ballistic missile development. The system is continually being modified to improve its capability and to accommodate new experiments, and thus represents a blend of old and new technology.

The need for field service teams knowledgeable in both old and new technology is also manifested in the Worldwide Engineering and Logistics Support (WELS) program, for which the Radar and Digital Systems Support group provides some 25 persons to perform modification and depot-level maintenance tasks on approximately 100 instrumentation radar systems employed on test ranges throughout the United States and at sites in Australia, England, West Germany, and the Far East. The systems represent a modification process that has extended over a number of years, so that the equipment histories mark stages in the evolution of radar technology. An overhaul facility for depot-level maintenance of WELS radar systems is located in Rockledge, Florida, and the Radar and Digital Systems Support group also staffs regional offices in three areas of greatest density of this equipment: Patrick Air Force Base, Florida; White Sands Missile Range, New Mexico; and Vandenberg Air Force Base, California.

Radar and Digital Systems Support is furnishing six field engineers for a short-term task to modify BMEWS (Ballistic Missile Early Warning System) tactical operations room display and control equipment at sites in Greenland and Alaska. Leaning heavily on modern digital technology, the new consoles are driven by a Data General minicomputer, which, in turn, interfaces with existing BMEWS hardware. In other support to BMEWS, the group has continued programming services initiated in the early sixties for the Display Information Processor (DIP) computer installed in the Cheyenne Mountain complex. A special-purpose display processor produced by RCA Communications Systems, the DIP computer processes data from all three forward sites for display of site status and ballistic missile raid information to the NORAD Duty Officer.

In other efforts, the group provides field testing of Tri-Service secure communications equipment for the TRI-TAC tactical switches (the AN/TTC-39 circuit switch, the AN/TYC-39 message switch, and the AN/TTC-42 unit level switch) and field support for installation, checkout, operation, and maintenance of MAGREC, a high-speed video tape recorder capable of recording extremely wide-band signals. MAGREC is used in naval aircraft for reconnaissance and to record special data for computer analysis.

RCA's prominence in radar and communications development over the years virtually assures a continuing demand for these products and, consequently, a continuing demand for field support backing future sales to the United States and foreign governments. Of existing programs, WELS and KREMS, the two largest—representing approximately 100 engineers, technicians, and support personnel—are expected to continue well into the foreseeable future. Other, short-term, efforts will most likely be replaced by new programs.

Automated Systems support

Intracorporate Support Services has furnished field and laboratory support to automatic testing systems produced by Automated Systems since the establishment of ICSS. The staff of approximately 22 persons assigned to the Automated Systems Support group of ICSS performs field and depot maintenance, field modification of hardware, laboratory and field validation of test program software, and customer assistance in operation and maintenance of the test systems, including informal on-the-job training of customer personnel.

The principal items supported by the Automated Systems Support staff are the microprocessor-based Simplified Test Equipment (STE), a field portable device initially developed to automatically test internal combustion engines, and the Automatic Test Equipment (ATE) system, a multirack, computer-driven test system which has evolved from the orginal EQUATE configuration and now tests mechanical as well as electronic elements. The Simplified Test Equipment system has also evolved to accommodate—in its test programming capability—turbine engines, weapons fire control systems, and electrical systems of vehicles.

Automated Systems Support of ATE operations extends to all branches of the military and many types of military hardware: communications equipment, tanks and military ground vehicles, remotely piloted vehicles, attack helicopters, airborne control and warning systems, and naval destroyers. Field support is furnished to the automated test systems which are used to service these hardware items at many locations in the United States and overseas.

Automated Systems Support provides services to automated test equipment used in the Army's attack helicopter program on operational testing sites at Uman Proving Ground, Arizona, and Hunter-Liggett Military Reservation, California, and at contractor locations in Orlando, Florida, and Culver City, California. In another major support effort under the direction of NORADCOM, field service representatives for ATE have been assigned to units at Pirmasens, West Germany, Fort Gordon, Georgia, and Fort Huachucha, Arizona, and a field support office has been established in San Leandro, California. For ATE support on the AWAC-E3A airborne warning system, resident field engineers are assigned to Robins Air Force Base, Georgia, and the contractor's facility in Seattle, Washington. Field support is provided to the Naval Air Rework Facility at San Diego, California; the Army's Divisional Air Defense (DIVAD) program at Newport Beach, California; and the Remotely Piloted Vehicle program at Sunnyvale, California.

Automated Systems Support services for Simplified Test Equipment associated with the M-1 tank include assistance to Automated Systems engineers in the development and validation of test programs, field upgrade of hardware and software, validation of test programs on the M-1 tank in the field, and assistance to users in field operations at various locations, including Aberdeen Proving Ground, Maryland; Fort Knox, Kentucky; and Yuma Proving Ground. The group is also furnishing coordination in the development of Simplified Test Equipment for the Fighting Vehicle System, an infantry and cavalry troop carrier vehicle. The group's support of other AS product lines includes field service for the AN/GSQ-184 Integrated Observation System, which employs the AS-developed AN/UAS-9 Laser Range Finder Designator. This service is provided to the Marine Corps Air-Ground Combat Center, 29 Palms, California. Support for the system entails all upper echelon maintenance, including depot-level support, and consultation on equipment performance at Fleet Marine Force locations in North Carolina, California, and Hawaii and on Okinawa.

Fleet support requirements for both ATE and STE systems are expected to increase sharply over the next several years. This is indicated by the fact that production is planned for a total of 150 ATE systems through 1985, over and above the 40 existing systems, and that upcoming production of the M-1 tank and development of the Fighting Vehicle System will create new field support requirements for the Simplified Test Equipment system.

Secure systems

In recent years, RCA Government Systems has experienced substantial growth in operations to develop classified distributed data processing (DDP) systems for various Department of Defense organizations. Each of these systems requires installation, testing, and follow-on operations and maintenance at widespread field locations. In response to the unique field support requirements these classified systems represent, ICSS established the Secure Systems Project Support group in early 1977. Consolidation of intracorporate support for secure systems has considerable merit for two important reasons.

First are the extraordinary security clearance requirements for personnel engaged in this activity. It is not unusual for individuals to wait as long as 12 months for the needed security clearance. Therefore, once an individual has obtained a high-level clearance, it is most desirable to assign this person to projects on which he can continue in a cleared status. In other words, a primary objective of the Secure Systems Project Support group is to build and retain a base of technical support personnel who have security clearances at a level necessary to support a given classified program.

Second, the technology employed in these systems is concentrated in the area of distributed data processing using commercial minicomputers and operating systems in conjunction with RCA-furnished digital equipment and special applications software. With this commonality of technology among systems which they support, Secure Systems personnel can move from project to project with relative ease, build upon their data processing and systems experience, and make significant technical contributions to each program.

The Secure Systems work force is made up of field engineers and technicians, software specialists, and training personnel. Although the work demands in-depth knowledge of hardware to the component level, all personnel must strive to function at the system level. This is particularly important in supporting DDP systems at user locations, where Secure Systems representatives train user personnel on-site in operations and maintenance tasks.

Recruiting and retaining properly cleared computer technology personnel in today's highly competitive labor market receives considerable attention at virtually all levels of RCA Service Company management. A substantial number of highly qualified personnel are actively engaged in supporting classified GSD field requirements worldwide, and intensive effort is continuing to meet the increasing needs of the immediate future.

Training

For more than 25 years RCA Service Company has furnished intracorporate training support to equipment produced by RCA for space and defense. Such services, provided by the ICSS Training Projects group, encompass all facets of training support. One element of the group, Training Plans and Analysis, conducts the necessary training and manpower studies, defines instructional requirements, and develops programs of training. Another element, Instructional Programs, prepares and presents classroom-type instruction meeting the specific needs of all trainees, whether they be Chinese, Mexican, Israeli, European, or U.S. military personnel. The third element, the Audio-Visual section, prepares and produces slide-tape programs and full-color videotape productions to augment live presentations (Fig. 3). Instructional topics range from general theory to equipment operation and detailed hands-on procedures for servicing mechanical, electrical, electronic, and electromechanical devices and systems.

The geographical limits of Training Projects operations have yet to be reached. The group sends its instructors where they will do the most good, to a satellite tracking station in the Australian bush or the Indian Ocean, a Chinese school on Taiwan, a training site in Israel, or an early warning radar station in the Arctic waste of Greenland. Conducting training projects at such remote locations is as commonplace to the group as presenting the training at RCA plants where the equipment is manufactured.

Normally the group is engaged in approximately six projects at any given time. While most range in length from nine months to a year, at least one, the IR^2 program, has continued for five years. The group's present clients are Government Communications Systems, Missile and Surface Radar, and Automated Systems. For Government Communications Systems, it supports the Integrated Radio Room (IR^2), Integrated Voice Communication System, Small Terminal Program, and several secure communications systems. For Missile and Surface Radar, the group supports HR-76 radar and the BMEWS TOR (Tactical Operations Room) program. For Automated Systems, it supports computer-based testing systems for instrument landing systems and assault helicopters.

A corollary service furnished to RCA manufacturing divisions by the Training Projects groups is proposal development. A group manager or leader works closely with proposal developers to formulate a training plan which responds thoroughly to the customer's requirements. During hardware design and development, a training analyst determines what tasks and skills will be demanded of operation and maintenance personnel. On the basis of the definitions so derived, the analyst develops intermediate and terminal learning objectives for the training program. The training specialists subsequently assigned to the effort work closely with engineering personnel and technical writers during design, fabrication, and testing of the hardware. This close interface makes possible the development of training documentation totally responsive to training specifications.

Videotape teaching represents a technological development the group has embraced to augment personalized classroom instruction. Among other advantages, this type

Fig. 3. Technical Instructor Jerry Gayster provides a hands-on demonstration of electronic service procedures. Video Production Specialist Lloyd Ritter trains the TV camera and appraises the shot on a monitor during the videotaping of an instructional presentation produced by the Training group of ICSS.

of instruction affords greater numbers of individuals immediate access to concentrated expertise and knowledge in a given subject. This advantage is not lost on educators, who have instituted substantial change in military and industrial education standards to accommodate it. To exploit the potential of this technique, the Audio-Visual section of the Training Projects group has developed a total videotape production capability, including writers, planners, illustrators, and production specialists. This group is concentrating on making video teaching an integral part of the training support it provides to RCA's manufacturing organizations.

Nick Strinkowski, Manager of ICSS' AEGIS Project Support, shows the other authors a feature of the AEGIS Combat System Engineering Development Site on the model displayed at RCA's Moorestown, New Jersey, facility. The authors are (left to right) Jack Bloeser, Nick Strinkowski, Ron Tracy, Mo Calvert, Joe Haik, and Duane Courter.

Nick Strinkowski, Manager of AEGIS Project Support, ICSS, Moorestown, New Jersey, has directed RCA Service Company participation in the AEGIS program since its inception 11 years ago. After joining RCA Service Company in television servicing in 1947, he subsequently managed various engineering activities, including the Missile Test Project (MTP) Development Laboratory, MTP Allocation and Schedules function, and Cape Range Safety facilities. On the BMEWS program, he held several senior management positions ranging from Manager, Installation Engineering, to Manager, Advanced Planning.

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Joe Haik, Manager of Secure Systems Project Support of ICSS in Cherry Hill, started his career with RCA in 1955 on the M-33 and SCR-584 radar training program at Fort Bliss, Texas. On the BMEWS program, he was Leader of Technical Training and Leader, Systems Coordination. Subsequently, he served as Manager of Systems Evaluation on NASA's Space Tracking and Data Acquisition Network (STADAN) program at Goddard Space Flight Center. Before assuming his present position in 1977, he was a Manager in Government Services Marketing.

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Jack Bloeser is Manager of Training Projects for ICSS in Cherry Hill. He joined RCA Service Company in 1954 on the M-33 fire control training program at Fort Bliss, Texas. Subsequently, he held key positions in various training programs, including that of Leader of Technical Training on the BMEWS program and Leader of ICSS Training Projects, Cherry Hill.

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Duane Courter is Manager of Automated Systems Support, ICSS, Burlington, Massachusetts. He joined RCA in 1964 as a Radar Signature Analyst on the Missile Test Project, stationed in Trinidad, and later served as Senior Systems Controller at that location and as Data Analyst in Florida. Subsequently, he was appointed Communications-Electronics Maintenance Supervisor on the Alaskan AC&W program and Test Engineer on the Defense Meteorological Satellite Program at Hightstown, New Jersey.

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Ron Tracy is Manager of Radar and Digital Systems Support of ICSS in Cherry Hill. He joined RCA in 1959 as an engineer on the BMEWS program and advanced through various Site I managerial positions to that of Site Manager. Since then, he has held several senior engineering management positions, including those of Leader, Senior Engineer, AEGIS Fire Control System; Manager, BMEWS Technical Operations; Manager, BMEWS Project; Manager, Defense Warning Systems; and Manager, Missile Test Project Reentry Ships.

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Mo Calvert, Manager of Satellite and Space Systems of ICSS in Cherry Hill, joined RCA in 1955 on the Missile Test Project, where he managed several radar and tracking operations at down-range stations before being assigned as Manager of RCA's Wallops Island project. He later managed RCA operation of the Navy Radio Transmitter Facility in Puerto Rico and the Orbiting Solar Observatory and International Ultraviolet Explorer satellites projects in the Satellite Operations Control Center at Goddard Space Flight Center.

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D.V. Rodman | G.J. Waas

Telephony — in digital evolution

Abstract: *After reviewing basic telephone technology, the authors explain the ongoing digitalization of the systems via VLSI technology. They cover interfaces, multiplexing and pulse code techniques and the single-chip codec filter.*

The transformation of the telephone system from analog to digital operation is being accelerated by a number of factors. First among them is the increased use of telephone transmission facilities: people are making more phone calls and businesses are increasing their volume of digital data transmission. This increased traffic places a burden upon existing facilities, a burden that can be lightened somewhat by converting voice signals to a digital format, which permits compression of information. In addition, by using digital multiplexing techniques in both the frequency and time domain, it becomes possible to increase system utilization manyfold without the loss of data integrity or analog fidelity.

The driving technological force behind the digitalization of the telephone system is the accumulated knowledge of the semiconductor industry and the advances made in VLSI (very-large-scale integration) technology. One advantage in using digital techniques over analog techniques is that noise is not additive in digital systems because of the use of pulse reconstruction (discussed further below). Another consideration is that digital techniques are widely known and readily applicable through integrated-circuit technology. The implementation of digital telephony by means of integrated circuits will result in less expensive, more versatile systems capable of more reliable performance.

In general, the public views a telephone system as a device used primarily for voice communication. While some awareness of digital techniques and the results of digitalization exists, the full impact of the use of semiconductors and digital methods on telephony has yet to be fully understood and experienced. Digital transmission of information has been in use since the early 1960s when the Bell System developed and installed the T1 system. This system multiplexed analog phone conversations by using a pulse-code modulation (PCM) technique. This PCM approach translated the analog format into a specific digital code, transmitted the digital code, and reconstituted the analog format at the receiving end. Today, approximately 50 percent of all telephone-system trunks have been converted to digital transmission, and the PCM technique is the commonly used modulation method.

A further impetus to digital conversion is being mounted by users of digital computers; digitalization would permit data transmission on the same pathways as the traditional voice information. A discussion of phone system organization, below, indicates how this will occur.

Telephone basics

To the typical user, the telephone is a device connected to the world by a pair of wires. The handset itself, while having many forms, always contains an earpiece (or receiver), a mouthpiece (or transmitter), and a signaling device (a dial or pushbuttons). There is also a sidetone circuit that feeds a portion of the transmitted signal back to the receiver so that the speaker can monitor the amplitude of his voice.

The transmitter converts sound energy into electrical energy by means of a carbon-granule microphone. Variations in the amplitude of the sound cause variations in the resistance of the path through the carbon granules; the result is a variable current flow proportional to sound amplitude and frequency.

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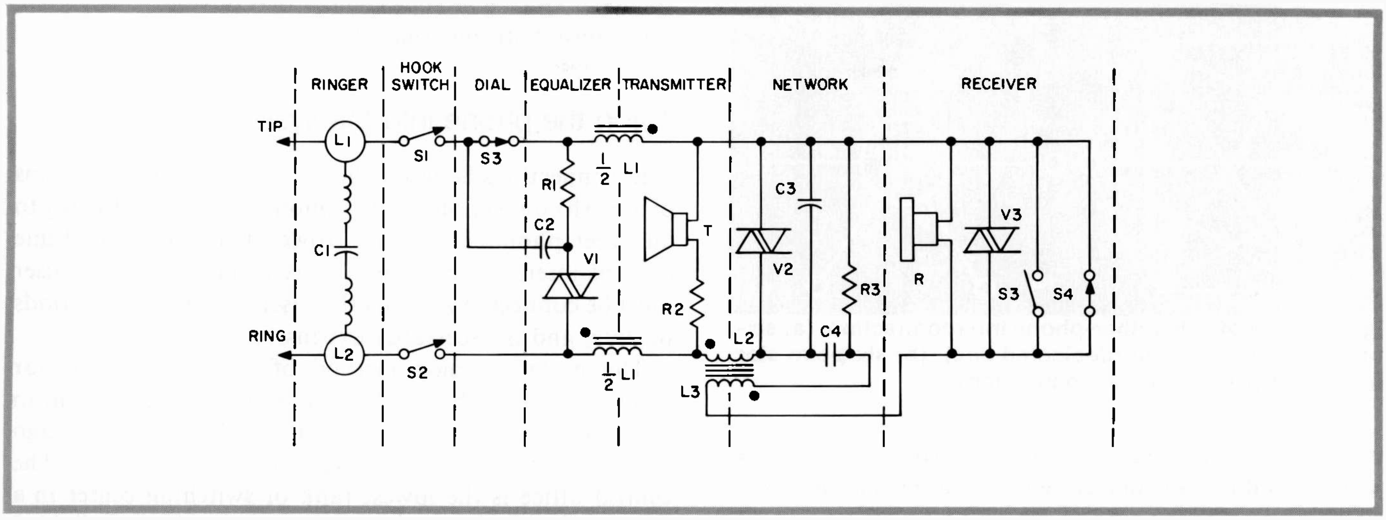


Fig. 1. A typical subscriber's telephone set, the model 500.

Sound is perceived in the telephone through an electromagnetic earphone. Current variations in the receiver coil cause variations in the magnetic field of this earphone. The varying magnetic field, in turn, causes an iron diaphragm in the earphone to vibrate and, thus, to generate sound waves.

A typical subscriber's telephone set is the model 500, illustrated schematically in Fig. 1. The set is connected to the central telephone-system office by a pair of wires called "tip" and "ring."* A voltage of 48 volts is provided the tip and ring wires by a central-office battery; this voltage provides the transmitter portion of the set with the current necessary for operation. To make the phone ring, a voltage of between 65 and 130 volts (typically 86 volts) with an approximate frequency of 20 Hz is applied to the ringer. When the receiver is lifted off the hook, switches S1 and S2 close, putting into effect a dc closure. Switch S3 opens, placing the telephone resistance (600 to 900 ohms impedance) across the line. To dial a telephone number, the line must be opened and closed at a repetition rate of 10 pulses per second; switch S3 is used for this purpose. Dialing the number 2 will yield two pulses, the number 5, five pulses, and so on. While dialing is in progress, switch S4 closes until each pulse sequence is completed. This switch closure allows the receiver to be short circuited which, in addition to the suppression provided by varistor V3, prevents the dial clicks from being heard.

In the equalizer section of the telephone, resistor R1 and capacitor C2 constitute a filter that suppresses radio interference. Varistors V1 and V2 and resistor R1 reduce transmitting and receiving efficiency on short loops from the central office in order to maintain reasonable matching limits; i.e., so that nearby phones will not sound louder than more distant phones. L1, L2, and L3 form a three-winding transformer that is used as an induction-coil hybrid circuit to provide the antisidetone-type circuit and to convert the two-wire circuit (tip and ring) to a four-wire circuit. It is this circuit that permits a single pair of wires to be used for both transmitting and receiving. V2, R3, C3, and C4 form the sidetone balancing network that makes available the controlled amount of sidetone (talker's voice audible in his own receiver) that permits the talker to maintain a natural level of conversation.

The mechanical to electronic conversion

In recent years, major manufacturers of telephones have been substituting solid-state devices for many electro-mechanical parts. The major factors in the substitution are the increasing cost of materials for the electro-mechanical parts, the much greater reliability provided by solid-state devices in comparison with their mechanical counterparts, and the fact that solid-state devices permit the addition to the telephone of features virtually unattainable with mechanical parts.

The rotary dial, generally of the single-lobe cam-and-pawl type and consisting of a spring motor and governor, has been replaced by an inexpensive keypad. The proper number of dialing pulses is generated by pressing one of the buttons on the pad. This advance was made possible through the development of the pulse dialer, a solid-state device, usually designed with CMOS technology, that converts keypad inputs into a pulsed signal output. The pulse dialer is used in areas where central offices have not been converted to the Bell System's Touch-Tone system (described further below). In addition to the pulse output, many pulse dialers contain a memory that can store a telephone number for redial purposes.

The original pulse dialer has been expanded into a repertory dialer, which performs the same functions as the pulse dialer, but has a much larger memory, thereby enabling storage of many telephone numbers. With repertory dialers, selected telephone numbers can be dialed by pushing a single keypad button.

The mechanical telephone bell has a solid-state replace-

* The terms "tip" and "ring" originated from the physical construction of the manual switchboard plugs. The tip is the round end of the plug. The ring is the insulated ring behind the tip of the plug.

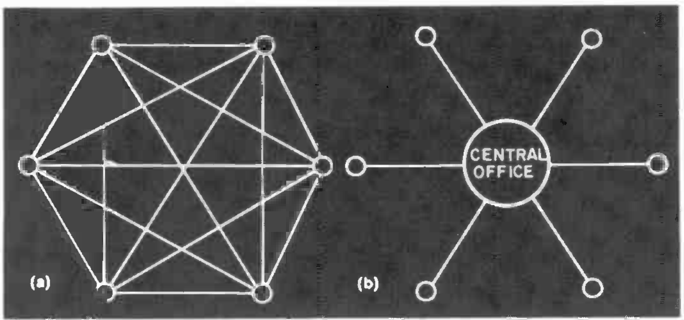


Fig. 2. Types of subscriber-phone interconnection: (a) six-point mesh connection (dedicated line), (b) six-point star connection (central office connection).

ment in the tone ringer. This device, which can drive a speaker, produces a sound closely simulating the telephone bell.

Keyboard dialing has also been spurred on by the introduction by the Bell System of Touch-Tone. In the Touch-Tone system, which allows the use of a longer subscriber loop and can speed the dialing function, each number is represented by a pair (two out of eight tones) of audio frequencies transmitted simultaneously. Devices like the RCA CD22859 Tone Generator[1] convert the keyboard input into dual-tone output.

Tying the phone into the system

Interconnections between phones could be made by means of a mesh connection, with all phones connected directly to all other phones (Fig. 2a). However, this dedicated-line type of interconnection is required only when each user must be connected with all other users for extended periods of time, and is necessarily expensive.

The more common method of connection is a star connection (Fig. 2b), in which all subscribers' phones in an exchange area are tied to a central switching office through a pair of wires, the tip and ring wires, shown in Fig. 1. The central office is the lowest rank of switching center in a hierarchy of interconnected telephone exchanges divided into primary, sectional, and regional switching centers; in order of ascending rank:

Central Office	Class 5
Toll Center	Class 4
Primary	Class 3

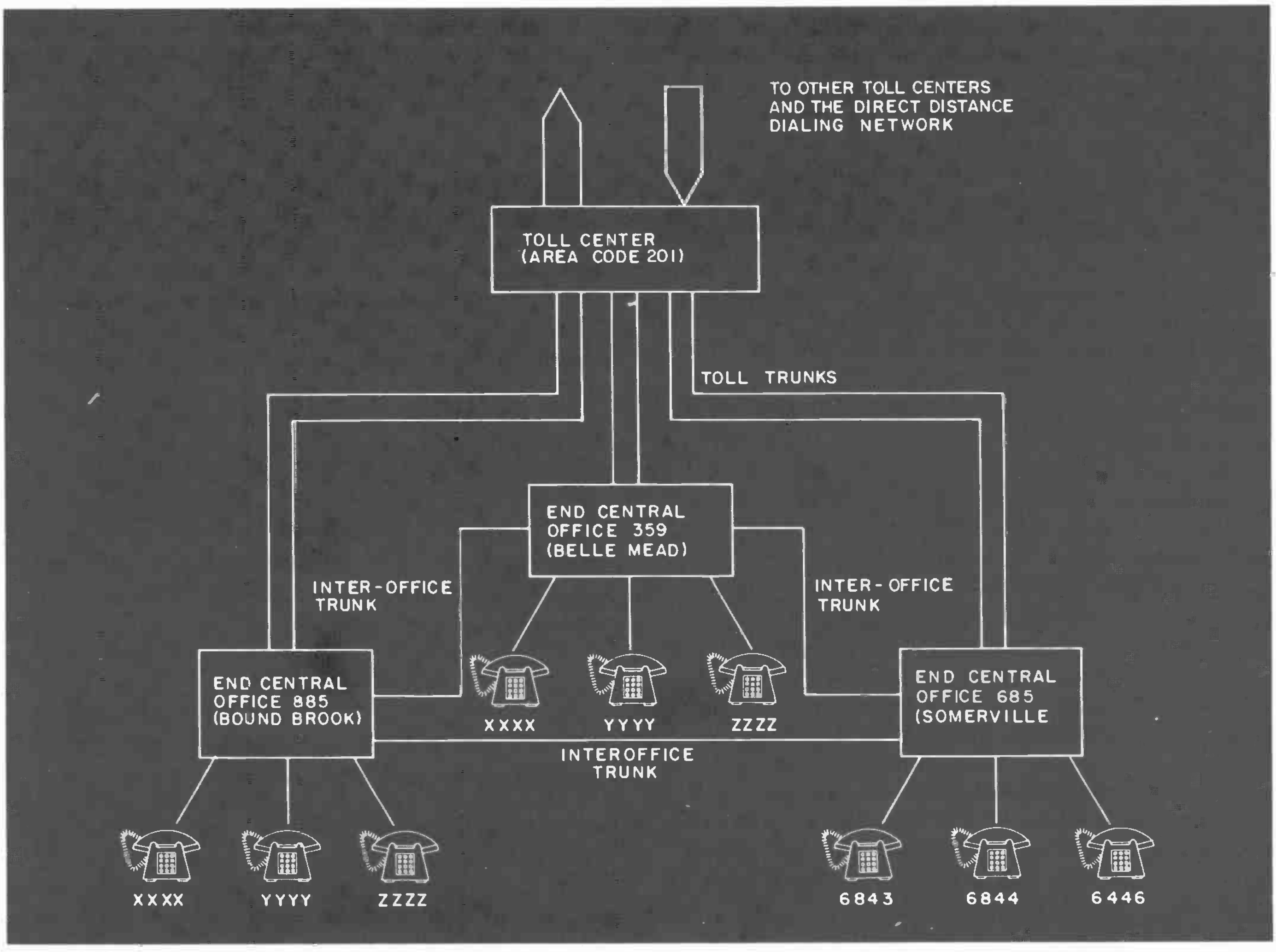


Fig. 3. Basic network organization for class 5 office.

Sectional	Class 2
Regional	Class 1

The central office (Class 5) is usually associated with one group of local numbers; for example, the RCA Somerville, New Jersey plant is tied into the 685-XXXX exchange (Fig. 3). Each central office also connects to a toll center (Class 4) for that region by means of a toll trunk. The toll trunk is a part of the overall complex known as the direct-distance-dialing (DDD) network (Fig. 4). This network, comprising the five classes of offices listed above, provides a multiplicity of voice and data channels which are used, not only for basic telephone voice service, but for such diverse telecommunications services as facsimile, television, teletype, and data processing.

Dialing within a central-office loop (e.g., 685-XXXX to 685-YYYY) is classified as a local call. Dialing outside the local area requires the addition of an area code to the local number.

The basic ten-digit telephone number used in North America can be used to illustrate the toll-dialing algorithm. Use, for example, the number 1-201-685-6000. The first digit "1" is used in some exchanges and indicates an out-of-area call. The next three digits are an area code and are assigned to a specific toll center. The first digit of the area code will never contain a zero or a one. The second digit is either a zero or a one (to distinguish a toll call from a local call). The third digit can be any number from zero to nine. The next three digits in the phone number designate a particular central office. The remaining four digits are used to identify an individual subscriber.

The voice channel

Before multiplexing could be applied to a telephone system, it was necessary to determine the minimum permissible audio bandpass. Sound fidelity is an extremely subjective topic. To establish a satisfactory telephone standard, engineers spent many man-years testing individual phone elements for gain (or loss) and noise-injection characteristics. The complexity of this situation can only be appreciated by recognizing that voice fidelity should be similar when comparing a local telephone call to a long-distance, overseas call.

The frequency response chosen is called a weighting characteristic. In North America, the frequency response is called C-message weighting, while in Europe, it is known as psophometric weighting; both follow typical voice responses (Fig. 5). The full voice channel is allocated 4 kHz. The actual voice occupies a passband width of 3100 kHz with a spectrum of 300 to 3400 Hz formed by low-pass and passband filtering.

Increasing system efficiency by multiplexing

In order to make maximum use of the trunk-system interconnection between the switching centers, it was necessary to implement a multiplexing system. This system is shown in Fig. 6. Analog systems most commonly use the frequency-division multiplex (FDM) technique, with either amplitude or frequency modulation. The multiplexing technique used for digital signals is time-division multiplex (TDM), generally with pulse-code modulation.

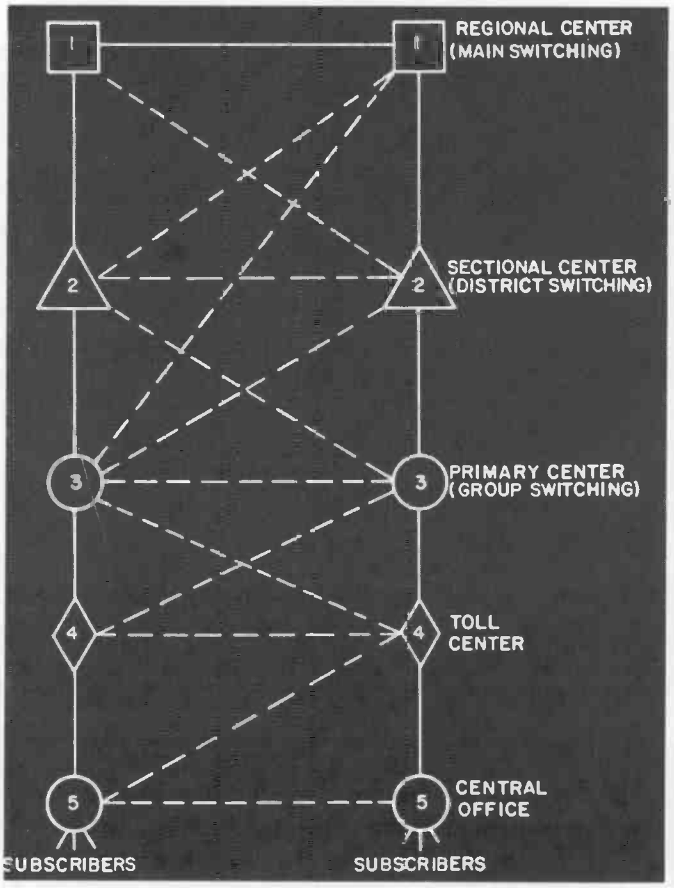


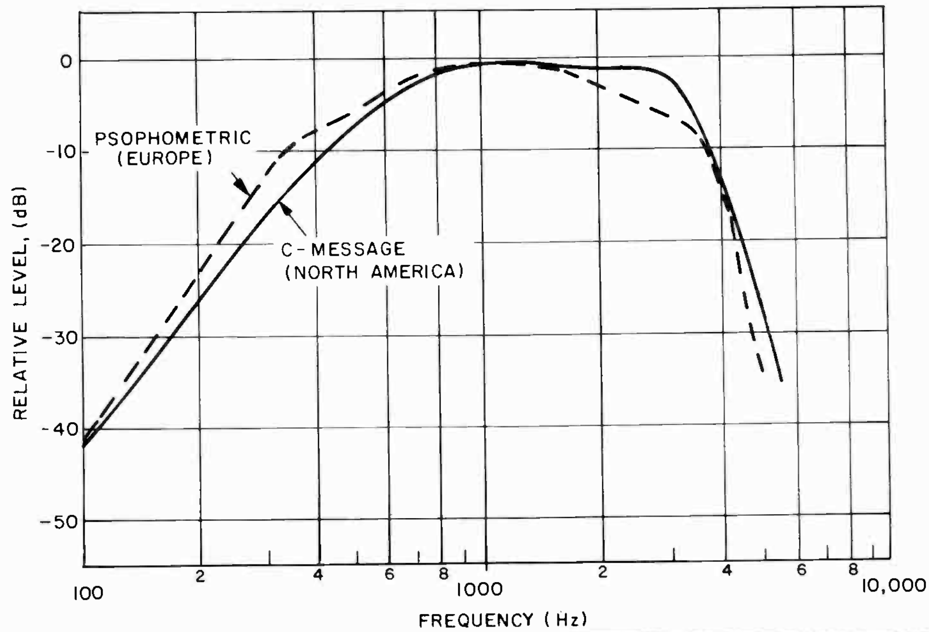
Fig. 4. Direct-distance-dialing (DDD) network hierarchy. Dashed lines are high-usage trunks.

In FDM, each voice channel is assigned to a discrete portion of a wide-band frequency system. This allocation permits several voice channels to be transmitted over a single transmission-channel medium. The standard medium, known as a "group," has 12 channels, and occupies a frequency band from 60 to 108 kHz (Fig. 7). Each voice channel is a typical 4-kHz bandwidth voice channel. Limitation of the voice channel to 4 kHz is the first requirement of making maximum use of limited bandwidth.

The most commonly used modulation technique for transposing a voice channel to a higher frequency band in FDM is a single-sideband suppressed carrier. In this technique, the voice channel is heterodyned with a particular carrier frequency. The output of the oscillator mixer circuit will be the original and both upper and lower sideband frequencies. By using a bandpass filter, all extraneous frequencies are suppressed, leaving only the lower sideband.

In both the North American L-carrier and European single-sideband carrier systems, the composite signal in the

Fig. 5. Comparison of psophometric with C-message weighting.



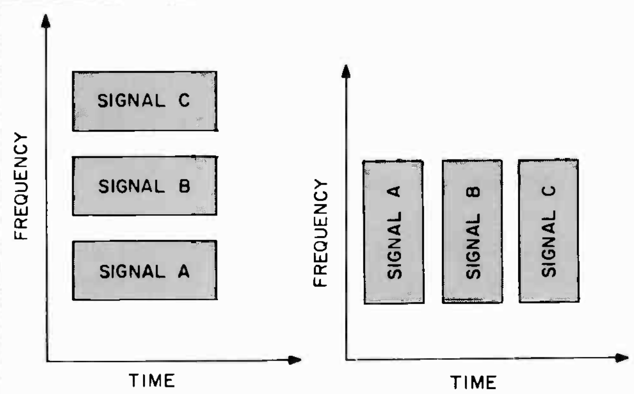


Fig. 6. Multiplexing techniques: (a) frequency-division multiplexing (FDM), (b) time-division multiplexing (TDM).

basic 12-channel group is modulated two more times. The first modulation combines five groups into a "supergroup" of 60 channels. This supergroup resides in the 312 to 552 kHz spectrum consisting of carrier frequencies of 420, 468, 516, 564, and 612 kHz. The second modulation forms a "master group." The North American master group divides 600 channels among ten supergroups. This L-channel master group is modulated in the 60 to 2788 kHz spectrum (Fig. 8).

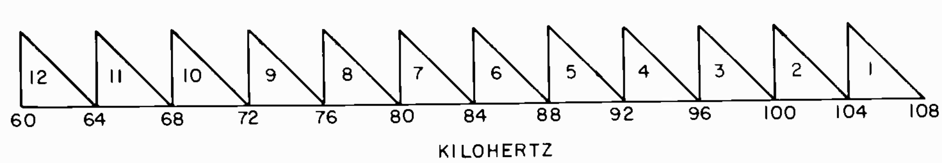
The European master group combines 300 channels into five supergroups, and is modulated in the 812 to 2044 kHz spectrum. The European system adds an additional modulation, combining three master groups into a 900-channel "super master group" occupying the 8516 to 12,388 kHz spectrum (Fig. 9).

Digital multiplexing and pulse-code modulation

Time-division multiplex (TDM) techniques are used to transmit digital signals. Information from several channels is sampled and placed in an assigned time slot before transmission. The samples are separated and the original information reconstructed at the receivers. The digital multiplexers presently used in North America for TDM are called D1, D2, D3, and D4 pulse-code modulation (PCM) channel banks, with D3 being the latest version. As with the FDM system, the TDM system requires that the analog signals first be modulated before they can be multiplexed. Again, the most commonly used modulation technique for digital systems is pulse-code modulation.

In the PCM system, analog signals are sampled at a fixed rate, quantized, and coded into a digital stream by means of an A/D converter. The received signal is demodulated by a D/A converter. This operation is performed by a circuit called a "codec." RCA manufactures two codecs, the CD22404 and the CD22407.[2] The CD22404 is manufac-

Fig. 7. Standard group organization. Each channel is single-sideband suppressed carrier modulated with the lower sideband selected.



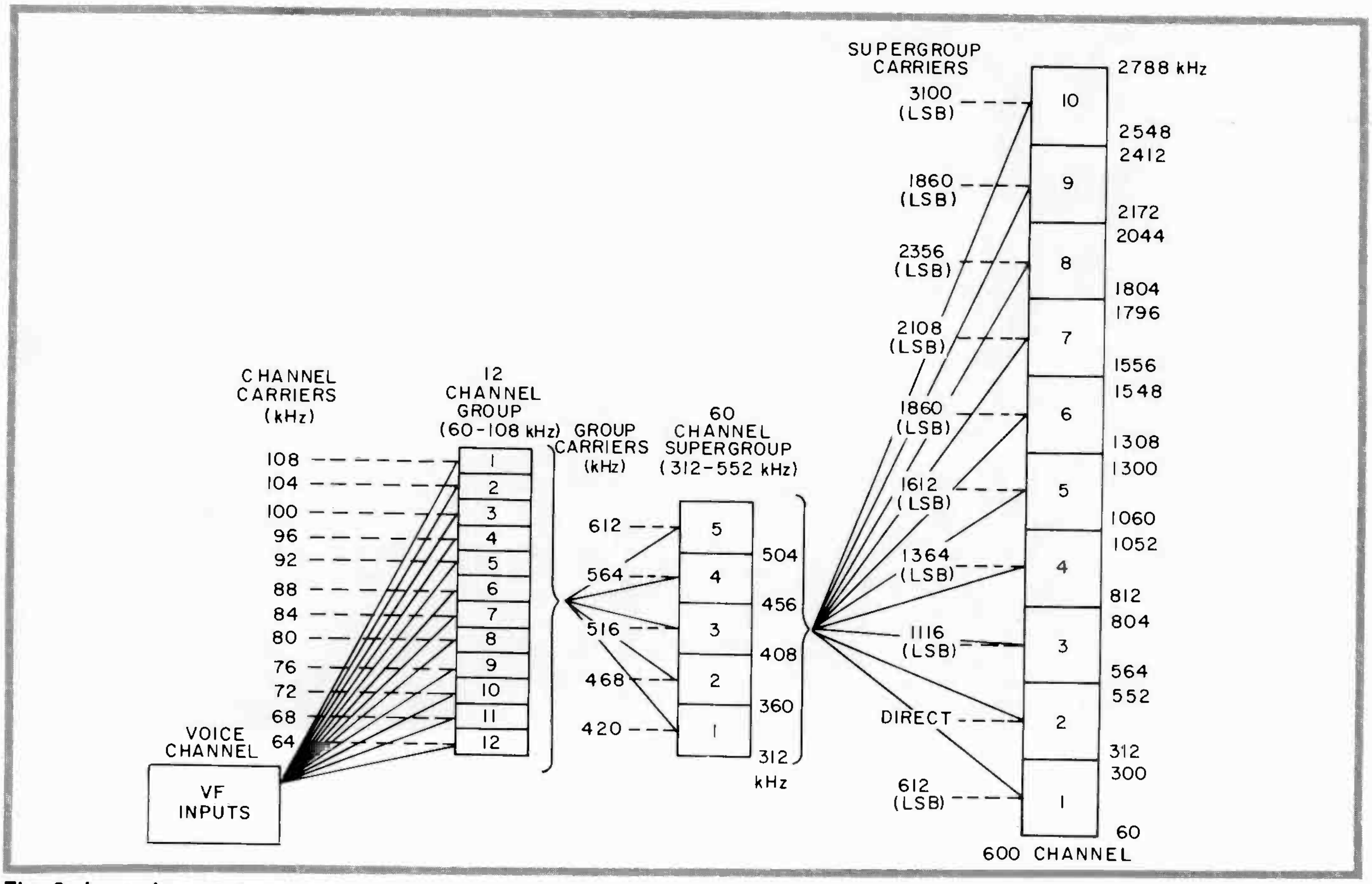


Fig. 8. L-carrier master group.

tured for the European market (A-law), the CD22407 for the North America market (μ-law) (Fig. 10). Both A and μ laws are discussed below.

The codecs include both A/D and D/A converters, but these converters differ greatly from typical converters in that the A/D encoder is nonlinear and compresses the

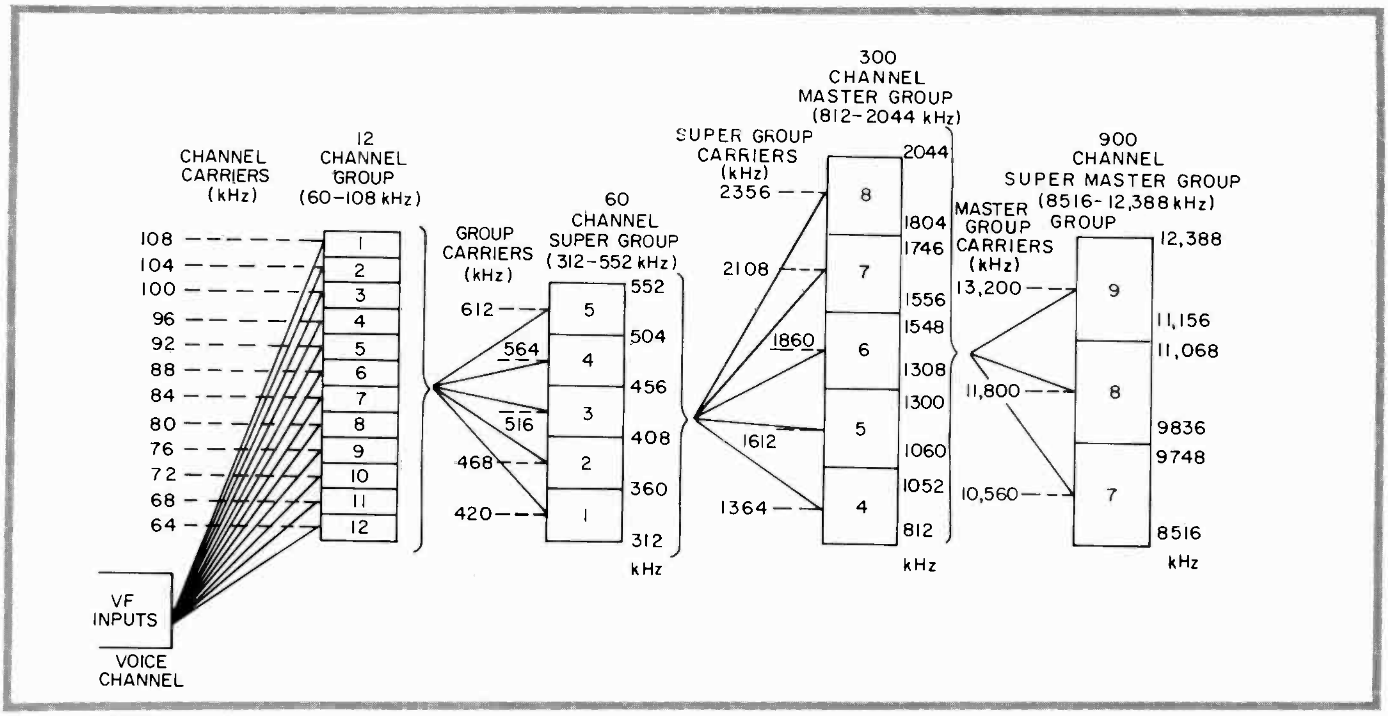


Fig. 9. CCITT standards super master group.

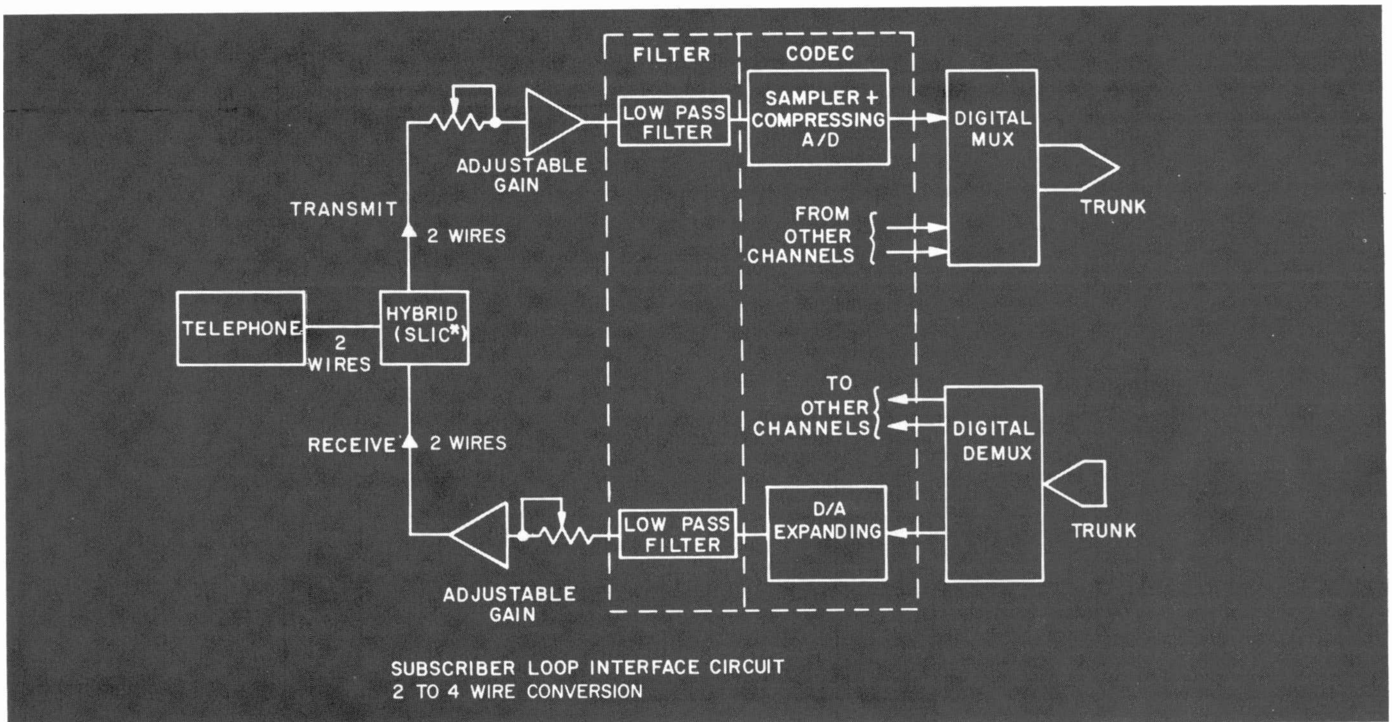


Fig. 10. Receive and transmit codec and filters.

higher-amplitude signals. Similarly, the D/A decoder expands those signals that eventually become the higher-amplitude signals. This compressing and expanding or "companding" function maintains a constant signal-to-noise ratio over the broad amplitude variation of speech typically handled by the telephone.

There are two companding algorithms currently in use. North America uses the μ-255 law proposed by Bell Telephone; Europe follows the CCITT A-law. These laws follow different transfer characteristics, both of which use 8-bit codes. A discussion of individual quantizing differences is covered in a Solid State Division Application Note, ICAN-6941[3]. This Note is abstracted in Table I. Coding and decoding characteristics for the μ-law are shown in Figs. 11 and 12.

Table I. A comparison of μ and A Laws.

	μ-255 *LAW*	*A-LAW*
Sampling Rate	8 kHz	8 kHz
Data Rate	1.544 Mbps	2.048 Mbps
Number of Channels	24	32
Type of Framing Control	Bit	Channel
Bits/Frame	193	256
Number of Segment	15	13
Approximations for Compression Curve		
Number of Steps Per Segment	16	First chord 32, remaining chords 16
Frame Duration	125 μs	125 μs
Origin Characteristic	Mid Step	Mid Riser
Dynamic Range	72 dB	66 dB
Coding	8 Bits 1 Sign 3 Chord 4 Step	8 Bits 1 Sign 3 Chord 4 Step
Resolution	12 Bits + Sign	11 Bits + Sign

Because both encoder and decoder codecs are sampled-data systems, filtering is required in both input and output to smooth the transitions into an acceptable analog signal. This filtering removes spurious high-frequency signals that can cause false signals; the appearance of false signals is called "aliasing." RCA codec filters, types CD22413 and CD22414,[4] provide the bandpass and lowpass filtering required to meet the stringent specifications of CCITT and the Bell System (Fig. 13.)

To calculate the digital switching rate, it is necessary to begin with a voice signal that is frequency limited to 4 kHz. Sampling theory requires an 8-kHz sampling rate for accurate reproduction of the audio frequency.* The Bell System D3/T1 carrier calls for 24 channels per carrier with an 8-bit word (256 quantizing steps), resulting in 192 bits plus an additional bit for framing and signaling control. The resultant frequency of digital transmission is the product of 193 bits and 8 kbps or 1.544 Mbps.

The European A-law system calls for 32 channels per channel bank. The resulting frame length is 256 bits. An 8-kHz sampling rate results in a digital data transmission rate of 2.048 Mbps (256 bits x 8 kHz). Framing and signaling

* The Shannon sampling therein states that sampling at twice the frequency of the information band limiter is necessary to get all the information. Thus, the 4-kHz voice band is sampled at 8 kbits per second (Kbps).

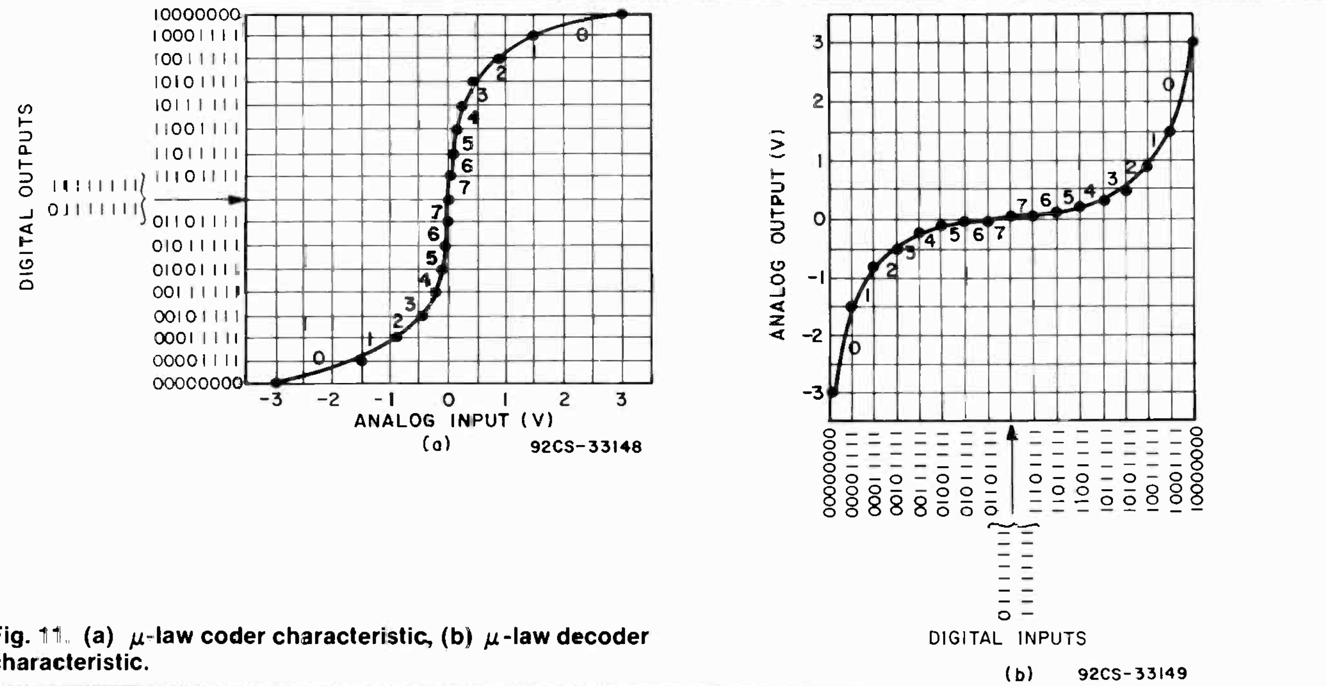


Fig. 11. (a) μ-law coder characteristic, (b) μ-law decoder characteristic.

are accomplished in one channel each, leaving 30 channels for voice transmission.

A codec filter and subscriber loop interface circuit (SLIC) form the interface between the subscriber's telephone and the digital switch that interfaces with the direct-distance-dialing network (Fig. 14). The SLIC performs all of the functions described in the acronym, BORSCHT (battery feed, over-voltage protection, ringing, supervision, coding, hybrid, and testing). Currently, SLICs are discrete circuits utilizing power transistors, high-current diodes, and transformers. The SLIC provides for lightning protection while performing a 2- to 4-wire conversion, switch-hook detection, and battery feed. It also plays a role in balancing the transmission line input by

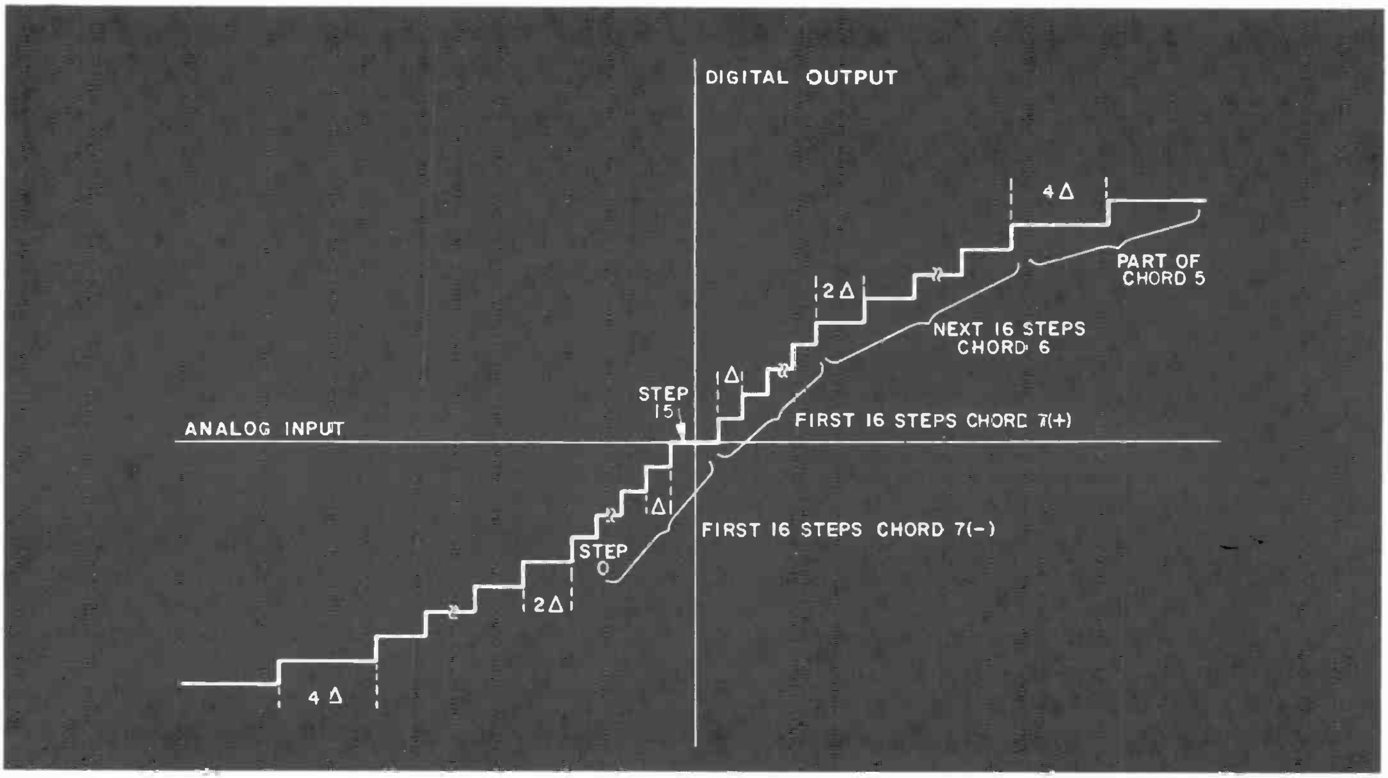


Fig. 12. Detail about origin of μ-law characteristic.

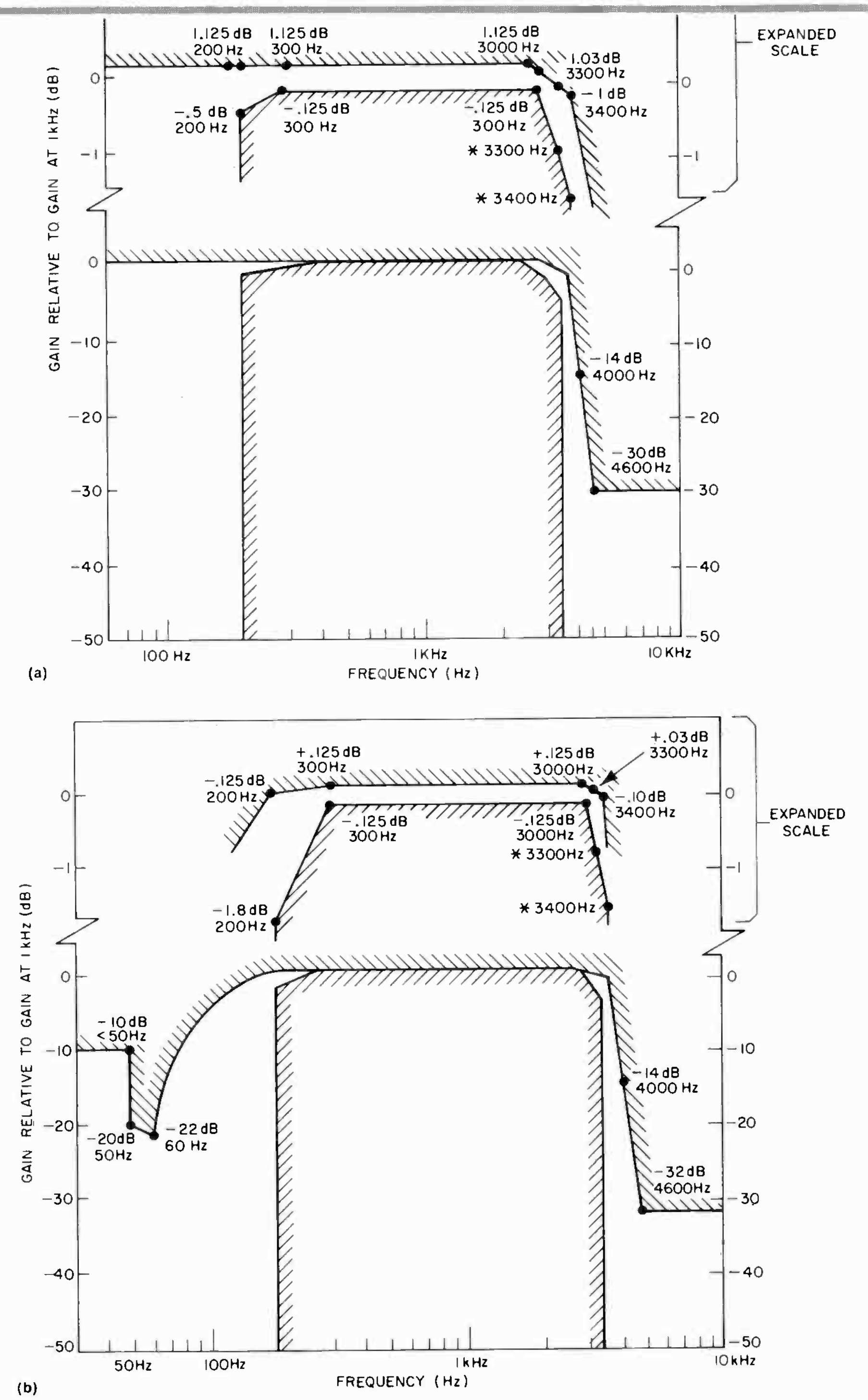


Fig. 13. Bandpass and low-pass filtering characteristics: (a) receive characteristics, (b) transmit characteristics.

suppressing transhybrid losses and balancing longitudinal signals.

The SLIC presents one of the greatest challenges to semiconductor circuit design because it contains both analog and digital circuits that must operate over voltage ranges that can differ by three orders of magnitude. RCA SLICs are inexpensive monolithic bipolar circuits that, in conjunction with external power transistors and a diode bridge, perform all the BORSCHT functions mentioned above.

The last circuit required in an all-integrated-circuit digital phone system is the time slot assignment circuit (TSAC). This circuit assigns up to 64 8-bit slots to codecs for transmission and reception of data. Control is maintained through processor or 8-bit-port control. The TSAC is strictly a digital circuit and contains no analog functions;

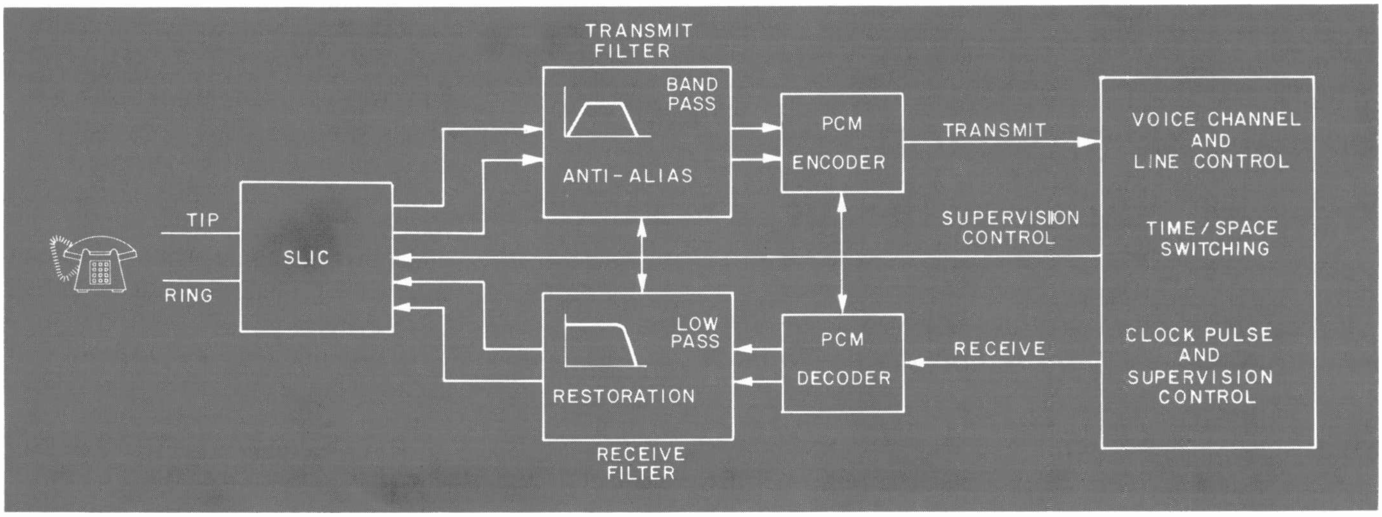


Fig. 14. A digitally switched voice channel.

it reduces backboard wiring complexity, and is an important link in the multiplexing scheme. The RCA CD22416 and CD22418 are monolithic CMOS TSACs with different line-control capabilities.[5]

Future developments

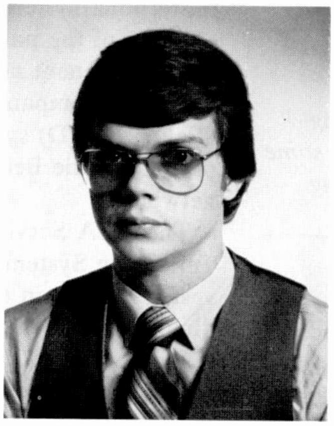
As the component density per integrated circuit increases, a greater number of functions will be performed by a single chip. This increased versatility will give the telecommunications industry greater latitude and flexibility in the development of newer and better services for the subscriber.

In Europe, plans are to eliminate the telephone book within five years. Each subscriber will have his own display — LCD or CRT — and access to a computer. The display, which will allow the subscriber to have a constantly up-dated telephone directory at his disposal, will show all information normally found in a telephone book.

With the single-chip codec filter now a reality, an all-digital business-phone system will be easier to achieve. In this system, the codec-filter will be contained in the telephone set itself, and only digital signals will be transmitted and received. Shopping at home, banking, home finance, education, and game playing through a CRT connected to a telephone will soon become a reality as newer generations of integrated circuits decrease the complexity of implementation of these functions while increasing the versatility of the system.

References

1. "COS MOS Dual-Tone Multifrequency Tone Generator," CD22859, RCA Solid State File No. 1257.
2. "COS MOS Pulse Code Modulation (PCM) Codec," CD22404, CD22407, RCA Solid State File No. 1280.
3. Rodman, D., "Digital Telephone-System Components — CODEC's and the μ and A Laws," RCA Solid State Application Note ICAN-6941.
4. "COS MOS Pulse Code Modulation Sampled-Data Filters," CD22413, CD22414, RCA Solid State File No. 1279.
5. "COS MOS Time Slot Assigner Circuits (TSAC's)," CD22416, CD22418, RCA Solid State File No. 1303.



D. Rodman

G. Waas

Dennis Rodman joined the Solid State Division in 1979 as a Member, Technical Staff with the CMOS Applications Group. His responsibilities include technical interface with telecommunication customers, and support of telecommunications products in the station, transmission, and central-office areas.

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J.W. Bakas

Digital transmission and switching systems

Digital controls can enhance the system — they're compatible with existing telephone equipment.

Abstract: *The engineer should be aware of the constraints and advantages of the existing telephone networks. New digital coding and companding formats may be considered for terminal switching and local distribution systems. However, the public telephone network's switching and transmission systems must first be used more effectively through digital enhancements.*

As intra-facility information systems become integrated, using digital technology, they must at some point interface with the changing public networks.

Recent advancements have been made in applying coding and companding formats in telephone switching and transmission systems. These formats are competitive with the older North American T-1 or the International CCITT standards in efficiency and fidelity.

T-1 is the name given to the basic Pulse Code Modulation (PCM) transmission standard used by telephone companies in North America. Each 4 kHz channel of a 24 channel system is encoded using an 8-bit word and a framing bit is added (24 x 8 + 1 = 193 bps). There are 8,000 frames per second which results in a 1.544 Mb/s stream (193 x 8,000 = 1.544 Mb/s).

CCITT is the PCM (International Standard) which encodes each of thirty-two 4 kHz channels (30 voice plus 2 signaling) using an 8-bit word. There are 8,000 samples per second resulting in a 2.048 Mb/s stream.

Whatever new types of PCM formats are used in the terminal system, be it a conventional telephone switch or a coaxial loop using wide band or base band transmission, at some point the terminal system will connect to one or more of the public networks. The most prominent network is the telephone companies' Direct Distant Dialing (DDD) systems, and in particular, the Bell System's AT&T network.

The RCA Service Company's Telephone Systems activity has a vested interest in the rate and the direction of change being made in AT&T's network. We want to be able to select the types of terminal equipment that will be most suited to take advantage of that changing network.

There are two areas that are becoming increasingly important as the network evolves with digital technology. One area is the more efficient use of the network's existing switching and interconnecting transmission facilities.

For instance, a considerable amount of equipment and channel time is used during the call set-up (dialing) and take-down (disconnect) process. Currently, efforts are being made to implement Common Channel Interoffice Signaling (CCIS). The dialing, call control, network management, and call disconnect are accomplished outside the normal message voice or data transmission and switching paths. CCIS uses control equipment (data processors) and a special channel (CCIS) to pass all network signaling functions between switching offices. This means better use of the message transmission and switching paths. CCIS presently uses a voice-frequency transmission link similar to a 3002 data channel. Digital links will most likely be used on future CCIS systems.

No network control signals are passed over the normal message (voice or data) paths, and special tones are used to check the continuity and quality of the path before final call set-up is completed. The originating office sends a 1780-Hz tone, and the terminating office sends back a 2101-Hz tone. If the check fails, or if the transmission quality is poor, another path is tried. The processors used at each end of the links are capable of sophisticated control and management functions. They operate with 28-bit words, and several "words" are used to set up, maintain, and disconnect each call.

Faster set-up and takedown time is allowed and this further improves the use of the transmission and switching equipment. CCIS links can carry a large amount of information, so more control and management data can be exchanged between switching offices. The calling-party's class of service (traveling class mark) can be forwarded to the terminating office, thus, allowing special service offerings such as special routing, queuing, and network management functions to follow the call.

An approach similar to CCIS is being used in some systems for signaling between the telephone sets and Private Branch Exchange (PBX) or Key Telephone Unit (KTU). A signal pair is used to transmit dial- and features-control signals to the switch processor. It is obvious that digital technology is not only necessary for more effective use of the message path (voice or data), but also to better manage the transmission and switching elements of a communication system, be it a telephone company, a specialized carrier, or a private network.

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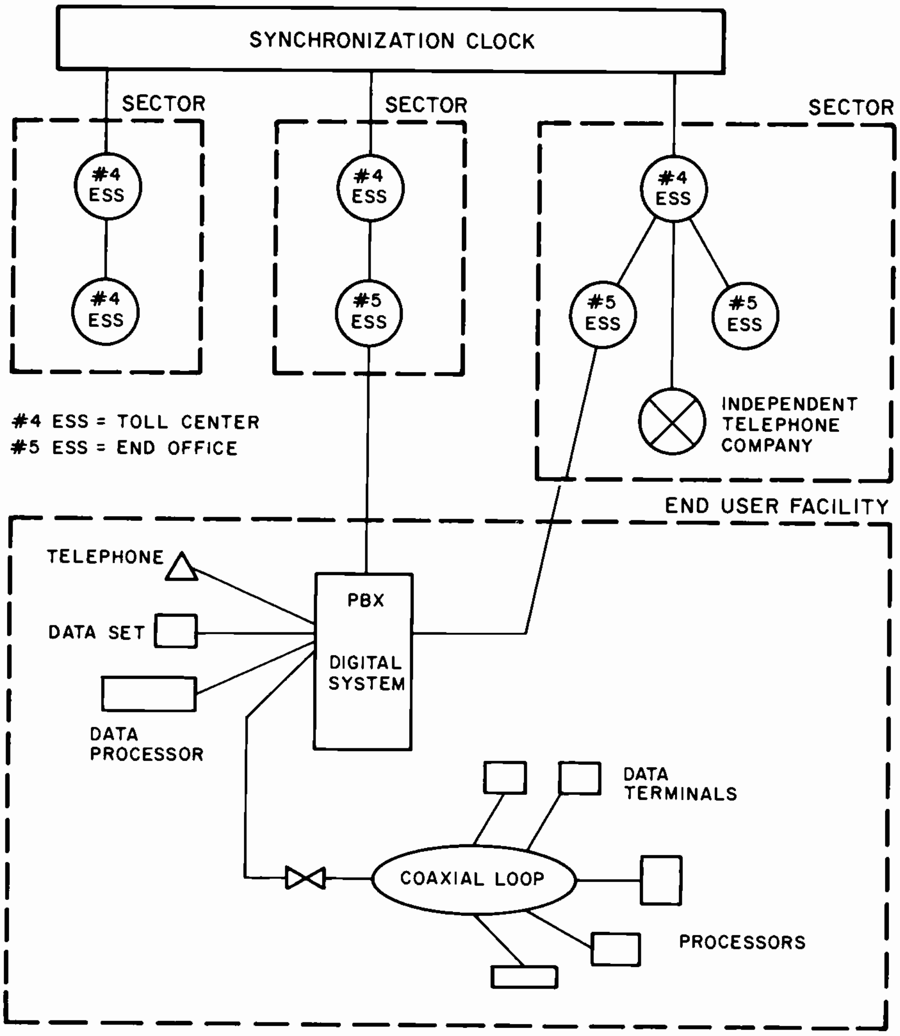

Fig. 1. Shown is the hierarchical TREE for the digital network synchronization. Each sector is administered as one system. Future digital terminal equipment configurations will take advantage of direct digital interconnection with network systems.

Another important area for consideration is the integration of digital transmission and switching systems. An aspect of this integration that will be receiving more attention is the synchronization of the digital signals as they are switched from one transmission segment to another.

AT&T has established a clocking hierarchy, called the Bell System Reference Frequency (BSRF), which is used to distribute synchronizing frequencies throughout the switched digital network. The purpose of BSRF is to provide synchronization on an end-to-end basis of not more than one "slip" in five hours. A "slip" in the T-1 carrier is a 125-ms overflow or underflow in the 1.544-Mbps bit stream.

AT&T has installed this system in its Hillsboro, Missouri facilities. The cesium-beam frequency-generation equipment consists of three units, each of which is accurate to within one part in 10^{11}. Two frequencies, 20.48 MHz and 2.048 MHz, are used, and they are distributed in an analog format to at least one #4 ESS switch per sector via the existing L-5 coaxial cable system. The distribution "tree" flows downward, using digital facilities, to other #4 ESS toll centers, to local switching, and then to other systems. These other systems can be the digital switching equipment of independent telephone companies or private systems (Fig. 1). A secondary (back-up) distribution is also provided. The slip rate objectives for each segment are:

Transmission facilities	1 slip in 10 hours
Toll switch	0 slips in 5 hours
Local switch (trouble-free)	0 slips in 10 hours
Local switch (one failure)	1 slip in 10 hours
End-to-end	1 slip in 5 hours

Normal frequency deviation from a #4 ESS is no more than 3.5 parts in 10^9, but under limited trouble conditions, slip rates can exceed 1 slip in 10 hours. Under extreme trouble conditions, slip rates should not exceed 255 slips per day.

Another problem is the closed loop, a condition that causes instability in the synchronizing frequency. Extensive planning, and management controls of the synchronizing clocks and their distribution channels, are necessary if closed loops are to be avoided. As the telephone network is integrated more closely with digital signals of office systems, data, and word processing, engineers will be challenged to develop effective and efficient synchronizing methods.

The Service Company, through its work at the several missile test ranges, has extensive experience in the generation and distribution of snychronization frequencies. This work involves video, telemetry, data transmission and switching systems, and telephone systems. This experience will enable us to continue to participate actively in the digital evolution of telephone and telecommunications systems.

John Bakas is Manager, Technical Planning and Support, Telephone Systems Services Support. He joined RCA Government Services in 1959 as a telephone systems engineer. After assignments to several test range projects and the Air Force's Datacom project, he joined Consumer Services, Telephone Systems, in 1971. He has wide experience in telephone transmission, traffic, and switching systems engineering. His present responsibilities are: assisting in evaluation of products for use in Telephone Systems' interconnect business and helping with the resolution of problems with the operating telephone companies.

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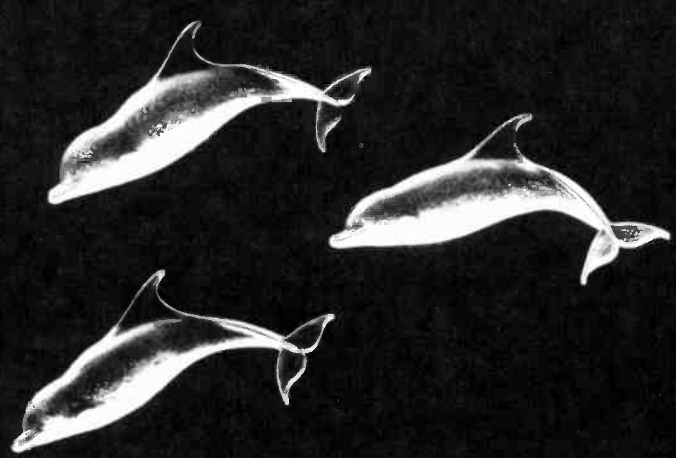
J.W. Mirsch

Acrylic Sculpture

A Precise Craft

The precision and discipline required in research work are assets transferred off-the-job by this hobbyist who creates unusual art objects.



In 1974, while browsing in a gift shop at the New Jersey seashore resort of Beach Haven, I was attracted to a small plastic block which contained a three-dimensional form of a flying sea gull. The form had been either carved or sandblasted into the block. This first contact with

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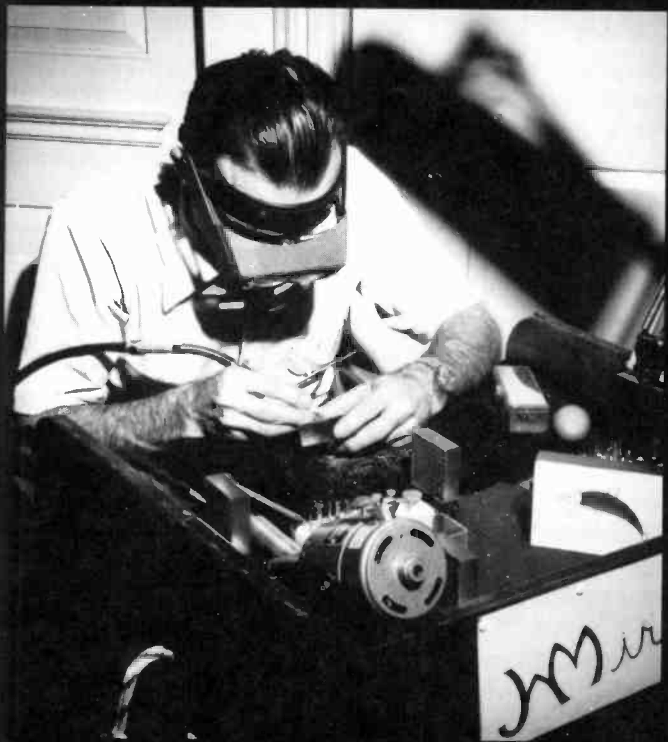

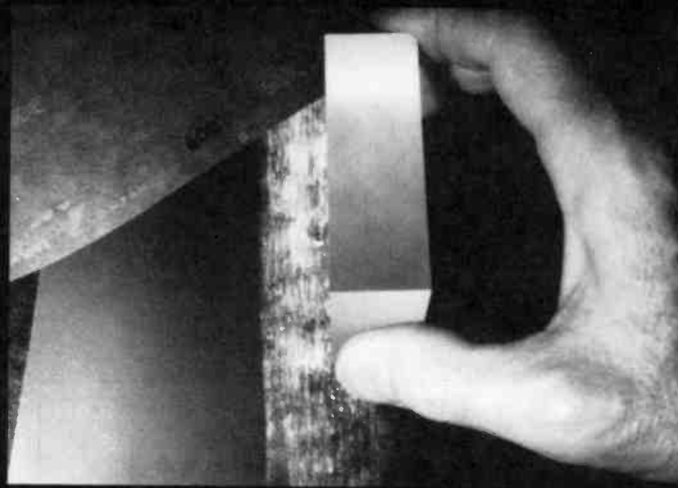

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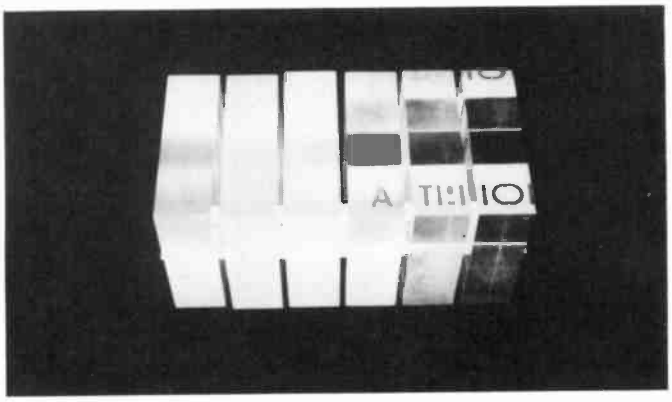
acrylic sculpture aroused my curiosity and started me on a hobby that has been rewarding financially as well as artistically.

My job at RCA Laboratories involves research in electro-optics and calls for precise, detailed work, characteristics that were a plus in my new pursuit. However, I was not an artist, nor did I draw or paint as a hobby. But, I did have training in mechanical drawing and dealt with perspectives, isometrics, tracings, and scalings in my work, which also made it easier for me to get into my hobby.



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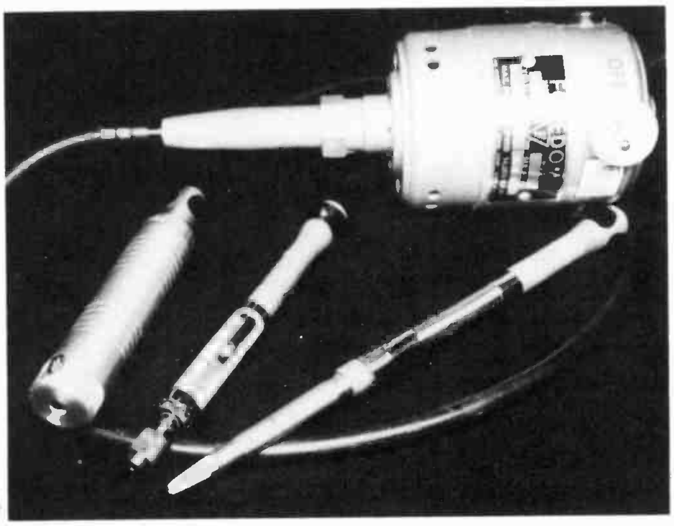

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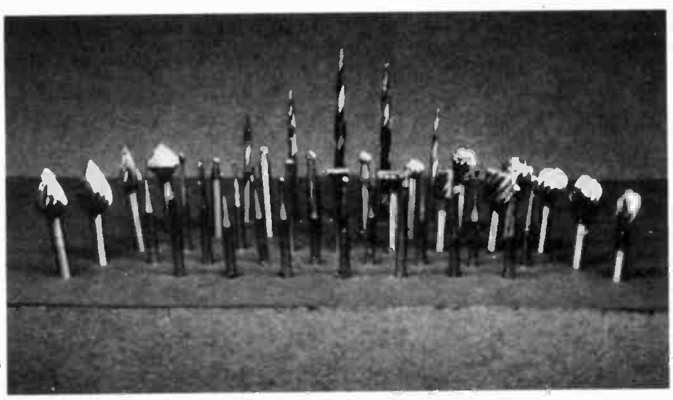

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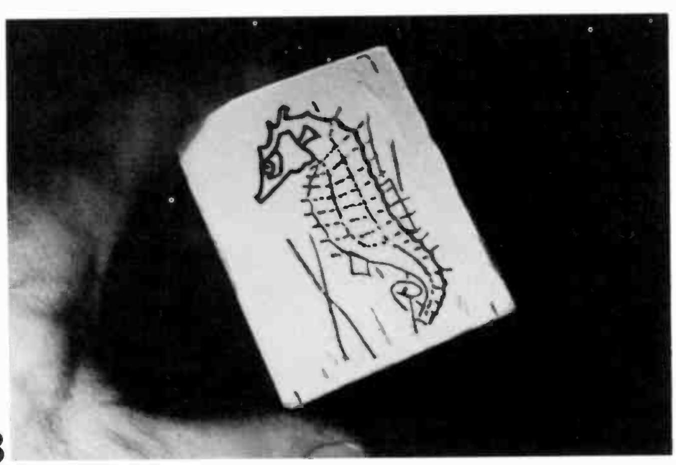

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Acrylic material

Acrylic is a group of glass-like thermoplastic resins made by polymerizing esters of acrylic acid or methacrylic acid. Sheets of acrylic are manufactured by Dupont, Rohm and Haas, and American Cyanamid under the trade names of Lucite, Plexiglas, and Acrylite, respectively. Acrylic sheets range in size from 1/16-inch to several inches thick. Many dealers will cut pieces to size. A block 12- by 12- by 1-inch (selling for approximately $10) can be cut into many smaller blocks, so the material cost is low.

Selecting a design

Because I had no formal art training, it was a challenge to create acrylic sculptures that would appeal to others. Most important, I had to find out just what subjects would lend themselves to deep carving in a block of clear acrylic. In the beginning I tried designs that were primarily flat, such as a seahorse, praying hands, and sea gulls, to name a few. I traced pictures or copied them from magazines, greeting cards and encyclopedias. I scaled these sketches to a size that would fit an acrylic block about 5- by 3- by 3/4-inches. I chose this size because of the size of cutters available for use in my miniature power tool. As time passed, I purchased smaller cutters and thus was able to carve smaller blocks.

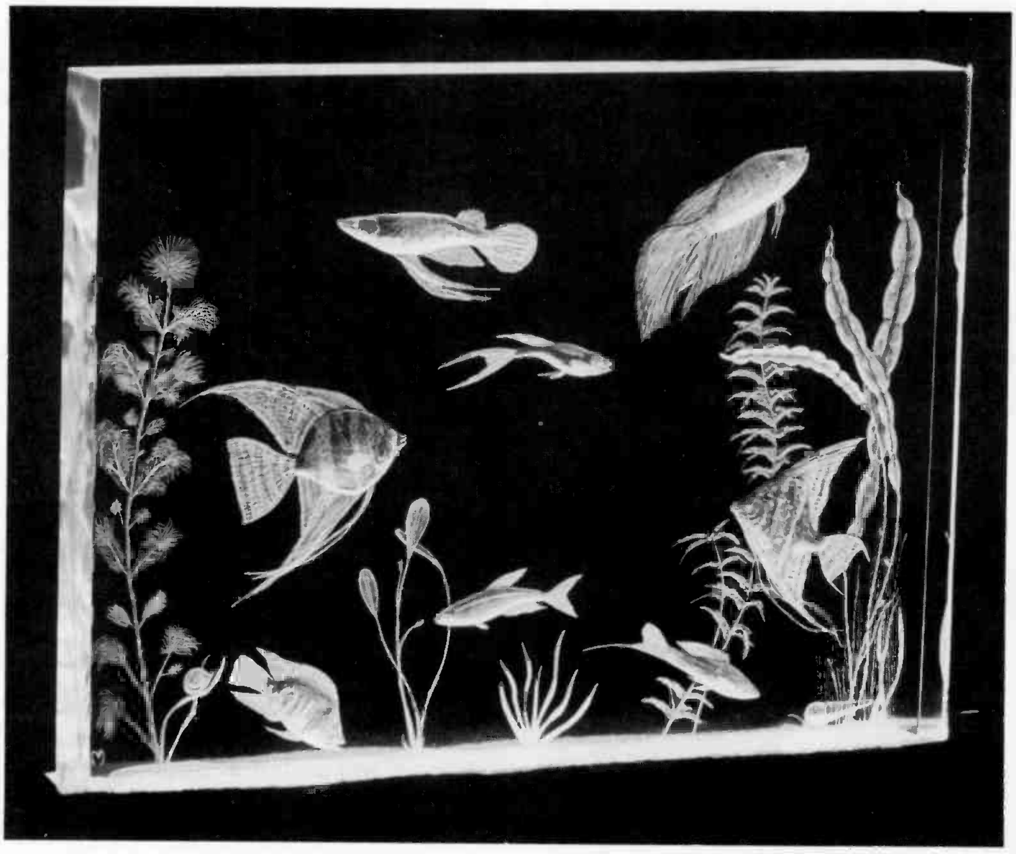
After a sketch is completed, a copy is made, then glued to the surface of the block with rubber cement. The sketch is minimal in detail and concentrates on the outline of the object to be carved. All the items are carved three dimensional. With this type of carving, the complete shape of the subject has to be known. Reference books come into play at this time.

Polishing acrylic

I decided, at the start, that my finished products would have polished edges, giving them a glass-like finish. Polishing acrylic is similar to achieving a fine surface on wood or metal. One starts with a coarse abrasive and graduates in steps to finer abrasives to end up with the polished surface.

Small quantities of various sizes of grits can be purchased at the local hardware store or supermarket. I tested commercial polishing and cleaning compounds until I found a suitable combination of products for polishing an acrylic block from a milled surface to a glass-like finish. These products include: silicon carbide paper, wet or dry, in three different grit sizes; Bon Ami Deluxe Polishing Cleanser; Noxon Metal Polish; and Gorham Silver Polish.

Figures 1, 2, 3, and 4 show the use of polishing compounds. Notice that, as the grit gets firmer, the edges take on a transparent appearance. Figure 5 is a



side-by-side comparison of all six steps, from the milled surface to silver polish. A lettered strip is under the six blocks, but only the last three blocks show the letters with some clarity. The higher contrast letters showing through the finished block indicate the block has little or no haze or surface scratches.

I polish the blocks by gently stroking them lengthwise against the abrasive. Each phase of the polishing is continued until all previous grit marks have been removed. Before going to the next finer grit, I make one or two passes with a diagonal motion. This puts cross lines in the block and makes those lines easier to distinguish in the next phase of polishing. Each step is repeated until all the scratch lines have been removed.

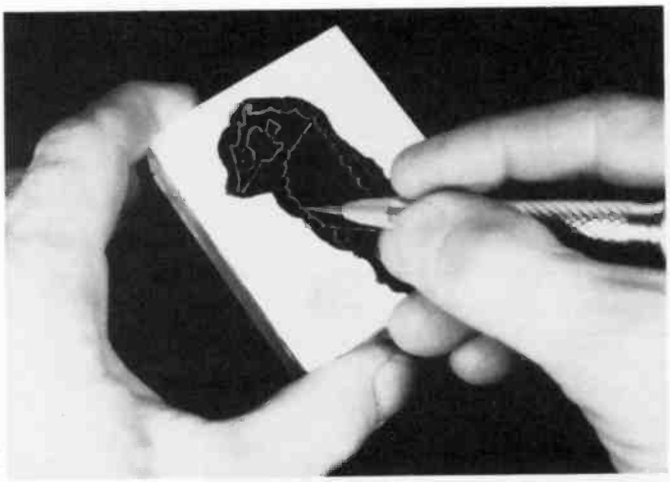
The silicon carbide paper is used with water to prevent clogging the paper with the fine powders removed from the acrylic. Any material (cloth or paper) that is less abrasive than the grit size may be used as a substrate when applying the powdered or liquid polishing compounds. If I am in doubt, I rub the surface of the acrylic block with the material in question, and I look for any marks the surface may have picked up from the friction. Then I try to calibrate the marks I find with one of the polishing compounds. The trick is to use nothing that will put in scratches coarser than the ones being polished out. After each phase of polishing, the blocks are washed in warm water and inspected. The final washing is done with a good window cleaner and a soft paper towel. It takes about one hour to complete the polishing on a 4- by 3- by 1-inch block.

Most of the blocks are given a prepolish before actual carving begins (this polishing usually includes the "Noxon step"). The prepolishing gives the carver a better sense of depth and symmetry when cutting into the block. Since the block is highly polished on all sides, the carved object must be perfect from all viewing angles. (The glass-like finish and deep carving produce an illusion of fullness and perspective; the subject is enhanced from all viewing angles.)

Carving tools

The basic tool for use in carving is a miniature power tool, preferably one that has a remote drive. This tool is coupled to a motor with a flexible shaft. There are several good tools on the market today: Foredom Electric Company's "Foredom tool" is used by many craftsmen. Dremel has recently introduced its version of a flexible shaft drive tool. Foredom, as well as Dremel, have a large variety of cutters and burrs. Figure 6 shows the basic motor tool sold by Foredom, the Model CC. The hand pieces, from left to right, are Foredom No. 30, 8, and 7D.

The miniature power tool can be varied in speed by three types of foot controls; wire wound, carbon pile, and solid state. The solid state control will deliver smooth power at slow speed. Most universal motors



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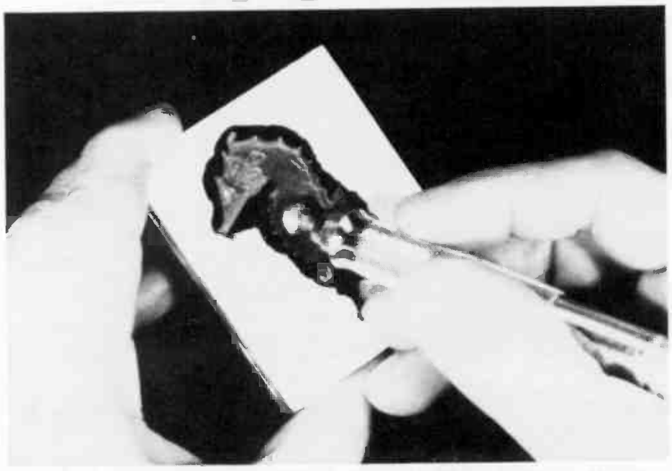

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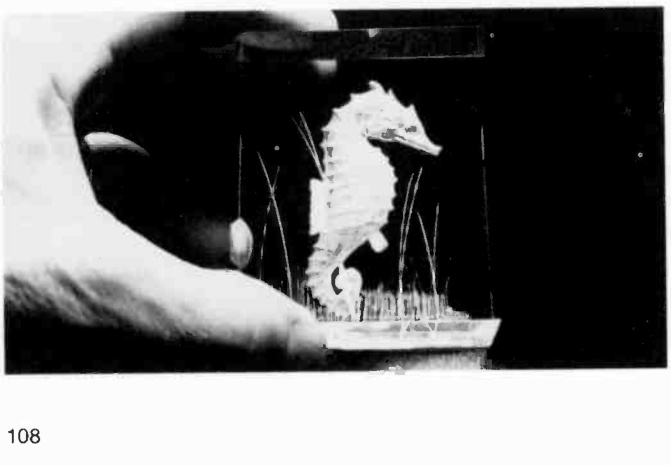

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can be used with a solid state control, and it is the one recommended. The other two controls are suitable, but not ideal for smooth speed control.

Figure 7 shows a few of the many cutters, burrs, and drills in my carving collection. Some have 1/8-inch shanks, others 3/32-inch, and others are as small as 1/64-inch. The No. 30 hand piece has a O-type Jacobs' chuck with a capacity of 5/32-inch. The No. 8 hand piece uses four collets which cover the range from 0.013-inch to 0.125-inch. The No. 7D hand piece will only accept 3/32-inch shanks.

The No. 30 hand piece is primarily used for heavy cutting, although for two years I used this for all my carving. Now I use the No. 8 for medium-depth carving and general use (it is used for about 60 percent of the carving). The 7D is used for fine detail where the cutters have to rotate on dead center. It is by far the best hand piece for this application.

I have also fashioned cutting tools from nails, drill rods, or anything that can be placed in the chuck of the hand piece and will make a mark in acrylic. Because acrylic blocks are not hard as metal, the cutters last a long time before wearing.

Speed, as mentioned before, is very important. Acrylic will soften at about 180°C. Too fast a speed when carving can generate enough heat to create heat strains in the acrylic blocks. These heat strains become visible as optical distortions within the block and destroy the beauty of the work. Although a slower speed takes longer, it gives a feeling of control comparable to that which the artist gets with a brush.

Carving procedure

Acrylic carving is deep intaglio (incise), as opposed to carving in relief, and done from the outside of the block inward and from the inside of the subject outward. One of the points to remember is that things are just the opposite from carving in wood or sculpturing in clay. The part of the subject that protrudes the most is carved the deepest.

A novice carver should start with a simple object and glue the paper pattern on the carving side of the block, as shown in Fig. 8. Also, the block should be prepolished to aid in proper depth and shape control.

I hold the block firmly in my hand and with a small burr inserted in the hand piece of the power tool, cut the periphery of the object through the paper into the acrylic block. This transfers the pattern to the block. I use a protective pad, such as felt, on the work table.

Figure 9 shows the result of this peripheral carving as well as some level of detail in the head region of the sea horse. After carving the outline, I use the largest cutter possible to contour the shape and depth to the desired amount. Then, I visually slice the subject in half and attempt to carve the cavity so half of the object will drop into the carved hole. While carving, I take time to look at all views through the prepolished

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edges of the block. The rough cut shape and depth is shown in Fig. 10 from the carver's view. The cutter being used is a large balled burr.

Figure 11 is a front view at the same stage of carving. The body is complete, and all that is required is putting in the boney structure and the grass reeds. I carved these with a small circular saw. The small reed that the tail of the sea horse wraps around is made with a small drill bit. The final result is shown in Fig. 12.

I use tool marks to create a texture that brings an otherwise bland carving to final completion with the distinct touch of the artist/craftsman. Many factors determine tool marks: the speed of the rotating cutter, how tight the hand piece is held, the way the tool is moved, and the cutting tool itself. There are no set rules that can be put on paper because each mark is the result of trial and error and the results are retained in the memory bank of the carver.

However, in general, I use the slowest speed possible to attain the best results. Speed will vary from 200 r/min. to about 600 r/min. For final touches, I use a slow speed in conjunction with a feather touch.

The time required to carve an object varies according to the size of the block and the complexity of the subject and can run between 5 and 45 hours. One rule I adhere to is that I never carve an object so small that I have to leave out detail. The smallest size block that I have carved was 0.38- by 0.38- by 0.125-inch. These were "doll house miniatures," made for adult-type doll houses.

The final product

Each carving is an individual work of art and no two are alike. The combination of the deep incise carving and the glass-like finish produce an illusion of the carved object being in the middle of the block. The crystal clear edges permit each piece to be viewed from all sides.

After "signing off" a piece, the completed carving is then taken through the final polishing steps necessary to bring it to a high luster. Information regarding the piece, such as size, subject, and date completed is filed away. Finally, I take a photograph and insert it in my portfolio.

As of December 1980, I have created 400 pieces. More than 300 of these were sold. Fifty were given as gifts. At arts and crafts shows, I have won four first-place ribbons, one second-place, and an honorable mention. In all, acrylic carving has been personally satisfying as well as rewarding.

Patents

Commercial Communications Systems

Breithaupt, D.W.
Remote control TV subcarrier phase shifter system—4266197

Unetich, R.M.|Shibler, W.
Regulated filament supply for high-power tubes—4267487

Waller, L.E.|Zorbalas, G.S.
Dual standard color framer—4261008

Consumer Electronics

Deiss, M.S.
Search type tuning system—4264977

George, J.B.
RFI shield for an IR input circuit—4262365

Sakarya, D.|George, J.B.
Regulator arrangement useful in an infrared remote control transmitter—4264896

Sakarya, D.
Drive circuit for an infrared remote control transmitter—4264982

Thornberry, G.E.
Radio frequency interference suppression apparatus—4267528

Willis, D.H.
Color television degaussing circuit—4262232

Government Communications Systems

Compton, B.L.|Pierson, P.B.
Optical scanner with variable scan line angle—4265524

Daniel, J.W., Jr.
Phaselocked receiver with orderwire channel—4270221

Government Systems Division

Hunka, G.W.
Signal detection system—4263555

Laboratories

Abbott, L.
Cancelling cross modulation in two color TV signals passed through non-linear path—4264919

Aschwanden, F.
Automatic deviation limit control circuit for SECAM encoders—4263609

Aschwanden, F.
Automatic chroma gain control circuits useful in SECAM coders—4264918

Astle, B.
Amplitude limiter with automatic duty cycle control for use in a phase-locked loop—4263565

Astle, B.
Voltage controlled oscillator—4263567

Ban, V.S.
Radiation heated reactor for chemical vapor deposition on substrates—4263872

Bell, A.E.
Information record—4270132

Bleazey, J.C.
Track skipper for video disc player—4262174

Datta, P.|Desai, N.V.
Method for the manufacture of multi-color microlithographic displays—4263386

Deckert, C.A.|Schnable, G.L.
Silicon nitride and silicon oxide etchant—4269654

Fitzke, E.V.|Wenner, D.B.|Polak, M.J.
Temperature insensitive filter for kinescope envelopes—4269616

Gibson, W.G.|Liu, F.C.|Muterspaugh, M.W.
Television signal processing system—4263611

Gibson, W.G.|Thompson, R.D.
Comb filter equalization circuit—4263612

Goodman, L.A.
Method for manufacturing a self-aligned contact in a grooved semiconductor surface—4268537

Ham, W.E.
Semiconductor-on-insulator device and method for its manufacture—4262299

Hinn, W.
Burst insertion apparatus for SECAM/PAL transcoder—4263608

Hinn, W.
Automatic kinescope biasing system—4263622

Ipri, A.C.|Flatley, D.W.
Method of making radiation resistant MOS transistor—4259779

Ipri, A.C.
Method of manufacturing short channel MOS devices—4263057

Ladany, I.
Etching of optical fibers—4265699

Levine, P.H.
CCD gain control—4262217

Olsen, G.H.|Cafiero, A.V.
Single-crystal hexaborides and method of preparation—4260525

Pampalone, T.R.|Gavalchin, E.J.
Positive resist medium and method of employing same—4262073

Pampalone, T.R.|Desai, N.V.|Poliniak, E.S.
Positive resist for electron beam and x-ray lithography and method of using same—4262083

Pampalone, T.R.
Method for the manufacture of multi-color microlithographic displays—4263385

Poliniak, E.S.|Desai, N.V.
Method for forming a shallow surface relief pattern in a poly (olefin sulfone) layer—4267257

Reichert, W.F.
Method of making a Schottky barrier field effect transistor—4266333

Schiff, L.N.
System for limiting intermodulation distortion of talkspurt signals—4262355

Siekanowicz, W.W.|Fields, J.R.
Modulator with variable launch conditions for multi-electron gun display devices—4263529

Siekanowicz, W.W.
Electron current collector for flat panel display devices—4266159

Theriault, G.E.
Double trapping of adjacent channel sound—4263619

Wang, C.C.|Bates, R.F.
Method of depositing an abrasive layer—4260647

Warren, H.R.
Headwheel servo lock verification with stationary head—4263625

Weisbecker, J.A.
Display system—4270125

Weitzel, C.E.|Scott, J.H., Jr.
Planar semiconductor devices and method of making the same—4263709

Wendt, F.S.
High frequency ferroresonant transformer—4262245

Wine, C.M.
Touch switch arrangement useful in a television receiver—4263618

Missile and Surface Radar

Schwarzmann, A.
Phase equalizer in microwave transmission line—4270104

Picture Tube Division

Branton, T.W.
Electron beam influencing apparatus—4261017

Vanrenssen, M.|Wardell, M.H., Jr.
Kinescope screen center locator—4261013

RCA Records

Chang, B.J.
Article transfer apparatus—4264254

SelectaVision® VideoDisc Operations

Burrus, T.W.
Stylus lifting/lowering actuator with improved electromagnetic motor—4266785

Nyman, F.R.|Smith, T.E.
Information record stampers—4262875

Torrington, L.A.
Video disc caddy having disc entrapment—4266784

Solid State Division

Ahmed, A.A.
Regulated current source circuits—4260945

Ahmed, A.A.
Current amplifier with regenerative latch switch—4260955

Ahmed, A.A.
Relaxation oscillator having switched current source—4270101

Balaban, A.R.|Steckler, S.A.
Differential amplifier current repeater—4266245

Dingwall, A.G.
Voltage Comparator—4262221

Edwards, T.W.|Pennypacker, R.S.
Manufacture of thinned substrate imagers—4266334

Grilletto, C.|Vowinkel, F.C.
Measurement of a gas constituent by a mass spectrometer—4260886

Hammersand, F.G.
Magnetron filament assembly—4264843

Harford, J.R.
Temperature compensating bias circuit—4260956

Isham, R.H.|Petrizio, C.J.
Oscillator circuit—4260960

Jindra, C.P.|Atherton, J.H.
Small signal memory system with reference signal—4270190

Miller, L.D.|Peterson, F.W.
Pickup tube having mesh support electrode aligning means—4264841

Petrizio, C.J.|Isham, R.H.
Relaxation oscillator—4267527

Rodgers, R.L., III
Peak-response controller for average-responding automatic iris—4268866

Schade, O.H., Jr.
Differential amplifier circuit—30587

Schade, O.H., Jr.
Bandgap reference—4263519

Schade, O.H., Jr.
Operational transconductance amplifiers with non-linear component current amplifiers—4267519

Shanley, R.L., II|Harwood, L.A.
Wittmann, E.J.
Controlled output composite keying signal generator for a television receiver—4263610

Shwartzman, S.
Two step method of cleaning silicon wafers—4261791

Steckler, S.A.
Low distortion signal amplifier arrangement—30572

Wheatley, C.F., Jr.
Reference voltage circuit using nested diode means—4260946

Wu, C.T.
System for ascertaining magnetic field direction—4267640

Pen and Podium

Recent RCA technical papers and presentations

To obtain copies of papers, check your library or contact the author or his divisional Technical Publications Administrator (listed on back cover) for a reprint.

Astro-Electronics

J. Badura|R. Gounder|K. Tung
Analytical (FEM) Evaluation of Composite Communications Satellite Antenna Reflectors Dynamics—Mechanical Engineering Symposium, RCA Moorestown, N.J. (4/23/81)

L. Freedman
The Space Shuttle Closed Circuit TV System—NAECON Conference, Dayton, Ohio (5/81)

R. Gounder
Advanced Composites Applications in RCA Communications Satellites—26th National SAMPE Symposium & Exhibition, Los Angeles, Calif. (4/29/81)

D. Hogan|A. Rosenberg
Simultaneous Lidar Measurement of Temperature & Humidity Profiles: Error Analysis—1981 Inter'l Geoscience and Remote Sensing Symposium, Washington, D.C. (6/9/81)

J. Keigler
Development of Satellite Systems for Domestic Communications—Kuwait Foundation for Advancement of Sciences, Safat, Kuwait (4/4/81)

R. Mathwich|D. Aubert|A. Martz
B. Reinisch|K. Bibl - Univ. Lowell
Lt. D. Lewis - USAF
An Advanced Mission to Map the Worldwide Topside Ionosphere—Effect of Ionosphere Symposium, Alexandria, Va. (4/16/81)

J. McClanahan
Multiple Application of GenRad 2500 Series FET Analysis System—Measurement & Control Seminar, Newark, N.J. (4/14/81)

A. Schnapf
The 1981 RCA Space Constellation—18th Space Congress, Cocoa Beach, Fla. (4/30/81)

Automated Systems

R.C. Guyer
The GVS-5: A Versatile Handheld Laser Rangefinder for Tactical Use—ASME Student Chapter, Northeastern Univ., Boston, Mass. (5/21/81)

Broadcast Systems

L.V. Hedlund
The New RCA One-inch Type C Helical VTR—Presented by J.R. West at the 1981 Montreux Exhibition in Montreux, Switzerland (6/1/81)

Government Communications Systems

S.P. Clurman
A Simple Tape Wrap Around A Guide: Some Complexities—IEEE Intermag 81 Conf., Grenoble, France, *Transactions* (9/81)

N.A. Macina
Maximum Entropy Modeling and Identification and Defection of Certain Classes of Dynamic Events—*RCA Review*

J.B. Sergi, Jr.
The Buffer Matrix for Dynamic Channel Allocation—Univ. of Pennsylvania, *Thesis* (5/81)

D.B. Wolfe
Natural Frequencies and Mode Shapes of Multi-Degrees of Freedom Systems on a Programmable Calculator—Nat. Noise & Vibration Control Conf. & Exhibition, Chicago, Ill., *Proceedings* (4/6/81

Laboratories

R.A. Bartolini
Media for high density optical recording—*Journal Vac. Sci. Technol.*, Vol. 18, No. 1 (1-2/81)

D. Botez|J.C. Connolly
Single-mode positive-index guided cw constricted double-heterojunction large-optical-cavity AlGaAs lasers with low threshold-current temperature sensitivity—*App. Phys. Lett.*, Vol. 38, No. 9 (5/1/81)

K.G. Hernquist
Studies of Flashovers and Preventive Measures for Kinescope—*IEEE Transactions on Consumer Electronics*, Vol. 27, No. 2, pp. 117-128 (5/81)

L. Jastrzebski, P.A. Levine
W.A. Fisher*|A.D. Cope
E.D. Savoye**|W.N. Henry**
Cosmetic Defects in CCD Imagers—*Journal Electrochem. Soc.*, Solid State Science and Technology (4/81)
*Electrochemical Society Active Member
**RCA Opto-Electronics Division, Lancaster, Pa.

W. Kern
Lecture Course on Chemical Vapor Deposition—American Vacuum Society, Arlington, Va. (5/81)

G.H. Olsen
InGaAsP Laser Diodes—*Optical Engineering*, Vol. 20, No. 3 (5-6/81)

L.S. Onyshkevych
Porcelain-Enameled Steel Substrates for Electronic Applications—*Appliance* (4/81)

A.N. Prabhu|K.W. Hang
E.J. Conlon|T.T. Hitch
Base Metal Thick Film System for High Temperature Porcelain Coated Steel Substrates—ISHM Meeting, Edison, N.J. (4/30/81)

A.N. Prabhu|K.W. Hang
E.J. Conlon|T.T. Hitch
Properties of Base Metal Thick Film Materials on High Temperature Porcelain Coated Steel Substrates—Electronic Components Conference, Atlanta, Ga. (5/11-13/81)

A.N. Prabhu|K.W. Hang
E.J. Conlon|T.T. Hitch
Properties of Base Metal Thick Film Materials on High Temperature Porcelain Coated Steel Substrates—*Proceedings*, Electronics Component Conference, Atlanta, Ga. (5/11-13/81)

G.L. Schnable|R.B. Comizzoli
CMOS Integrated Circuit Reliability—*Microelectron Reliab.*, Vol. 21, No. 1, pp. 33-50, Printed in Great Britain (1981)

P.G. Stein (and Howard Shapiro)
The Joy of Minis and Micros—Hayden Books (1981)

T. Takahashi, O. Yamada
Cathodoluminescence of Terbium Activated Metaphosphate Glasses—*Japanese Journal of Appl. Phys.*, Vol. 20, No. 5 (5/81)

R. Williams|J. Blanc
Inhibition of Water Condensation by a Soluble Salt Nucleus—*Jour. Chem. Phys.*, Vol. 74, No. 8 (4/15/81)

Missile and Surface Radar

E.M. Allen|W. Sherry
Long Range Imaging Radar: Near Real-Time Radar Imaging—27th Annual Tri-Service Radar Symposium, Naval Post Graduate School, Monterey, Calif., Symposium *Record* (6/81)

J.A. Bauer
Application of Computer Graphics for Electronic Products—National Computer Graphics Conf., Baltimore, Md. (6/81)

J.A. Bauer
Chip Carrier Technology—Workshop Panel and Presentation International Electronic Packaging Society, New York, N.Y. (6/81)

J.A. Bauer
Meeting Chip Carrier Packaging Goals—IEEE Computer Packaging Workshop, Monterey, Calif. (5/81)

F.J. Buckley
A Standard for Software Quality Assurance Plans—A Status Report—First International Conference on Computers in Civil Engineering, New York, N.Y., Conference *Proceedings* (5/81)

P.J. Buckley
Software Quality Assurance—IEEE Software Quality Assurance Course, Three-day Continuing Education Seminar, Williamsburg, Va. (5/81)

F.J. Buckley
The Application of Distributed Computers to a Real-Time System—New Jersey Institute of Technology, Newark, N.J. (4/81)

M.W. Buckley, Jr.
Project Management—Univ. of South Alabama, Mobile, Ala. (4/81); Shamrock Hilton, Houston, Texas (5/81)

C.L. Christianson
Next Generation Fire Control Modular Evolution—AIAA New Directions in Technology—Sensor Systems Conference, Washington, D.C., and Boston, Mass. (6/81)

W.V. Goodwin
Industry's Role in the Defense Acquisition Process—AEGIS, a Case Study—MBA Graduating Class, Monmouth College, Ft. Dix, N.J. (5/81)

D.R. Higgs
Reports and Proposals—Planning, Organizing, and Doing—Technical Writers Institute, Rensselaer Polytechnic Institute, Troy, N.Y. (6/81)

C.J. Hughes|T. Murakami|R.S. Johnson
Advanced AEGIS Signal Processor—27th Annual Tri-Service Radar Symposium, Naval Post Graduate School, Monterey, Calif. (6/81)

H.D. Lewis
Using Phased Array Radar for Communications—IEEE NAECON Conference, Dayton, Ohio, Conference *Proceedings* (5/81)

J.M. Lucash
Government Expectations and Contractor

Fulfillment of the Intent and Application of MIL-Q-9858A—U.S. Navy Atlantic Undersea Test and Evaluation Center (AUTEC), Andros Is., Bahamas (4/81)

F.E. Oliveto
Software Reliability—IEEE Twelfth Annual Reliability Symposium, Valley Forge Sheraton, King of Prussia, Pa. (4/81)

J.W. Parnell
Preparing for Your Career in Engineering—RCA-MSR Minorities in Engineering Program, Moorestown, N.J. (5/81)

R.L. Schelhorn
Thin Film and Thick Film Fabrication Techniques—Hybrid Technology Lecture, Drexel University, Phila., Pa. (5/81)

Schelhorn, R.L.
Thick Film Copper for Microwave Circuit Applications—Eleventh Annual Symposium on Hybrid Microelectronics, Baltimore, Md., Symposium *Proceedings* (4/81)

D.P. Schnorr
Printed Wiring—The History of a Technology—Printed Circuit World Convention, Munich, West Germany, published in *Proceedings of the Printed Circuit World Convention II*, Vol. 1, pp. 6-14 (6/81)

S.A. Steele
Panel Moderator, "Technology Graduates in Industry," Panelist, "Computer Knowledge Requirements for Industry", ASEE Annual National Conference, Los Angeles, Calif. (6/81)

S.A. Steele presenting for
T.A. Martin
Software Configuration Management and Quality Assurance for Operational Computer Programs in the 1980s—AIAA Conference on Software Operational Support in the 1980s, Washington, D.C. (5/81)

E.J. Stevens
A History of ARFTG—ARFTG/MTTS/APS Symposium, Los Angeles, Calif. (6/81)

H. Urkowitz|N.A. Ricciardi
Classification Experiments with Upgraded BMEWS Radars—*Journal of Defense Research*, Vol. 13, No. 1, pp. 60-89 (Spring 81)

L.H. Yorinks
Rectangular Coaxial Line Split-T Power Dividers—1981 IEEE/MTT-S International Microwave Symposium, Los Angeles, Calif. Summary published in *Proceedings* (6/81)

RCA Ltd.

A. Lightstone|R.J. McIntyre|P.P. Wegg
Electron Traps in Silicon Avalanche Photodiodes—Spring Meeting, Ontario, Quebec Section, Electro-Chemical Society, Concordia Univ., Montreal (4/24/81)

SelectaVision® VideoDisc Operations

W.M. Workman
The VideoDisc Player—Electro 81, Sheraton Centre Hotel, Indianapolis, Ind. (4/8/81)

Engineering News and Highlights

Bogantz is *RCA Engineer* TPA

Gregory A. Bogantz is Technical Publications Administrator (TPA) and Technical Program Coordinator of the Record Division. He received his BSEE and MSEE degrees from Purdue University in 1969 and 1970. He worked as service manager of Production Audio Service in Lafayette, Indiana, until he joined RCA Record Record Engineering, Indianapolis, Indiana, in 1973. There, he has specialized in disc recording technology including cutting, processing, and playback.

His prior work includes the development of the RCA Quadulator, a compact encoding system for the mastering of CD-4 records, a combination broadband gain leveling and 3-band peak limiting system for the recording of duplicating master tapes, and a chart-recording automatic test system for impulse-noise testing of phonograph records. His current work includes the design of computer-aided automatic test systems for trouble-shooting complex automated machinery.

He has contributed to the work of the Electronic Industries Association panel P8.2; is a member of the AES Digital Audio Technical Committee, and is a fellow of the Audio Engineering Society.

He has read papers for Audio Engineering Society conventions on several occasions and has addressed the Midwest Acoustics Conference on the topic of digital audio.

Contact him at:
RCA Records
Indianapolis, Ind.
TACNET: 424-6141

Staff Announcements

Commercial Communications Systems

James Vollmer, Group Vice-President, Commercial Communications Systems Division, announces the appointment of **J. Edgar Hill** as Staff Vice-President, Market Planning; and **Joseph B. Howe** as Division Vice-President and General Manager, Commercial Communications Systems Division.

Joseph B. Howe, Division Vice-President and General Manager, Commercial Communications Systems Division, announces the organization of the Commercial Communications Systems Division as follows: **Stanley E. Basara,** Division Vice-President, Video Systems; **Joseph C. Volpe,** Division Vice-President, Transmission Systems; **William L. Firestone,** Division Vice-President and General Manager, Cablevision Systems; **Robert B. Alleger, Jr.,** Division Vice-President, Finance; **Jack E. Banister,** Division Vice-President, Marketing; **Arthur J. Barrett,** Division Vice-President, Manufacturing; **Francis X. Carroll,** Division Vice-President, Special Studies and Analysis; **Arch C. Luther,** Division Vice-President, Engineering and Product Assurance; **C. Robert Montgomery,** Division Vice-President, Industrial Relations; and **Albert V. Pescatore,** Division Vice-President, Business Planning.

Consumer Electronics

Bennie L. Borman, Director, Manufacturing Engineering and Technology, announces the organization of Manufacturing Engineering and Technology as follows: **Alfred Crager,** Manager, Test Technology;

John J. Drake, Manager, VideoDisc Player Manufacturing Technology; **Charles J. Limberg,** Manager, Manufacturing Technology Center; **Robert E. Fein,** Manager, Manufacturing Planning and Services; and **Robert R. Russo,** Manager, Process Development.

James E. Carnes, Manager, Television Advanced Development, announces the appointment of **James L. Newsome** as Manager, Technology Applications.

Gary A. Gerhold, Manager, Cartridge Manufacturing Operations, announces the organization of Cartridge Manufacturing Operations as follows: **Alfred P. Bowles,** Manager, Production Scheduling and Material Control; **David W. Keller,** Manager, Quality; **George A. Kim,** Manager, Advanced Technology Development; **Dennis R. McCarthy,** Manager, Manufacturing Engineering; and **Lyndon T. Shearer,** Manager, Manufacturing and Test.

J. Peter Bingham, Division Vice-President, Engineering, announces that **Willard M. Workman,** Director, VideoDisc Player Engineering, will report to the Division Vice-President, Engineering.

John J. Drake, Manager, VideoDisc Player Manufacturing Technology, announces that **Woodrow L. VonDielingen,** Manager, Player Technology Center, will report to the Manager, VideoDisc Player Manufacturing Technology.

D. Joseph Donahue, Acting Director, Special Products, announces that **Gary A. Gerhold,** Manager, Cartridge Manufacturing Operations, will report to the Director, Special Products.

James R. Smith, Director, Product Assurance, announces that **Francis T. Scearce,** Manager, VideoDisc Player Product Assurance, will report to the Director, Product Assurance.

Leonard J. Schneider, Division Vice-President, Manufacturing, announces that **James J. McDowell,** Manager, VideoDisc Player Manufacturing Operations, will report to the Division Vice-President, Manufacturing.

Government Systems Division

Paul E. Wright, Division Vice-President and General Manager, Government Systems Division, announces the qppointment of **Lawrence J. Schipper** as Division Vice-President and General Manager, Government Communications Systems.

William V. Goodwin, Division Vice-President and General Manager, Missile and Surface Radar, announces the appointment of **Joseph T. Threston** as Division Vice-President, Naval Systems Department.

Laboratories

Alfred H. Teger, Staff Vice-President for Systems Research at RCA Laboratories in Princeton, N.J. announces the appointment of **Arthur Kaiman** as Director, Advanced Systems Research Laboratory.

Carmen A. Catanese, Director, Picture Tube Systems, Research Laboratory, announces the organization of the Picture Tube Systems Research Laboratory as follows: **David L. Staebler,** is appointed Head, Kinescope Systems Research; **Frans VanHekken,** continues as Head, Electron Guns (TTL, Lancaster); **Peter J. Wojtowicz,** continues as Head, Electron Optics & Deflection Research; and **William H. Barkow** continues as Fellow, Technical Staff.

Robert D. Lohman, Director, Display Processing and Manufacturing Research Laboratory, announces the organization of the Display Processing and Manufacturing Research Laboratory as follows: **Thomas L. Credelle,** Head, Advanced Display Systems Research; **John J. Moscony,** Manager, Advanced Development, Masks (Lancaster); **Louis E. Potter,** Manager, Advanced Development, Manufacturing Technology (Lancaster); **P. Niel Yocom,** Head, Display Materials and Processes Research; **Karl G. Hernqvist,** Fellow, Technical Staff; and **Simon Larach,** Fellow, Technical Staff.

Fred Sterzer, Director, Microwave Technology Center, announces the organization of the Microwave Technology Center as follows: **Erwin F. Belohoubek,** Head, Microwave Circuits Technology; **Barry S. Perlman,** Manager, CAD and Testing; **Ho-Chung Huang,** Head, Microwave Process Technology; **S. Yegna Narayan,** Head, Microwave Device Technology; **Markus Nowogrodzki,** Head, Subsystems and Special Projects; and **Herbert J. Wolkstein,** Manager, Space and Countermeasure Programs.

RCA Communications, Inc.

Andrew F. Inglis, President, RCA Network Services, Inc., announces that responsibility for the Corporate Telecommunications activity is transferred to RCA Network Services, Inc., and the appointment of **David Mer** as Director, Corporate Telecommunications.

SelectaVision® VideoDisc Operations

Roy H. Pollack, Executive Vice-President, announces the appointment of **James M. Alic** as Vice-President, Electronic Services and VideoDisc Operations.

Roy H. Pollack, Executive Vice-President, announces the organization of The Electronic Services and VideoDisc Operations as follows: **Bruce G. Babcock,** Staff Vice-President, VideoDisc Business and Operations Planning; **Jay J. Brandinger,** Division Vice-President and General Manager, SelectaVision® VideoDisc Operations; and **George D. Prestwich,** President, RCA Service Company.

Jay J. Brandinger, Division Vice-President and General Manager, SelectaVision® VideoDisc Operations, announces the appointment of **James L. Miller** as Division Vice-President, Systems.

Solid State Division

Robert S. Pepper, Vice-President and General Manager, Solid State Division, announces the organization of Solid State Division as follows: **Erich Burlefinger,** Division Vice-President, Electro-Optics and Power Devices; **Larry J. French,** Division Vice-President, Solid State Technology Center; **Peter A. Friederich,** Division Vice-President, Industrial Relations; **Walter J. Glowczynski,** Division Vice-President, Finance; **Stephen L. Pletcher,** Division Vice-President, Marketing; and **Carm J. Santoro,** Division Vice-President, Integrated Circuits; and **Carl R. Turner,** Division Vice-President, Product Assurance and Planning.

Erich Burlefinger, Division Vice-President, Electro-Optics & Power Devices, announces the organization of Electro-Optics & Power Devices, Lancaster, as follows: **Charles W. Bizal,** Manager, Operations Support EOD - Lancaster; **William E. Bradley,** Manager, Quality & Reliability Assurance EOD - Lancaster; **Clarence H. Groah,** Administrator, EOD - Lancaster; **Leonard W. Grove,** Director, Conversion Tube; **Harold R. Krall,** Director, Solid State Systems Products; **Ronald G. Power,** Director, Solid State Emitters & Detectors - Montreal/Lancaster; **Carlton L. Rintz,** Director, Power Devices; and **Eugene D. Savoye,** Manager, CCD & Silicon Target.

Leonard W. Grove, Director, Conversion Tube, announces the organization of Conversion Tube as follows: **Scott I. Alexander,** Manager, Product Planning and Customer Services; **George S. Brody,** Manager, Conversion Tube Marketing and Applications Engineering; **William H. Hackman,** Manager, Conversion Tube Manufacturing; **Fred A. Helvy,** Manager, Conversion Tube Engineering; and **C. Price Smith,** Manager, Systems Planning.

Ronald G. Power, Director, Solid State Emitters & Detectors, Montreal/Lancaster, announces the organization of Solid State Emitters & Detectors - Montreal/Lancaster, as follows: **Hui-Cha Cook,** Administrator, Financial Services - Montreal; **Thomas Doyle,** Manager, Engineering & Manufacturing - Montreal; **Adrian Dumais,** Administrator, Quality Control & Inspection - Montreal; **Frederick Hughes,** Manager, Solid State Emitters Products - Lancaster; **Robert McIntyre,** Manager, Research & Development - Montreal; **Ronald Swarbrick,** Manager, Marketing; and **George Symeonides,** Manager, Materials & Services - Montreal.

Carlton L. Rintz, Director, Power Devices, Electro-Optics and Power Devices, announces the organization of Power Devices as follows: **Don R. Carter,** Manager; **Claude E. Doner,** Manager, Engineering; **Peter Harvest,** Manager, Fabrication and Processing; **Walter E. Kaufmann,** Manager, VCO Operations; **John G. Kindbom,** Manager, Large Power & Broadcast Manufacturing; **William S. Lynch,** Manager, Neutral Beam Source Project; **Herbert W. Sawyer,** Manager, Medium/Small Power and Pencil Tube Manufacturing; and **Joseph D. Schmitt,** Manager, Production Planning.

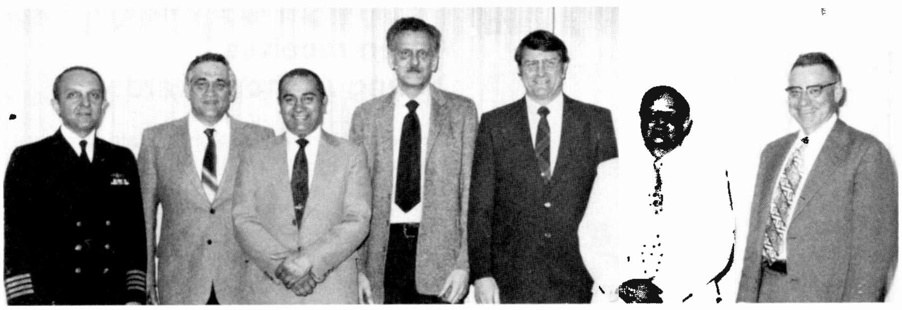
William E. Bradley, Manager, Quality & Reliability Assurance, E.O., Lancaster, announces the organization of Quality and Reliability Assurance as follows: **Gerald J. Buchko,** Manager, Power Devices Quality and Reliability Assurance; **Joseph J. Carroll,** Manager, Solid State Systems Products, Quality and Reliability Assurance; **Gary J. Giering,** Manager, Conversion Tube Quality and Reliability Assurance; and **James A. Molzahn,** Manager, Quality and Reliability Assurance Services.

Robert L. Rodgers III, Manager, CCVE Engineering, announces the appointment of **John L. Stevenson** as Manager, CCVE Mechanical Design.

Eugene D. Savoye, Manager, CCD & Silicon Target, announces the organization of CCD and Silicon Target as follows: **Thomas W. Edwards,** Manager, CCD & Silicon Target Engineering; **N. Richard Hangen,** Manager, CCD & Silicon Target Marketing and Applications; and **William N. Henry,** Manager, CCD & Silicon Target Manufacturing.

Professional Activities

AEGIS Excellence awards at Automated Systems



Left to right: Captain W. Szczypinski, R. Nohelty, S. Pascale, E. Leach, J. Barnes, K. Weydemann, Dr. H.J. Woll.

Five Automated Systems employees recently received Individual AEGIS Excellence Awards for their outstanding performance on the AEGIS program.

The AEGIS Weapon System is the nucleus of an advanced Navy combat system intended for installation in a new class of ships. The AEGIS Weapon System, integrated with other ship combat system elements, provides the Navy with a ship capable of air, surface, and underwater-warfare mission support.

RCA Automated Systems in Burlington, Massachusetts, builds the Operational Readiness Test System (ORTS), which detects, isolates and reports malfunctions of many combat system elements in the AEGIS ships. RCA Missile and Surface Radar in Moorestown, New Jersey, is the prime contractor for the AEGIS Weapons Systems.

Herb Groff, Manager of Program AEGIS-ORTS Operations, explained that the recipients of the awards "...have contributed to AEGIS-ORTS beyond expectations." Receiving the awards from **Captain Walter Szczypinski, Jr.,** CG-47 Class Cruiser Manager (PMS400D) in the AEGIS Shipbuilding Project, United States Navy, were:

- **Joseph S. Barnes,** Production Administrator for AEGIS, for successfully coordinating manufacturing, repair-parts, and materials activities.
- **Earl R. Leach,** Senior Project Member, Production Engineering Staff, for designing special test equipment and associated computer programs.
- **Richard A. Nohelty,** Technician Specialist, for technical support of AEGIS components at major subcontractor sites, as well as in-plant repair service.
- **Sal Pascale,** Senior Engineering Specialist for effectively monitoring, controlling, and reporting financial performance on the AEGIS-ORTS program.
- **Kurt Weydemann,** Senior Project Member, Production Engineering Staff, for his part in developing, adapting, and improving the special test equipment used in production testing of ORTS.

Enstrom chairs Electrochemical Society

Ronald E. Enstrom, Display Processing and Manufacturing Research Laboratory, has been elected to a two-year term as Chairman of the Electronics Division of the Electrochemical Society. The 2500-member Electronics Division sponsors Spring and Fall symposia on the growth, processing, technology and science of silicon and other materials for electronic device applications.

Vossen on AIP board

John L. Vossen, Head, Thin Film Technology, has been elected to a three-year term on the governing board of the American Institute of Physics.

Sigma Xi elects RCA men

Rabah Shahbender has been Secretary of the Princeton Chapter of Sigma Xi as of July 1979. As of July 1981, he will be Vice-President of the Chapter.

Richard (Dick) Klensch has been treasurer of the same Chapter since July 1979, and as of July 1, 1981, will be Secretary.

Olson awarded Gold Medal by Acoustical Society

Dr. Harry F. Olson, retired RCA Laboratories scientist, has been awarded the Gold Medal of the Acoustical Society of America for "his innovative and lasting contributions in acoustic transduction, sound reproduction, electronic music and speech synthesis, and his service to the Society." The award was announced at the Society's convention in Ottawa.

Degrees awarded

Danny Chin, Consumer Electronics Research Laboratory, and **Daniel R. Goldsmith,** VideoDisc Systems Research Laboratory, have received M.S. degrees in Electrical Engineering from Columbia University.

ATL honors authors, speakers, inventors

Fifty members of GSD Advanced Technology Laboratories were honored April 28 at a Reception for authors.

speakers, and inventors. The Reception, held in the RCA Lunch Club in Camden, was hosted by **Fred E. Shashoua,** Director, ATL, and attended by **James B. Feller,** Division Vice-President, Engineering, GSD; and **Paul E. Wright,** Division Vice-President and General Manager, GSD. This is the sixteenth annual ATL event to recognize those who have presented and/or published papers, and those who have filed and/or been granted patents.

Stein's book published

The Joy of Minis and Micros
by Philip Stein (RCA - Princeton) and Howard Shapiro, published by Hayden Books, 1981, is available from the author or at technical bookstores and computer stores nationwide. This is a book about small computer systems — how to use them in your application, how to decide whether you need one, what to buy if you do need one, and what is sure to "bite" you before you get it all working.

This is a technical book for technical people, but it is written in a free and readable style which makes absorbing the material inside very easy. Typical topics include:

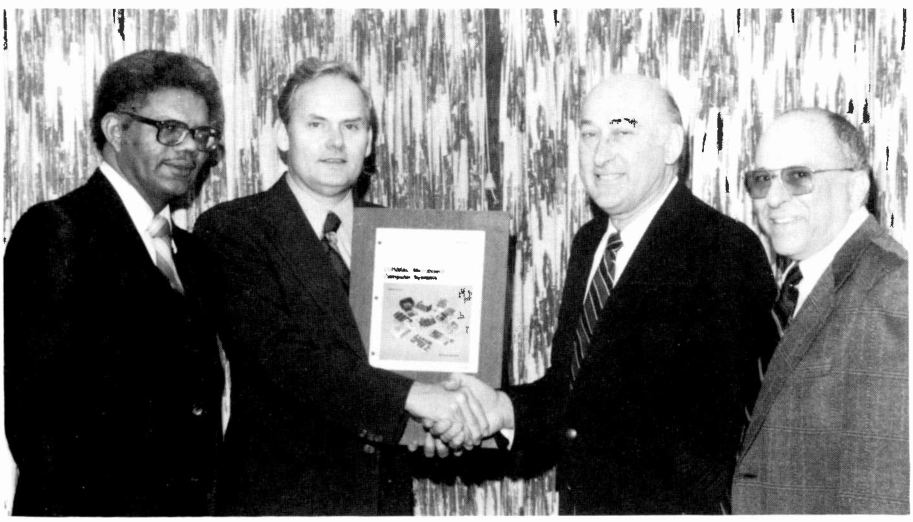
- BASIC, PASCAL, or what other language to use.
- How to pick the RIGHT mini or micro for my job.
- How much should I listen to vendors?
- My minicomputer is free.

The book is co-authored by Philip Stein, a member of the technical staff at the RCA Princeton Laboratories. He has also co-authored a basic text, *Computer Hardware and Software,* and *Interdisciplinary Introduction,* available from Addison-Wesley.

Furnstahl judges engineering display

On June 12 and 13, 1981, Northeastern University - Lincoln College, held their annual Creative Engineering Design Display. Mr. John S. Furnstahl, Automated Systems, Manager Project Management was one of 29 invited distinguished guest judges on the design display committee. All projects focused on design solutions for handicapped people. The five winning designs will represent Northeastern University at the American Society for Engineering Education display at the University of Southern California this summer.

RCA-SSD receives Gold Book "Literature Excellence" Award



Electronics Design's Gold Book has granted their award for "Literature Excellence 1981" to RCA Solid State Division for the catalog "COSMAC Microboard Computer Systems," CMB-250A. According to **George Weingarten,** Gold Book Editor, "the catalog was judged by a panel of design engineers on the basis of technical content, graphics appeal, and over-all impression of effectiveness; the award, therefore, represents a true evaluation of the catalog by those who use it."

Carl Turner, Vice-President, Product Assurance and Planning presented the Gold Book award (see photo) and offered congratulations for a "terrific job" to **Charles Meyer,** (second from right) of Engineering Publications, Editor of the *Microboard* catalog. **Tony Bianculli,** Manager, Publications and Standards (far right), and **Frank Jones,** Manager, Engineering Publications (far left), also congratulated Charlie for "an award well deserved" and for "one bit of recognition in a career characterized by excellence."

Engineering Publications has just issued a new edition of this booklet which it considers to be even better than the prize-winning one, not only for its enhanced appearance, but also for its expanded technical coverage. Fifteen new CMOS Microboards for computer systems were added along with a greatly expanded line of microprocessor-system supporting hardware and software.

Olsen receives Young Author Award

Gregory H. Olsen, Solid State Devices Laboratory, received the first Young Author Award of the American Association for Crystal Growth. Dr. Olsen has written more than 40 publications, coauthored several books on crystal growth and delivered numerous invited lectures at international conferences on his research. The Young Author Award was presented at the AACG conference in San Diego.

Laschever elected Vice-Chairman IEEE Boston

Norm Laschever was elected Vice-Chairman of the IEEE Boston Section. Mr. Laschever has been active in both the Boston Section of IEEE and Electro, serving as Elected Committee-Man, Editor of the *Reflector,* and as Secretary/Treasurer of the Section and Chairman of the Electro Board. He has received honors from Eta Kappa Nu and Men of Science. Norm has a BSEE from M.I.T. and an MSEE from Northeastern University. He has been with RCA since 1962, and is presently Principal Scientist on Staff.

Obituary

Otto H. Schade, Sr.

Otto Schade devoted some forty years of his professional career to research on television and allied disciplines mostly at RCA in Harrison. His numerous contributions have been formally recognized by a number of awards and honors. These include the Liebmann Award of the IEEE, the Sarnoff Medal and the Progress Award of the Society of Motion Picture and Television Engineers, the Fairbanks Award, an honorary degree from the Rensselaer Polytechnic Institute and election to the National Academy of Engineering. These are the bare outlines of his honors.

Those of us who had the privilege of working with Otto know him as totally committed to innovation in the science of imaging. It is difficult to imagine anyone who was more continuously excited by the quest for understanding.

This was the depth of his involvement. The breadth of his contributions was truly remarkable. It would be no exaggeration to call him the Renaissance Man of television and the other imaging sciences.

Otto's work was many dimensioned. He addressed himself to all components of the television chain from the camera and its optics to and including the observer and his visual system. Foremost, he brought his innovations to a demonstrable stage and then clarified the theory and principles involved.

In the 1930s and 1940s, there were separate languages, concepts, and literatures used by the experts on lens optics, photographic film, television systems, amplifiers and the human visual system. Otto succeeded in unifying these widely separated disciplines by his invention of a common language of "modulation transfer functions." His ideas seeded a revolution in the characterization of lenses, photographic film and the properties of the human eye.

I remember in the early days of television there was a general consensus that the picture quality of the television medium rated a poor second to the quality of motion pictures. It was Otto's consummate skills in the television system on the one hand and the photographic system on the other that combined to demonstrate that a television system properly designed and properly photographed could easily rival and even surpass the performance of motion pictures. Much of the evidence of this work is gathered in his book *Image Quality: A Comparison of Photographic and Television Systems.*

Otto's contributions remain for anyone to see; his pure delight in the pursuit of science is confined to the memory of his colleagues.

— — *Albert Rose*

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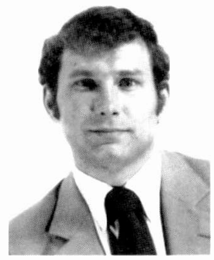
technical excellence

CE Technical Excellence awards for fourth quarter 1980


Allen

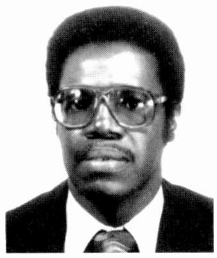

Billings


Graves

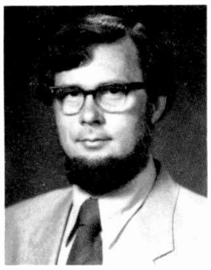

Bell

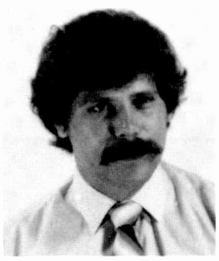

Chaney

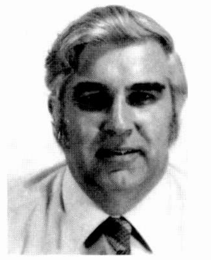

Fling


Boone


Knight


Lagoni


Pitsch


Tomory


Powell


Rigsbee

Dr. D.J. Donahue, Division Vice-President, Operations, announced the following winners of the quarterly Consumer Electronics Division Technical Excellence Award.

John Allen, Darrel Billings, and **David Graves,** for an innovative approach for high-density PC board automatic alignment using each stepping motor to perform four alignments through electro-magnetic clutches.

Tom Bell, John (Jack) Chaney, Russell Fling, for the development of a data management system for the analysis of engineering data. This system contributed to the success of the CTC-111 pilot testing program.

Leroy Boone, for exceptional work in developing a process improvement for the IHVT epoxy-encapsulated tertiary, significantly improving thermal shock characteristics.

Peter Knight, William Lagoni, Robert Pitsch, and **John Tomory,** for the establishment of a chassis/ATE test correlation procedure and its subsequent application to a CTC-111 chassis; a level of test integrity was achieved that led to a successful pilot.

Jerry Powell, for the design and construction of an automatic focus alignment apparatus forming a key part of RCA's instrument automation program.

William Rigsbee, for the development of a numerical control system for an IHVT tertiary winder that achieves 4-axis control with a multiplexed 2-axis controller.

Mountaintop award given


Van Horn


Hollands

Clyde Van Horn and **Rob Hollands** are recipients of the Mountaintop Technical Excellence Award for January, 1981. The committee will honor these recipients at a luncheon and also at an annual dinner.

The Mountaintop Technical Excellence Award is designed to recognize and reward members of the technical community who have consistently exhibited qualities of initiative, leadership, technical competence, attitude and follow-up.

Findlay TEC awards given


Michel


Horne

Findlay's Technical Excellence Committee Award for Technical Excellence was presented to two individuals who have reached beyond the requirements of their jobs, to achieve a special level of Technical Excellence.

For their effort, the TEC recognizes:

Emory Michel — Engineering Coordinator of the JPL Galileo Program. Emory provided technical guidance in Wafer Fabrication, Circuit Probe, Assembly, Final Screening, and Test. He served as chief technical liaison between Findlay's Manufacturing effort and the Jet Propulsion Laboratory. As a result of his dedication, this program was highly successful. Goals were met which meant high profits and good customer relations. Being a part of Galileo has been good for everyone, thanks to Emory Michel.

Ray Horne — Member Technical Staff. Ray was assigned the task of resolving the dirty tweezer problem in the wafer "fabs." He devised a method of holding the tweezers for economical routine cleaning and identifying each pair of tweezers with its user. Solving the problem for the salary personnel was a little tougher as they usually carry the tweezers on their person. He found the little "cigar tube" that the "Exacto" brand razor knives come in was a perfect container for the job.

Awards banquet for Mountaintop TEC

The recipients for 1980/81, pictured with their wives, from left to right, are **Pat and Rita Duncan, John and Eileen Merges, Clyde and Darleen Van Horn, Frank and Carolyn Wheatley, Gary and Millicent Wicks, Ed and Kay Zuber, Rob and Mary Ann Hollands,** and **Ron and Martha Matenkoski.**

On Saturday, June 13, 1981, the Mountaintop Technical Excellence Committee celebrated their third annual awards banquet, honoring the recipients of the recognition award during the 1980/81 year.

Invited guests were the recipients' spouses and the Technical Excellence Committee with their spouses.

The guest speaker for the evening was **William C. Hittinger,** Executive Vice-President, Research & Engineering, who commented that the support of the spouses can be very meaningful in helping the technical people meet the challenges they face.

MSR Technical Excellence awards for first quarter 1981

Smith

Spencer

Wiegand

CETEC has completed its review of the Technical Excellence Award nominations for the first quarter 1981 and has selected three winners. The citations are summarized below.

E.B. Smith — for design and development of a state-of-the-art dual-bandwidth waveform generator for the Lincoln Laboratory millimeter wave radar. The unit provides four different bandwidths under computer control, including one of 1000 MHz. Performance data taken on this waveform verified that the stringent requirements for time sidelobes (-30 dB) and phase jitter (8.0° RMS) were greatly exceeded in this new design, establishing a new wideband performance standard for the industry.

J.S. Spencer — for outstanding technical achievement in designing and testing a new high-performance replacement A/D converter assembly for the AN/SPY-1A signal processor. The result of his efforts is a tested design with improved performance, 60-percent fewer parts, lower manufacturing costs, easier maintenance, and double the reliability of the existing design.

B.A. Wiegand — for his initiation and implementation of a complete system for three-dimensional design, modeling, documentation, and manufacture of complex microwave structures. His direction and coordination of a team of microwave and mechanical engineers, drafters, and production engineering and machining specialists resulted in the first successful part produced on MSR's new Bridgeport numerically controlled miller.

The annual award winners will be honored at a special function to be held early next year, and each will also receive a commemorative desk plaque and a current text or reference book.

Automated Systems Technical Excellence awards for first quarter 1981

From left to right: D. Priestley, R. Mark, K. Klarman, B. Hendrickson, F. Pratt, H. Fitch, D. Blough, A. Arntsen, F. Martin.

The Burlington Technical Excellence Committee has reviewed nominations submitted during the first quarter of 1981. The result is selection of the Seeker Stabilization System design team for a Technical Excellence Award.

While the design challenges were difficult, the schedule challenges were no less demanding. A complex electro-mechanical system was carried from a concept to a demonstration model in less than one year. Cited for their achievements are:

A.P. Arntsen
D.F. Blough
H.E. Fitch
B.E. Hendrickson
R.B. Mark
F.L. Pratt

The team designed and demonstrated a system for stabilizing and pointing of an IR sensor, for application to the developmental Tank Breaker anti-tank missile. Difficult technical design goals were involved in this feasibility demonstration project. The Tank Breaker program is a competitive contract program for advancing the technology involved in the design of a new, improved missile for defense against the latest type enemy tanks.

RCA, teamed with McDonnell-Douglas, is one of four contractor teams conducting Phase I investigations and demonstrations. RCA is responsible for the Seeker Stabilization System. The RCA design involves a 2-axis gimbal assembly with free gyro stabilization, an IR sensor in a cooled dewar, IR optics and servo electronics. The total package fits inside a 4-inch diameter cylinder and performs all of the necessary stabilization and tracking functions. The requirement for a long focal length optics, a wide field of look-angles and the necessary compact assembly dictated that this new design be configured with the best elements of existing and advanced technology.

Microprocessor applications symposium held

Another of a series of RCA Corporate Symposia covering the very active topic of microprocessor applications was held at RCA Laboratories in Princeton on May 20, 1981.

About 90 attendees from well over a dozen RCA business units and locations followed a full program, viewed an SSD microprocessor-related system display and engaged in very lively cross-communication.

The symposium was organized and chaired by **Wendell Anderson** from GSD engineering staff.

Jim Feller, Division VP Engineering, GSD, opened the symposium and pointed out the pervasion of microprocessors into all areas of engineering throughout the corporation. Over a dozen presentations provided a look at some of the many new microprocessor uses in the corporation. The speakers and their topics are listed below. If you have a need for specifics on a particular talk, contact the respective author(s).

Adaptive Mode Switch
Don Kleinschnitz
RCA Service Company

Airborne Microprocessor-Controlled Radar
Will Croly/Douglas Shaw
Missile and Surface Radar

Electronic Scan Generator for Phased Array Antenna
David Costello
Missile and Surface Radar

Microboard Controlled Transistor Test Set
William Schilp
Solid State Division

Microprocessor FM Modem for Satellite Communication Control
Neil Coleman/Dick Allen
Government Communications Systems

IR CCD Diagnostics and Detection
Dave Gandolfo/William Borgese
Advanced Technology Laboratories

A^3 for Project Seaguard
Paul Berrett
Automated Systems

Microprocessors for Communication Signal Analysis
Steve Nossen
Government Communications Systems

Microprocessor Development
Dave Caracappa/Nils Ny/G. David Ripley
RCA Laboratories

Experience Developing the Satcom Attitude Logic Firmware
Paul LeVine
Astro-Electronics

Practical Problems in Applying Microprocessors
Herb Resnick
Automated Systems

Microprocessor Courses in CEE
Bob Horen
Corporate Engineering Education

ROMBIC Digital Ignition Controller
Tony Robbi
RCA Laboratories

New Video Course Now Available from CEE:

CAD/CAM for Printed Circuit Board Applications

Recent advances in Computer-Aided Design and Manufacturing (CAD/CAM) have led to dramatic productivity improvements in the electronics industry. CAD/CAM systems for printed circuit boards (PCBs) have been particularly successful. This course provides a comprehensive, practical foundation for applying CAD/CAM in automated printed circuit board design, manufacturing and test.

The course begins with an overview of a fully integrated CAD/CAM system for PCBs. The computer-aided design process is covered, and each step is illustrated with videotape of practical examples performed on CAD systems. Computer-Aided Manufacturing (CAM) and the CAD/CAM interface are described and illustrated in detail. Throughout the course, the emphasis is on practical techniques for system analysis, selection and implementation.

This course is intended for design, manufacturing and test engineers, PC designers, and their managers. The course is applications-oriented, and a background in computers is not required. This course is designed to develop an awareness of opportunities for applying CAD/CAM technology; to provide a common understanding to bridge the gaps between engineering, drafting, manufacturing and testing personnel; and to improve PCB design and manufacturing productivity.

The course was produced by Integrated Computer Systems, Santa Monica, Calif. To schedule this course at your location, contact your local training representative. For more information on course contents, contact Bob Horen at Corporate Engineering Education in Cherry Hill, TACNET 222-5020.

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Contact your Editorial Representative at the TACNET numbers listed here to schedule technical papers and announce your professional activities.

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Krishna Praba	Gibbsboro, New Jersey	222-3605
Andrew Billie	Meadowlands, Pennsylvania	228-6231
Cablevision Systems		
*John Ovnick	Van Nuys, California	534-3011

Consumer Electronics (CE)

*Clyde Hoyt	Indianapolis, Indiana	422-5208
Francis Holt	Indianapolis, Indiana	422-5217
Chuck Limberg	Indianapolis, Indiana	422-5117
Don Willis	Indianapolis, Indiana	422-5883

Government Systems Division (GSD)

Advanced Technology Laboratories		
*Merle Pietz	Camden, New Jersey	222-2161
Astro-Electronics		
*Frank Yannotti	Princeton, New Jersey	229-3246
Carol Klarmann	Princeton, New Jersey	229-2919
Automated Systems		
*Ken Palm	Burlington, Massachusetts	326-3797
Dale Sherman	Burlington, Massachusetts	326-2985
Government Communications Systems		
*Dan Tannenbaum	Camden, New Jersey	222-3081
Harry Ketcham	Camden, New Jersey	222-3913
GSD Staff		
*Ed Moore	Cherry Hill, New Jersey	222-5833
Missile and Surface Radar		
*Don Higgs	Moorestown, New Jersey	224-2836
Jack Friedman	Moorestown, New Jersey	224-2112

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		TACNET
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*William Hartweg	New York, New York	323-7300

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*Greg Bogantz	Indianapolis, Indiana	424-6141

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Ray MacWilliams	Cherry Hill, New Jersey	222-5986
Dick Dombrosky	Cherry Hill, New Jersey	222-4414

Research and Engineering

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*Hans Jenny	Cherry Hill, New Jersey	222-4251
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Eva Dukes	Princeton, New Jersey	226-2882

SelectaVision® VideoDisc Operations

*Nelson Crooks	Indianapolis, Indiana	426-3164

Solid State Division (SSD)

*John Schoen	Somerville, New Jersey	325-6467
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Harold Ronan	Mountaintop, Pennsylvania	327-1633 or 327-1827
John Cadra	Somerville, New Jersey	325-6909
Integrated Circuits		
Dick Morey	Palm Beach Gardens, Florida	722-1262
Sy Silverstein	Somerville, New Jersey	325-6168
John Young	Findlay, Ohio	425-1307
Electro-Optics and Devices		
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