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RCA Engineer

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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 among various groups at RCA □ To create a community of engineering interest within the company by stressing the interrelated nature of all 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 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.

Excellence and the competitive spirit

In recent years our world has become more competitive in almost every facet of life. Nations compete intensively for capital to provide living standards and for markets to sell their products and thereby sustain employment. Governments deregulate industries to encourage the production of enhanced products and services at lower prices. Books on excellence capture broad readership. Barriers to imports are lowered in the face of pressure for protectionism.

Nowhere are competitive pressures greater or more pervasive than in our electronics, communications and entertainment businesses. This demands a constantly increasing level of excellence in individual and group performance and product quality.

RCA has chosen to operate in the mainstream of competition. It must remain at the forefront of technology and is shaping its strategies accordingly. Success will depend on many factors. Of salient importance is technical excellence — the process of continuous individual and group professional growth in basic skills and performance of task.

Evidence of company support of excellence is plentiful. The prestigious David Sarnoff Awards for Technical Achievement are held in very high esteem, and are visibly supported by management. Continuing education is encouraged. Technical Excellence Committees work hard at improving the technical climate. On another front, to improve RCA's competitiveness, strong and growing capital spending is providing for advances in mechanization and automation of design and manufacture. (A concerted effort is being made to improve all aspects of manufacturing technology.) RCA is participating in joint research and development programs, such as Microelectronic and Computer Technology Corporation, Semiconductor Research Corporation and the Center for Advanced Television Studies, aimed at increasing the competitiveness of U.S. industry in world markets.

As RCA renews its commitment to excellence, the task ahead is becoming more challenging. Software is growing in importance in every aspect of the business at a faster rate than hardware. Exploiting product and services opportunities in international markets is more important than ever in achieving economies of scale over competitors. Emphasis on quality of products and services requires fresh thinking in dealings with suppliers and customers. The "Just-in-Time" concept, for example, which can contribute to cost effectiveness and quality, requires new manufacturing methods and control systems that have not been used by RCA in the past.

Leadership in this competitive world will go to those who are committed to excellence through self-renewal. RCA understands the challenge and accepts it.

William C. Hittinger

W. C. Hittinger
Executive Vice-President
Corporate Technology

RCA Engineer

Vol. 29/No. 4 July/August 1984

in this issue ...
technical excellence at RCA

■ *"Electronics, in the race to achieve new triumphs, is run on the big track of Time, on which there is room for all who would compete. There is no finish line."*

■ *"There are no engineers who, collectively, are more ingenious or inventive than American engineers..."*

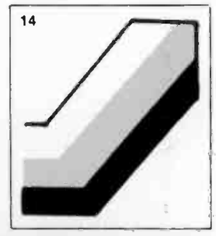
■ **D'Arcy:** *"The purpose of this recognition is to 'emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical affairs, but in a variety of other ways.'"*

■ **Seeley:** *"The successful employment of motivational tools results in a more motivated engineer who is more productive."*

21 TANGIBLE REWARDS

4

14



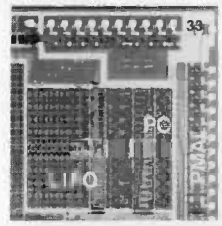
20 **The Engineer's Notebook**

■ **Law:** *"Although color broadcasting standards remained in doubt for a long period of time, there was no doubt about the utility of the shadow-mask tube,..."*

■ **Conklin:** *"...if MCC succeeds, the technology will be crucial to RCA's future competitiveness in several vital areas."*

■ **Ramondetta:** *"With ATMAC-II's pipelining and functional concurrencies considered, effective performance levels as high as 20 MOPS are achievable."*

■ **Butler/Edmondson:** *"The full Ku-band system will be in operation by January 1985."*



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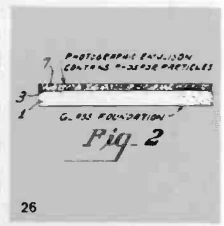

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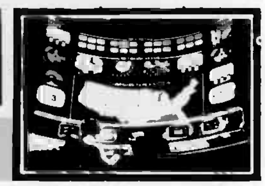
MCC ? 31

42 SKY PATH



■ **DeBaylo:** *"Successful companies realize that business is a customer-satisfying process."*

■ **Alexander:** *"Just-in-Time is an operations philosophy, an operations strategy; it is not a system."*

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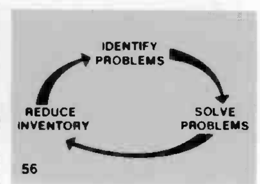

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■ **Schnitzler:** *"I believe that much of the time participative techniques are not used because the manager involved is concerned about his or her lack of control under such circumstances."*

■ **Nigam:** *"The analogy between chess and business problems is clear in the application of decision-tree analysis."*

69

The Cast 65

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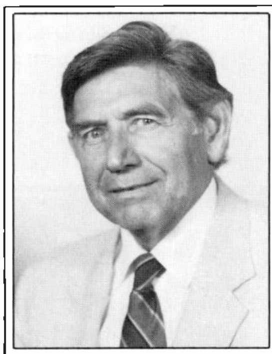
in future issues...
materials science applications,
imaging technology,
RCA's communications businesses

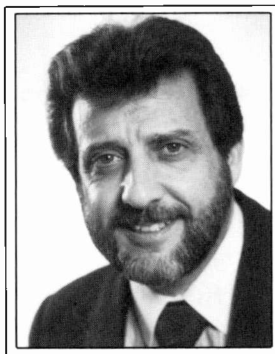
The 1984 David Sarnoff Awards for Outstanding Technical Achievement

"Electronics, in the race to achieve new triumphs, is run on the big track of Time, on which there is room for all who would compete. There is no finish line."*

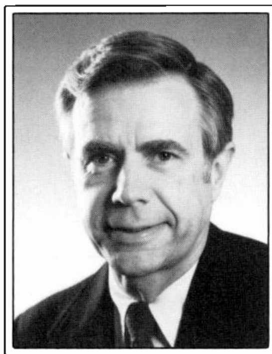
CITATION: For major reliability improvement in plastic encapsulated integrated circuits.



Richard Denning
Staff Engineer
RCA Laboratories

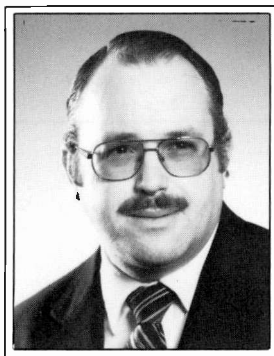


Larry J. Gallace
Director, Product Assurance
RCA Solid State Division



Leonard H. Gibbons, Jr.
Manager, Market Development, Industrial (formerly Manager, Reliability Engineering Laboratory)
RCA Solid State Division

Lewis A. Jacobus
Manager, Logic Products Engineering
RCA Solid State Division



Maurice I. Rosenfield
Manager, Packaging Development and Assembly Engineering
RCA Solid State Division

*David Sarnoff, in an address before American Institute of Electrical Engineers, New York City, January 31, 1955.

ACHIEVEMENT

This award is for the 1983 solution to a reliability issue that had plagued the solid-state industry for years. A team effort consisting of Reliability Engineering, Package Engineering, Manufacturing Engineering and Product Development Engineering was primarily responsible for this development, which resulted in superior product performance. The team improved the reliability of plastic-encapsulated integrated circuit devices very significantly through a systematic technological and statistical investigation of materials and processes that directly relate to reliability. Changes in materials, designs, and processes were successfully implemented into manufacturing at two offshore assembly facilities and one domestic wafer-fabrication site. Methods of predicting and accessing reliability levels were also developed and introduced into manufacturing.

Electrolytic metal attack (EMA) was identified as a prime source of long-term failure for plastic-encapsulated integrated-circuit devices. Analytical procedures and engineering experiments indicated that halide contamination was a major cause of device degradation, or failure. Corrosive acids were generated when the plastic package was exposed to a moist environment: corroding and eroding of the aluminum metallization used as interconnects for the integrated circuit devices resulted.

After a year of intensive investigation, analytical analysis, and engineering experiments involving plastic materials, assembly and device processes, and package designs, nine major changes were introduced to manufacturing. They included: the use of improved plastic encapsulant material; optimization of the molding technology; development and use of a new lead frame that retards moisture ingress; the development of halide-free precleaning and fluxing in the lead-soldering process; and the optimization of the post-mold curing process.

The engineering developments concerning the curing of plastic material and the nonhalide soldering process put RCA and RCA Solid State Division in an advanced position in these areas. Changes made to improve the wafer-fabrication process included halide-free cleaning procedures, elimination of wafer back lap, and the monitoring of halide levels in the wafer process. More than sixty statistically designed engineering experiments were completed which allowed process and materials changes to be implemented in one-third the time previously experienced for this type of program.

Based upon the results obtained from these design, process, and reliability studies, and the successful execution of these technologies in manufacturing, the reliability of RCA Solid State Division plastic-encapsulated devices is now competitive with all domestic suppliers. With the technological experience acquired during this effort, the stage is set to advance the reliability of plastic-encapsulated integrated circuit devices to a worldwide leadership level. The new QMOS technology introduced in 1983 shows reliability results significantly better than any known to date.

BUSINESS IMPLICATIONS

The majority of semiconductor devices are now packaged in thermosetting polymeric materials. RCA Solid State Division plans to manufacture approximately 500-million plastic-encapsulated integrated circuits, or 90 percent of Solid State's total integrated-circuit production, in 1984. Plastic-encapsulated devices do not offer the reliability of their hermetically sealed counterparts, largely because of permeability of moisture. The industry, however, requires greater reliability performance as plastic-encapsulated integrated circuits find wider applications in various types of hostile environments.

It is impossible to put a money value on this achievement. Without the increased reliability obtained, present and future business for RCA Solid State Division could be seriously jeopardized. Major customers such as GM, IBM, Ford, RCA-CE, and ITT have increased their requirements for plastic-device reliability, and have disqualified vendors who do not meet stringent reliability standards.

The achievement of upgraded reliability, and the reduction in failure rates of plastic-encapsulated standard integrated circuits, as measured by the industry standards of humidity-temperature-bias tests from the 15-percent to the 1-percent defect level, places RCA Solid State Division in a high competitive position within the semiconductor industry, and the stage is set for even further improvements. The new CMOS technologies introduced for future growth in high-speed logic, memory and microprocessor areas show at least a very significant improvement over the 1-percent level of standard integrated circuit product. Based on the published reliability data worldwide, these results put RCA Solid State Division in a leadership position.

INDIVIDUAL CONTRIBUTIONS

Larry J. Gallace became Program Manager of the Reliability Program in January, 1983 because of his years of experience in the reliability engineering of solid-state devices. He was responsible for organizing and coordinating the various disciplines involved. His emphasis on, and expertise in, experimental design and statistical analysis were the keys to determining the significant results in multivariant experimentation. He made numerous trips to the offshore and domestic manufacturing locations for the purpose of coordination, communication, and direction. He was responsible for designing or directing the more than 60 experiments that produced the engineering data for the reliability improvement obtained.

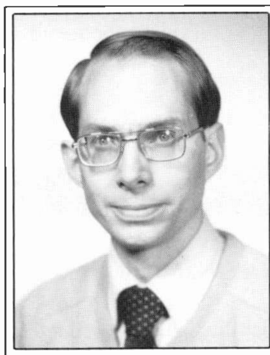
Leonard H. Gibbons was responsible for all the required environmental stress testing. He was responsible for the development and correlation of accelerated methods of reliability testing. A high-temperature, high-humidity accelerated test was developed that resulted in an acceleration factor of 100:1. Through his efforts, accurate and rapid results were obtained, which led to successful technological changes.

Lewis A. Jacobus was responsible for specifying improvements in the wafer-fabrication process. Halide-free wafer processing and improved passivation were just two of the technological improvements that led to superior, finished integrated circuit chips.

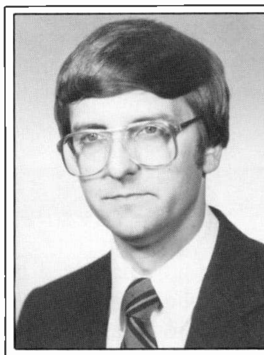
Maurice I. Rosenfield was responsible for package design and assembly-related processes. His broad knowledge of materials and their properties as well as the assembly-package finishing process allowed him to efficiently direct technological changes. The lead-frame design change, the plastic material change and the molding-technology improvements were primarily developed and accomplished under his direction. He made several trips to offshore manufacturing locations with the program manager to coordinate the necessary changes in processing.

Richard Denning was involved from the beginning of the reliability program. He was instrumental in developing the models for product degradation and failure. His initial analysis accurately indicated the major technological cause of product degradation. His recommendations for improving the process and design, and for accelerating the testing, were implemented. Studies on device passivation and its effect on device reliability were also conducted and recommendations made. He acted as liaison between the research laboratories and the major operating units in a successful transfer of the necessary technological information required for the reliability improvement.

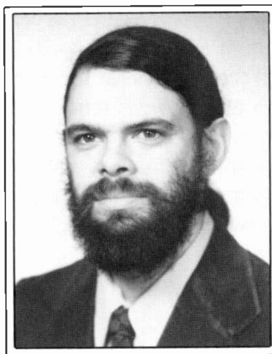
CITATION: For the development of the physical understanding and computer software for simulating electron trajectories in picture tubes.



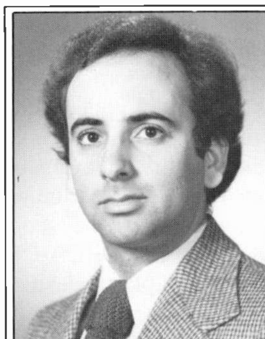
John R. Fields
Member Technical Staff
RCA Laboratories



Thomas C. Lausman
Member Technical Staff
Technology Transfer Laboratories,
Gun Technology
Video Component and Display Division



Ronald Sverdlove
Member Technical Staff
RCA Laboratories



Norman D. Winarsky
Group Head, Electron Optics & Applied Mathematics Research
RCA Laboratories

ACHIEVEMENT

This award is for the development and implementation of a computer software system, BEAM3D, that simulates full three-dimensional trajectories of electrons in picture tubes, including the effects of electric fields, magnetic deflection and electron space charge repulsion. The need for such a simulator has been recognized for several years, but the complexity and difficulty of the task have also been clear: the presence of three-dimensional electron/electron interactions carries this problem into the order of massive nonlinear computation similar to hydrodynamic flow and air-foil simulation.

To achieve simulation of electron paths that is both accurate and economical required a combination of mathematical inventiveness and computing skill that makes this work a major technical achievement. In fact, there were three separate mathematical problems corresponding to three different environments that the beam encounters: (1) the spacing-charge-dominated emission region near the cathode, (2) the electric and magnetic field regions of the gun and yoke, and (3) the long electric field-free region to the screen where space charge is a perturbation but with substantial effects accumulating over the long distance.

Spanning these local environment problems was the overriding major problem of beam representation: increasing the number of trajectories used to approximate the beam shape increases accuracy, but at the cost of very rapidly increasing execution time. The solution to this dilemma was a novel mathematical representation of the beam in terms of beamlets whose interactions can be expressed analytically to provide economical computation.

The outcome of this work, then, was a major piece of computer software — including 12000 lines of program code — that is one of the most sophisticated pieces of mathematical software ever developed within RCA, or in the TV industry generally. Furthermore, this computational sledge hammer is packaged within a user-friendly interface. The interface was developed in collaboration with a Lancaster engineer who joined the team early in development as a "practice user" with major responsibility for testing the program accuracy. This "user-friendliness" was further enhanced by the development of a simple CAD language that allows the non-mathematician to easily specify three-dimensional electrode surfaces without attention to the massive subdivision of surfaces that the language program generates automatically.

BUSINESS IMPLICATIONS

Applications for picture tube displays have broadened in the last several years well beyond traditional television entertainment. These applications include high resolution computer monitors, arcade games, and medium resolution home terminals. This proliferation is expected to continue as further reductions in IC costs drive new applications, such as progressive scan, enhanced definition and high-definition television.

The business implication of the BEAM3D computer program is tied to this need for an increasing variety of picture tube designs with more and more demanding specifications in shorter turnaround times. For the first time, the engineer can fully model conventional or novel guns and yokes to determine the effect of design changes on resolution at any current and at any place on the screen. This greatly shortens the time required for arriving at optimized designs, especially designs that involve major changes in shapes and spacings.

A second major application that is currently underway with BEAM3D is the determination of tolerances on gun fabrication. These tolerances are typically less than .001 inches, making experimental determination difficult; with BEAM3D, spot size variations due to fabrication errors can be modeled to directly determine parts tolerances.

In summary, the development of BEAM3D provides RCA engineers a number of competitive advantages in one of its major product areas, television displays. This includes advantages in productivity, in time response, in manufacturability, and in the type of exploratory efforts that result in invention. It is a first-rate example of the fruitful application of advanced mathematical and physical theory to the solution of economically important problems.

INDIVIDUAL CONTRIBUTIONS

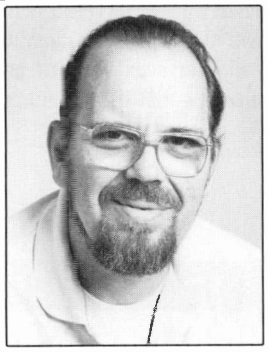
John Fields had primary responsibility for that part of the BEAM3D program that calculates the space-charge forces in the near-cathode region and estimates the emitted current. He also was a principal contributor to the interface of BEAM3D with the other existing electron-optics programs, thereby achieving an integration of all the major electron-optics simulation capabilities into a single program. He was the designer and major programmer of the CAD language that provides the program user with a simple method of specifying the three-dimensional electrode surfaces that make up the electron gun.

Thomas Lausman was the Lancaster engineer responsible for assisting in the development of specifications for the user interface, for verifying the accuracy of BEAM3D and for transfering the program to the Video Component and Display Division (VCD). He was responsible for educating users both at VCD and at RCA Laboratories in BEAM3D. He is also a principal user of BEAM3D.

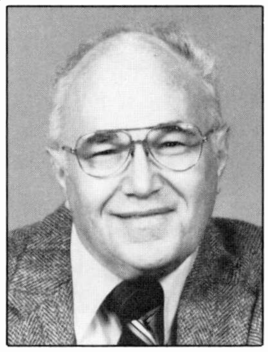
Ron Sverdlove was a principal contributor to both the mathematical and the programming effort in BEAM3D, and derived the fundamental theory used in beam representation. He contributed to development of the user interface, to the extensive graphics capabilities of the program, and to the CAD language.

Norman Winarsky served as project leader in the BEAM3D program, and he contributed directly to the mathematical implementation of the beam representation and the electron-electron interaction calculation.

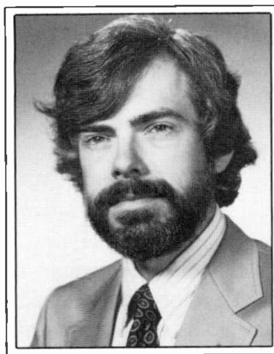
CITATION: For developing CCD high-performance television cameras.



Donald F. Battson
Member Technical Staff
RCA New Products Division

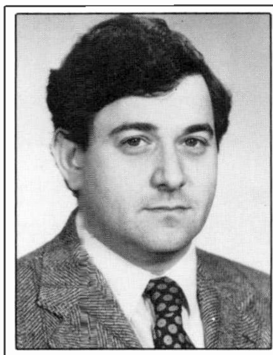


Sidney L. Bendell
Unit Manager(retired),
CCD Camera Development
RCA Broadcast Systems Division

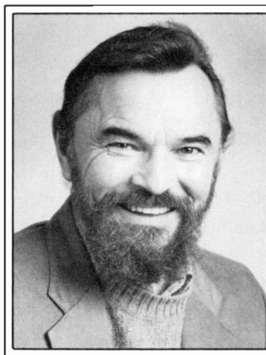


Gary W. Hughes
Head, CCD Imagers and Systems Research
RCA Laboratories

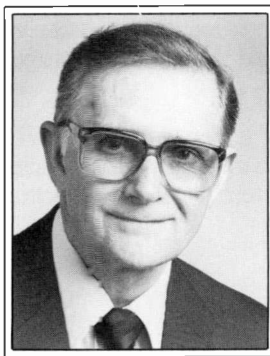
Walter F. Kosonocky
Fellow, Technical Staff
RCA Laboratories



Peter A. Levine
Member Technical Staff
RCA Laboratories



Eugene D. Savoye
Director, CCD and Silicon Target Operations
RCA New Products Division



L. Franklin Wallace
Member Technical Staff
RCA New Products Division

ACHIEVEMENT

The CCD imagers developed on this program have demonstrated the best performance of any CCD imagers that have ever been made anywhere. The major program objectives have been achieved well ahead of schedule and RCA has established at least a two-year technological lead over any known competition. The devices combine very high dynamic resolution (512 x 403 pixels) with absolute blooming control, maintain very high quantum efficiency particularly in the blue (essential for color TV), have CCD registers with very low noise read-out (fundamentally lower than tubes), with excellent transfer efficiency, together with outstanding overall cosmetic quality. These new CCD imagers have been incorporated into prototype broadcast TV cameras that have demonstrated absolutely outstanding and unprecedented performance, which promises to revolutionize broadcast-TV capability. In particular, under conditions of low light level, with moving scenes and bright lights, the CCD picture quality is excellent, whereas on direct comparison conventional tube-camera pictures are not usable.

The major technical areas in which significant contributions have been made in the success of this program include:

- Fundamental CCD design concepts for CCD imager architecture to best match requirements of TV systems compatibility.
- Process development including multi-level-poly gate structures with novel reflow borophosphosilicate glass to realize manufacturability.
- Specific development of novel self-aligned blooming-control structures to meet imaging requirements.
- Thinned device technology to provide 10-micron device thickness with good uniformity for high quantum efficiency.
- Design and development of low-noise on-chip amplifiers and associated circuits for optimum performance.

The overall program has been remarkably successful in meeting the stringent performance and timing objectives, and provides an outstanding example of close cooperation between RCA Laboratories and New Products Division personnel in getting the job done.

BUSINESS IMPLICATIONS

The achievement of fully broadcast-compatible CCD imagers has major business implications in two principal divisions of RCA, namely Broadcast Systems Division and New Products Division.

BSD has long been a leader in broadcast television cameras, and has been highly profitable. In recent years this leadership and profitability have been severely challenged by competition, particularly from the Japanese. High-performance tube cameras are becoming available at significantly lower cost. The CCD imager developed under this program provides the basis for a new family of high-performance all-solid-state cameras that can offer substantial performance advantages that cannot be matched by tube cameras, particularly in the important area of sensitivity. Successful implementation of these CCD imagers into a new broadcast camera can thus preserve RCA's leadership position in this traditionally vital area and help assure the continued excellent profitability of BSD.

In addition, the outstanding performance characteristics of the CCD imagers developed on this program lend themselves well to use in general-purpose television applications, including those presently addressed by NPD with tubes. In particular, markets requiring black-and-white surveillance, industrial controls, robotics, and consumer security applications can be satisfied using the somewhat lower cosmetic quality "fallout" devices not suitable for broadcast use. Potential sales of cameras exceeding $10 million annually are anticipated for these markets in the near term, with potentially explosive growth.

A third major market area with significant potential sales dollars ($1 million annually) and large prestige potential is that of scientific applications, particularly astronomy. CCD imagers resulting from this program with modified design are already in use at most of the major observatories in the world. These devices are vastly superior to photographic film for some critical observations, and hold promise of revolutionizing deep-space astronomy. Some of the more outstanding results have attracted wide attention, and have already been featured in RCA corporate advertisements.

INDIVIDUAL CONTRIBUTIONS

Eugene D. Savoye developed the overall plan, coordinated all efforts, and assumed responsibility for all major decisions. Specific technical contributions included patent disclosures on dark lines (with D. F. Battson), buried drains (with L. F. Wallace and W. Kosonocky), interlace and flicker reduction, and a patent granted for reduced blooming (with T. W. Edwards and L. F. Wallace).

Donald F. Battson was responsible for device design, layout, digitizing mask development, and electronic test and evaluation of devices. Specific technical contributions included patent disclosure on dark lines (with E. D. Savoye) as well as continuing outstanding device analysis and diagnostics.

L. Franklin Wallace served as the outstanding technical expert on semiconductor processing and analysis. Specific technical contributions included development of the fundamental method for blooming control with self-alignment of blooming drains and barriers (patent issued), as well as a patent on reduced blooming (with E. D. Savoye and T. W. Edwards) and patent disclosures on buried drains (with E. D. Savoye and W. Kosonocky).

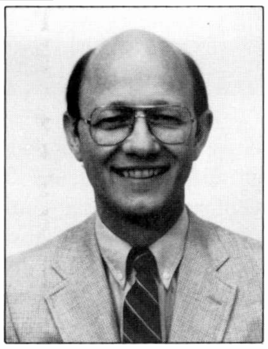
Sidney L. Bendell was responsible for the technical guidance of the developmental efforts to assure a device that would provide acceptable performance for an electronic news gathering camera to be produced by the Broadcast Systems Division. He compiled the technical specification for the imager, made measurements of the various parameters of sample devices, and developed circuitry necessary to get the needed performance from the device.

Gary W. Hughes was the Group Head responsible for the coordination of the Laboratories' program with the Lancaster engineering effort. Specific contributions include important areas of multi-level-poly processing, and utilization of BPSG reflow glass. His leadership and managerial skills were an important factor in the success of the project.

Peter A. Levine is an electronics, circuits, and television expert responsible for development of test circuits to drive the new CCD imagers. Specific technical contributions include complete design and fabrication of test cameras for 540 × 512 and 403 × 512 imagers, invention of new low-noise methods of CCD operation, and analysis and characterization of experimental CCDs.

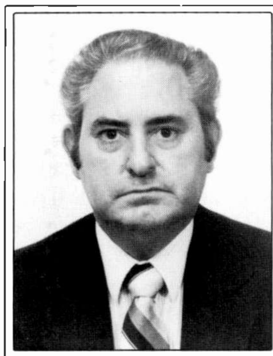
Walter F. Kosonocky is an expert in all aspects of CCDs, both theoretical and practical. His specific technical contributions include complete design and process definition of the first 540 × 512 imager, and design of new improved on-chip amplifiers. He is also co-inventor of methods for CCD blooming control and other CCD structures and processes used in the fabrication of the commercial 403 × 512 CCD imager.

CITATION: For development of compact television receivers and monitors

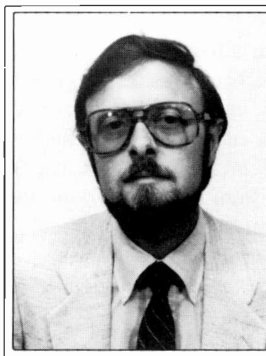


James J. Kopczynski
Manager, Project Engineering
RCA Consumer Electronics

James Hettiger
Manager, RF Systems
RCA Consumer Electronics



James A. Milnes
Member, Engineering Staff
RCA Consumer Electronics



John F. Benford
Engineering Specialist
RCA Consumer Electronics

ACHIEVEMENT

This award is based upon the successful development and introduction of RCA's compact 25-inch television receivers and receiver-monitors. The project goal was the design of a 25-inch receiver that would be compact enough to occupy the same space as a typical 19-inch receiver. This would have been a challenging goal to achieve for a standard television chassis not burdened by the additional complexity of a full-featured video in/out monitor.

A new concept was developed that allowed the picture tube to be mounted to an internal structure instead of the mask as it is traditionally done. The mask could then be removed from the front of the TV receiver so that auxiliary and channel-address controls could be inserted along the top of the picture tube. As a consequence, very little additional front surface was needed for locating these controls.

To achieve compactness, side-firing speakers were required. In the past these speakers have resulted in a degradation of acoustical performance. Excellent acoustical performance was achieved in the compact design through the use of small, high-performance woofers, tweeters angled at 45°, and compensating circuitry in the audio electronics.

Another obstacle was the small amount of space permitted for audio and video in/out circuitry. Isolation for the many external connections required on the monitor version was achieved through the use of optical-isolation circuitry that coupled audio information across hot-cold barriers. This optical isolation circuitry, along with small video transformers, achieved the monitor function isolation while still maintaining design compactness.

BUSINESS IMPLICATIONS

This effort has created a new, substantial compact 25-inch table model market with RCA as the dominant force and, in effect, has created a new business in a high-end, high-margin product. Further, it has provided a strong foundation for expanded high-end business in monitors and component-audio-video systems — both are strong growth areas for the 1980s and beyond. Consumer tastes are changing, favoring smaller models that accommodate new life styles in reduced living space. It was expected that this type of consumer would welcome a large picture in a small size.

In 1982, the sales figures for 25-inch table models were promising, and included an increase in RCA's share of the over-$700 product category. But 1983 figures really indicate the impact of this new product. Total RCA sales to dealers in this category increased by 256 percent. Industry sales in this category were up over 100 percent. RCA held a 28.6-percent market share of this 25-inch table-model category as compared with an overall market share of 18-percent.

Another important assessment of the success in a new product area is the number of imitators. Several competitors in 1983 have responded with copies, or "knock-offs" of our design and we anticipate more in 1984. It is rare when a new idea or concept results in such a rapid growth of a new market segment and results in such a substantial profit contribution. This team contributed to the execution of a design that could be manufactured and that would provide the best performance in the industry.

INDIVIDUAL CONTRIBUTIONS

James J. Kopczynski, Project Manager, was instrumental in guiding the mini-compact project. Under his direction, the timely resolution of instrumentation issues and the coordination of diverse engineering and manufacturing teams to resolve the first-time production challenges resulted in the successful introduction of RCA's uniquely styled mini-compact, ColorTrak 2000 series.

James Hettiger was responsible for the monitor system design as well as the basic circuit design of the monitor interfaces. In addition, the technical design coordination and technical leadership functions were performed by him.

Hot/cold barrier isolation presented particularly difficult design tasks in both audio and video signal processing. The creative solutions to these problems were predominantly due to Mr. Hettiger's personal technical accomplishments. These solutions ranged from circuit inventions to development of new components in optical coupling of audio and video and video transformer coupling.

The small size of the slimline monitors imposed severe problems due to electromagnetic and electrostatic interference between audio and video circuitry and the deflection and power-supply circuits. His dedication and ingenuity were the keys to the solutions of these problems.

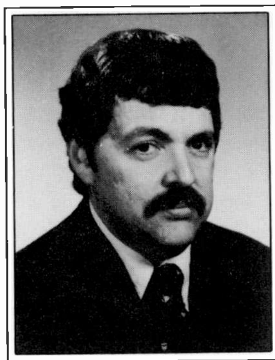
Jim Milnes was responsible for the mechanical design of the instrument and the picture-tube mounting, which was such a key factor in achieving the project objectives. The design approach was to use the strength of the wood cabinet to directly support the picture-tube mounting, contrary to more conventional approaches. This resulted in a much thinner and simpler mask structure. Shock and vibration tests have proven this to be one of the most rugged instruments in the product line.

John Benford was responsible for solving the unique acoustic and acoustic-related problems associated with high-power audio in such a compact 25-inch cabinet.

These constraints required development of new speakers and speaker-mounting arrangements to provide balanced sound to the front of the instrument. An additional task was to effectively shield the speaker magnetic fields to prevent picture-tube beam-landing errors. This was accomplished through co-development among speaker vendors, acoustic design and mechanical design.

Another difficult task was the elimination of vibration of the picture-tube shadow mask in response to speaker acoustic energy. Mr. Benford developed real-time spectroscopy techniques to analyze cabinet and picture-tube resonances, identifying from these the areas of the picture tube and the cabinet that required mechanical stiffening. Through these new techniques, Mr. Benford was able to develop guidelines for the design of high-performance audio in the slimline-style instruments.

CITATION: For leadership in the understanding, development and manufacture of solid-state optoelectronic devices.



Michael Ettenberg
Group Head,
Optoelectronics Research Group
RCA Laboratories

ACHIEVEMENT

This award is based on Dr. Ettenberg's continuous outstanding contributions over a 15-year time span in the solid-state optoelectronic arena. The contributions run the gamut of new device structures, reliability studies and device improvements, systems applications, improved manufacturing techniques, and technology transfer to and diagnostic support for the divisions.

Since joining RCA Laboratories in 1969, he has received 25 U.S. patents, all related to optoelectronic-devices or system applications of such devices. Recognized as a worldwide authority, he has published 95 papers, 91 of which are in the optoelectronic arena. In addition, in recent years he has presented several invited or tutorial papers annually. His major RCA interactions are with the New Products Division (NPD) and Government Systems Division (GSD), and he is often called upon to assist in system proposal preparations, factory manufacturing problems, and technical commercial and government interactions. To best illustrate his accomplishments, one can note a few of his significant developments.

Dr. Ettenberg, with Dr. Harry F. Lockwood, developed the multibin liquid-phase epitaxial system for the manufacture of heterojunction lasers and LEDs. This system is used worldwide for production of lasers and LEDs. Dr. Ettenberg undertook the transfer of this process to Lancaster for production and supplied RCA with an early edge in manufacturing.

The ability to grow controlled thin active layers led to Dr. Ettenberg's concept and development of the edge-emitting LED with H. Kressel. In 1982, Kressel wrote: "The edge-emitting LED employed for fiber optic communication was first thought of and fully developed by Dr. Ettenberg. The value of this structure is even greater for the new 1.3- and 1.55-μm LEDs used with the more recent low-loss fibers." This device led to reduced diffraction effects, increased speed, and significantly improved fiber coupling over the existing surface-emitter LEDs. Its importance to the telecommunications business is self-evident.

Dr. Ettenberg was a key participant in the discovery of the beneficial reliability effects of adding aluminum to the active region of cw lasers and placing facet coatings on the mirror faces of the laser diodes. These developments led to the first reliable laser diodes with lifetimes in excess of 10,000 hours. Once again, Dr. Ettenberg was responsible for transferring these now-standard processes to production.

Dr. Ettenberg was a key figure in the world arena in establishing a reliability database for optoelectronic devices. These studies and the associated reliability database were and are key features for government and telecommunications customers.

More recently Ettenberg's activities have extended into the optical detector arena (NPD-Montreal) and include papers on the reliability and applications of detectors and lasers at long wavelengths (telecommunications fiber optic wavelength). He also holds a number of "firsts" in the area of VPE (vapor-phase epitaxy) growth of the first room-temperature VPE laser and the first cw VPE laser. VPE offers increased throughput with better thickness control. In the systems area he had made contributions both in the communications and optical recording areas.

Dr. Ettenberg and F. Hughes (Manager, Emitters — NPD) have developed a successful technology transfer approach in which each plays a major role at his location in effecting the transfer. The transfer is accomplished gradually while customer sampling is carried out. Dr. Ettenberg has been the key figure on the RCA Laboratories side in effecting this transfer. This approach has been extended to NPD-Montreal in the detector area and is working equally effectively.

BUSINESS IMPLICATIONS

It is always difficult to document quantitatively the dollar benefits to RCA by virtue of an improved liquid epitaxy growth system or a passivation process that provides life and reliability. Clearly it did provide RCA with an early advantage that led to good opportunities in the marketplace.

Double-heterojunction large-optical-cavity pulsed laser. This technology was transferred from the Labs to Lancaster.

Pulsed lasers for OTDR (optical time-domain re-flectometry). These devices are used to determine the location of fiber-optic breaks. Again, Dr. Ettenberg was responsible for the transfer of these devices.

CW laser transferred by Dr. Ettenberg. Has been a steady business since 1978.

High-speed edge-emitter. The device was developed and transferred by Dr. Ettenberg. This business began in 1979.

Long-wavelength detector business. Dr. Ettenberg was a strong force in effecting this transfer to Montreal.

Dr. Ettenberg has demonstrated that a bright, creative engineer does not have to confine his involvement to the research bench. He has extended himself strongly to the factory and marketplace to ensure that Laboratory developments did not end up as scientific curiosities.

Technical Excellence

There are no engineers who, collectively, are more ingenious or inventive than American engineers but, at the same time, there is no assurance that American engineering superiority will persist without constant care and feeding. The nurturing that is necessary involves education, accessibility to state-of-the-art information, and a working environment that encourages and recognizes engineering excellence. It involves a partnership between engineer and employer. The engineer, on one hand, must be

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dedicated to maintaining technical proficiency and be willing to make a personal commitment in time, effort, and expense to that goal. The employer, on the other hand, must demonstrate an understanding of the value of the technical staff by providing adequate workplaces and facilities, the opportunity to enhance the engineer's professionalism and effectiveness, and appreciation of the engineer's efforts through highly visible awards. A strong program exists at RCA to facilitate this partnership. This program centers around the operation of Technical Excellence Committees (TEC) at each participating location.

Most Technical Excellence Committees are composed of between six and twelve working engineers (no supervisors) who represent the major engineering activities at their location. Subcommittees with specific charter responsibilities are identified to cover the broad areas of **education, information, professionalism** *and* **recognition**. *The overall TEC responsibility is to conceive, develop, and execute programs in the four charter areas to enhance the professionalism of the technical staff.*

TECs are operating at 20 domestic RCA locations and also in Taiwan. The organizations that they serve range from as few as seven to as many as 900 engineers. The disparity in size and organizational goals necessitate some differences in TEC programs but, without exception, all TECs are dedicated to maintaining their engineers' currentness and viability through programs in the four charter areas. Their efforts in these areas are best described by actual initiatives that have been implemented.

Education: *In many cases, the TEC surveys its engineering community to determine what educational courses the engineers themselves feel would be valuable to their continued development. Armed with this information, TECs may arrange to sponsor appropriate courses at the location. Although they may invite local colleges to conduct courses of more general interest, all TEC locations use video-based technical courses that are offered by the Corporate Engineering Education (CEE) activity. Over seventy video courses are available from this source and they range from state-of-the-art technology to basic business, mathematics, and writing courses. At those locations where the TEC assumes responsibility for continuing technical education, it seeks and provides an associate instructor to serve as an in-class source to answer questions and monitor classroom activity. In 1983, 2,455 students attended 187 CEE classes at 32 RCA locations. The TECs at a third of these locations played a role in planning, organizing, or conducting CEE classes.*

Recognition: *TEC participation in engineer recognition programs is universal. Usually, nominations for awards are accepted from anyone who is familiar with the nominees' work—their supervisors or their peers. Some TECs have a formal evaluation system that considers a number of performance factors and scores each to provide a ranking or overall standing. Others use interviewing techniques. Successful candidates for recognition may receive a certificate or plaque, a gift of nominal value, or be honored at a luncheon or reception. One TEC inscribes the names of their TEC award recipients on a permanent display board that is mounted where all visitors and employees can see it. All TECs publicize their award winners in-house organs and local newspapers.*

Information: *Information transfer among RCA engineers and from authoritative outside sources to our engineering staff is essential for them to maintain their proficiency at the cutting edge of technology. The TECs facilitate the transfer of technical information by sponsoring in-house technical meetings. The media employed may be live speakers from within or outside of the organization, video tapes (some obtained from the Technical Excellence Center's library), or ad hoc "training" courses. One TEC invites speakers from vendor organizations to describe their complex and highly technical products. The information meetings are sometimes held at noon, sometimes after the workday ends.*

Another important area in which many TECs participate involves the location library. At those locations large enough to support a staffed library, TECs serve as an advisory role to the librarian. At some smaller locations, TECs have organized and maintain their small library collections or "reading rooms."

Professionalism: *TECs throughout the Corporation encourage membership in professional societies, obtaining professional licenses, and disclosure of inventions. They support the publication of technical articles in outside journals and in widely distributed in-house publications such as the* RCA Engineer, *or* TREND. *Engineers are also encouraged to lend their knowledge to community affairs away from the workplace. They speak on technical subjects at local high schools and make contributions of their time and expertise to local organizations.*

The fact that there are 21 successful TECs operating throughout RCA is testimony that the concept is viable—it works. Perhaps the best way to underscore that viability is to let some of the TECs speak for themselves.

Consumer Electronics

Bloomington, Ind. Bloomington's TEC feels that significant progress has been made in making itself known and useful to its technical constituency. Major efforts this past year have been: Presentation of technical lectures and displays; institution of an awards program; and a recognition banquet held for TEC award winners and CEE course participants.

Bloomington TEC's sponsoring of pertinent lecture topics and equipment displays has helped increase our technical community's awareness of new and existing technology, thus enhancing technical competence. Topics presented in recent months included: Stereo Audio for TV and "L" Line Videodisc Player Operation, which directly addressed products that Bloomington was scheduled to build. Thus, a foundation of general knowledge and familiarization was constructed for those directly involved in these products, contributing to their effectiveness and understanding. Further, equipment displays helped technical personnel broaden their knowledge of current technology that was not presently in use on a large scale in Bloomington. Displays included "Pick and Place" Robotic equipment, as well as a demonstration of three personal computers.

Institution of an awards program highlighted TEC's year. A great deal of effort and discussion in previous years was culminated late last fall when an awards charter and nomination evaluation method were put together and approved unanimously.

We are excited about this program because it shows potential for awarding individuals in areas other than Design or Development, to which awards are normally limited. In our estimation, technical people in any department who exhibit technical excellence are eligible for an award. This should be a motivational factor to those in areas such as Quality Control, Industrial Relations, and Manufacturing who are not normally involved in "building something." Rewarding technical excellence in performing one's task, whatever it happens to be, is our goal.

Overall then, through an awards program and other activities, TEC has enhanced technical knowledge and motivation to excellence. We look forward to finding new avenues to promote competence in our technical community, and urge everyone's participation.

Indianapolis, Ind. The purpose of the Indianapolis Technical Excellence Committee is to promote, encourage and enhance the professional growth of the Consumer Electronics Division engineering community by means of education, communication and recognition activities. The committee is composed of seven members representing the engineering functions at the Indianapolis location, an Employee Relations liaison (non-voting member) and the engineering librarian (non-voting member).

The TEC has been very active in the area of education. Two years ago, the TEC conducted an education survey. The survey pointed out the need for a course on television. Currently, the TEC is developing two courses on television, in cooperation with the Corporate Engineering Education Staff. Other education activities include recommendations of CEE courses and course sequences to the engineering community and reviewing and recommending books for the engineering library.

Two continuously visible activities of the TEC are biweekly lectures and newsletters. Lecture topics include new and current product technologies, technical presentations by vendors, and reviews of the activities and responsibilities of engineering departments. A communication activity that is valuable to new engineers at Indianapolis is the Engineer's Orientation Manual. The manual includes maps, organizational charts, and many other things a new engineer needs to know, but previously was not available in one place.

Recognition activities center around Technical Excellence Awards. Quarterly and annual awards are made. The annual awards are announced at an annual recognition and communications banquet, which is attended by the entire engineering staff.

New Products Division

Lancaster, Pa. This organization comprises nine members who serve 3-year terms. Three members are replaced every year to provide a smooth transition of assignments to incoming members. Additional members include a management and industrial relations representative. Two liaison individuals from the technician education committee and the video components and display components TEC Committee round out the group. The Lancaster plant contains two separate operating divisions, and therefore has two TEC groups.

The major activity of the new products TEC is the technical lecture series. Five to seven times a year, experts are asked to talk in-plant on a variety of subjects pertinent to the interests of the plant. These lectures have been well-attended in the past and will continue to be the prime activity. A second activity is the showing of monthly films on topics of general interest to the entire community over lunch periods.

A means of issuing newsletters is available to the committee and is used about three times a year. We want to double this rate because we feel that a newsletter is a valuable form of communication. It will also provide visibility for the recently initiated recognition awards program. This is an annual program, but it may be considered for twice a year.

There are four other areas of activity: Resource Directory, Education, Professionalism and Computers for Engineers. These are ongoing activities, but the newly-formed computer committee will be providing insights for engineering involvement with computers. Far too often the engineer's problem is too specialized for "canned" programs, or the program is too generalized to provide the desired quick answer. Thus the need to implement a scientific language on a local system. The technical excellence committee is an appropriate way of coordinating these requirements and can provide management with additional information to use the machines and software more effectively. The intention is to explore resources and educational needs and to offer recommendations.

Efforts have been made to keep the technical excellence committee in view as a reminder for the rest of the community that technical excellence is a daily concern for both the individual and RCA.

Video Component and Display Division

Lancaster, Pa. The Picture Tube Engineering Excellence Committee in Lancaster has been reactivated under the acronym VEEC (Video Engineering Excellence Committee).

In keeping with our new name, we have rewritten our Charter and are currently revising the Committee Bylaws. A detailed questionnaire has been distributed to our constituents in order that we may better function on their behalf. The areas surveyed include in-house and dinner lectures, continuing education and personal computers.

Although still in the planning stages, the following programs are being considered:

- Technical Lectures — Providing seminars by authoritative speakers and bringing pertinent state-of-the-art information into the plant.
- Dinner Lecture Series — Bringing programs of interest to everyone together under an informal atmosphere.
- PC Information Clearing House — Promoting computer literacy and improved efficiencies both at work and at home.
- Quarterly and Annual Engineering Recognition Awards — Highlighting contributions by the Division's most outstanding engineers.
- Continuing Education Opportunities — Providing opportunities for the development of new and existing skills.
- "Career Night" Open House — Enhancing the reputation of engineering within RCA and the surrounding community.

This committee possesses a revitalized commitment to addressing the needs of the Lancaster VC&DD engineering community.

Marion, Ind. The Marion Video Component and Display Division manufactures color cathode ray tubes for entertainment and display devices. The technical staff consists of about 200 engineers and technicians from nine different departments. Twelve persons represent these departments on a pro-rated basis. Each person serves a two-year, renewable term. Each member is appointed to serve on one of four subcommittees — Education, Lecture/Film, Recognition, or Information/Publicity.

The Education subcommittee sponsors courses that are available to employees, including hourly, if they are interested and the course is approved by supervisors. Courses may be in the form of live lectures, video tape, audio tape or self-study workbooks. Areas covered have been computer languages, effective writing, microprocessors, and manufacturing quality control. Sources of material may be RCA-CEE, computer manufacturers, or technical societies.

This year about 25 individuals are registered in the course "Chemistry for the Non-Chemist," which was obtained on audio cassette with workbook from the American Chemical Society. The course is monitored by technical staff members with chemistry degrees. The purpose of the course is introductory and serves as a first or refresher chemistry course to technical staff involved with many of the chemical processes at a picture tube manufacturing plant. Other courses planned for the year include industrial hydraulics and an engineering exam refresher.

The Lecture Film committee has shown a video tape on tube manufacturing in Brazil and one on clean room environment. The highlight lecture of the year is given by the Plant Manager, B. D. Brumley, in the fall. Usually, one speaker outside RCA is also invited to talk at this series.

Each quarter of the year the Recognition subcommittee presents an award to an outstanding engineer and technician. Nominations are submitted by peers on the technical staff. They are evaluated according to some outstanding contribution made to RCA. The award consists of a monetary sum, a certificate and a luncheon in the plant's private dining room.

Newly established this year is a separate Information/Publicity subcommittee. Its goal is to publish a quarterly newsletter on TEC activities. Also, plans have been established to upgrade the Marion RCA Library by purchasing new books and organizing a periodicals shelf.

We believe that the Marion Technical Excellence Committee has made, and continues to make, vital contributions in support of RCA's picture tube manufacturing.

Automated Systems(GSD)

Burlington, Mass. See Paul Seeley's article later in this issue.

Astro-Electronics (GSD)

East Windsor, N.J. The RCA Astro-Electronics Engineering Excellence Committee was organized in 1967 as part of the Chief Engineer's staff to foster professional growth, encourage and recognize outstanding engineering performance, and enhance Astro's engineering reputation. Since its inception, Astro's Engineering Excellence Committee has, through the work of its subcommittees, awards, library, education programs, colloquium, and Technical Excellence Newsletter, worked toward achieving these goals by offering a variety of well-received programs and services.

One of the most important programs for the Committee during the year is the Engineers' Week Activities. During this week, the Committee presents its Engineering Recognition and Excellence Awards. This year one Engineering Excellence Award, one Engineering Recognition Award, and one team Engineering Recognition Award were presented. Other Engineers' Week activities included:

- A speaker presentation entitled "How to Display Data Badly"—Howard Wainer, Senior Research Scientist, ETS, Princeton, NJ
- A taped colloquium presentation about Saturn
- Several customer-developed marketing films showing how Astro satellites will be used, as well as showing other product markets in which the customer is involved
- A display window showing pictures of the award winners, letters from President Reagan and Astro's Division Vice-President Charles A. Schmidt, and an audio-visual description of Astro's engineering wing currently being built

Taped presentations are not limited to Engineers' Week. Tapes on various topics are presented throughout the year. Over the years, presentations have included topics such as:

- The Universe
- The Voyager Mission
- AEGIS
- Space Shuttle: Mission to the Future

Another program the Committee is involved in is the after-hours education program. The Committee surveys the engineers to determine what courses should be offered. The results of this survey are presented to Astro's Manager of Training and Organizational Development, who then coordinates the offering of the courses. The Committee has, over the years, aided in the offering of courses in both the tape and live speaker media, such as:

- Basics of Celestial Mechanics
- Digital Signal Processing
- Mechanical Vibrations
- Introduction to Computers
- Systems Engineering and Management
- Telecommunications and the Computer

A Library Subcommittee was formed several years ago to advise the librarian on library services, policies, and purchases. In carrying out these objectives, the Library Subcommittee developed and distributed a survey requesting engineers' inputs concerning what library services they use on a consistent basis, as well as how to improve the library. The survey resulted in the purchase of many new books and periodicals, the purchase of Princeton University Library Cards, and the addition of new full-time library help. With the help of Astro's Engineering Excellence Committee, the Astro Library has enhanced its collection of engineering reference books and state-of-the-art periodicals.

RCA Astro's Engineering Excellence Committee is staffed by at least one representative from each major engineering activity. These representatives provide the link between the engineering community and the Committee. It is partially through this link that new ideas for professional development and recognition programs for engineers as a whole can be presented to the Committee for action.

Astro's Engineering Excellence Committee is devoted to the goals set forth at its creation. It will continue to be a principal source of professional development and recognition programs for the engineering staff at RCA Astro-Electronics.

Missile and Surface Radar (GSD)

Moorestown, N.J. This year, the Technical Excellence Committee at MSR is proudly celebrating its 20th anniversary. Conceived in July, 1964, the Technical Excellence Program was formally announced in December 1964. Early in the following year, the Chief Engineer's Technical Excellence Committee (CETEC) was established. This committee has continued to serve the technical community to promote productivity and excellence in our careers. The Chief Engineer's Newsletter has become a frequently published bulletin to highlight technical achievements and publications and to serve as a communications link directly from the Chief Engineer to the MSR engineering community.

CETEC comprises representatives and alternates from all activities with engineering responsibilities. Each representative serves a 2-year term, and these terms are staggered so that each annual reorganization replaces approximately half the members. This provides a balance in membership of incumbents and new members, and creates a dynamic council incorporating disciplines of the entire technical community. The committee charter is to provide a communications link to the Chief Engineer, to review technical achievements nominated for Excellence Awards, and to identify and respond to specific needs of the technical community as a whole in promoting productivity and excellence. Projects such as local public relations, seminar programs, and noon-time presentations and film series have been fostered by CETEC.

Perhaps the most valued activity directed by CETEC is the Technical Excellence Awards Program. The CETEC council-of-peers recommends to the Chief Engineer those individual accomplishments to be recognized in the form of Technical Excellence Awards. Candidate nominations are entertained quarterly by the committee and formally reviewed. The evaluations are based on technical achievement, business value, and individual performance. From the Quarterly Awards, CETEC selects one outstanding technical achievement for an Annual Award. Each Award winner receives a distinctive plaque and a text or reference book. The Award recipients are also honored at a special dinner hosted by the Chief Engineer as part of MSR's annual celebration of National Engineer's Week in February.

Missile and Surface Radar has maintained a high regard for CETEC and its activities over its 20-year history. The adaptability of the Technical Excellence Program to current concerns of the technical community will ensure its continued role to encourage increasingly higher levels of technical achievements at MSR.

Americom

Princeton, N.J. At RCA American Communications, the Technical Excellence Committee serves approximately 90 engineers. They are dispersed throughout 15 departments that comprise the Technical Operations Group headed by John Christopher, Vice President.

The engineering skills of each department range from spacecraft operations to facilities engineering in support of a very successful, fast growing domestic communications satellite system serving commercial and government applications.

Due to the varied nature of the departments, inter-group communications are usually limited to an output-only mode. The TEC, recognizing this limitation and attempting to promote a better understanding among the engineering community of the working relationships between departments, has initiated a lecture series whereby a different department is highlighted each month. A key individual from the department describes its inner workings, recognizes group members, describes their tasks and provides a focus on how the department output is developed.

Additionally, specialized advanced design programs being developed at the nearby David Sarnoff Research Center that may have an effect on Americom's future applications are being dovetailed into the lecture series with invited guest speakers.

The Americom TEC, in an effort to give the newly-hired engineer a definite orientation within the Technical Operations group, has developed a "welcome wagon" packet that is personally delivered by a TEC Liaison Officer. The packet consists of:

- Welcome message from the TEC Chairman
- Current issue of the TEC Newsletter
- TEC committee membership list and the name of the department representative

- Summary description of Technical Operations Group functions
- Organization Chart for the new engineer's department

The Employee Relations Department and Americom's management have been active in encouraging the activities of its Technical Excellence Committee.

Solid State Division

Mountaintop, Pa. Two CEE Courses, Introduction to Computers, C15, and Design of Experiments, M20, were offered to the Mountaintop Technical Community in 1983. A total of 19 and 8 individuals completed each course, respectively.

The TEC also offered an in-house course on personal computers which attracted 50 individuals. Separate courses dealing with the Texas Instrument 99/4A, Atari, Commodore 64 and TRS 80 home computers were presented by Mountaintop personnel.

The following Technical Seminar 1983-1984 Program was formalized:

- Process Design Overview
- High Voltage Planar Passivation
- Process Induced Defects
- Power MOSFETS
- Use of FOCUS Database Program in Mountaintop's MOS Activity
- COMFET—A New Gate-Controlled Device
- Silicon Device Reliability

Palm Beach Gardens, Fla. A Technical Excellence quarterly award committee has been formed, and two quarterly awards have been presented. One was an individual award, and the other was a team award that included Somerville personnel.

Technical seminars have been held using in-house resources and an outside consultant. The material presented by the consultant was developed jointly with Princeton. The subjects covered were statistical process control, experimental design and fundamental semiconductor technology.

Somerville, N.J. The Somerville technical community, consisting of the Solid State Government Systems Division Technology Center, and the Solid State Division at the Somerville location, represents an unusual opportunity for technical excellence. Daily work involves individual thinking, original ideas and opportunities to develop true technical innovation. One of the major goals of the TEC Program is to promote innovative team effort to insure that we remain leaders in a very rapidly changing semiconductor industry.

The Somerville area is particularly proud of the participation in the Continuing Education program. The number of in-plant courses and active attendance has steadily increased over the past three years. Through coordination with the Corporate Continuing Education Program a full list of technical courses is made available. A recent example is the addition of a full course outline in preparation for the Professional Engineer's Exam. The course, consisting of 26 video tapes and supplementary information, is presently in progress.

Other TEC Program goals are:

- Active scheduling of technical lectures and seminars
- Improved cataloging of technical information through the library and other research locations
- Sponsor the Technical Awards Program

The structure and organization of the Somerville TEC Program is such that all of the technical community is invited to participate. The committee is always open and welcomes suggestions for specialized lectures, outside tours, recommended library additions or any other means of professional enhancement.

A future goal is the encouragement of one or more computer clubs where members can exchange ideas and discuss problems or successes involving either company or personal computers. Such clubs have been highly successful in other RCA locations.

The recognized success of the Technical Excellence Program is due to the present RCA organization where full assistance is provided by the Corporate Technical Excellence Center located at Princeton, while at the same time each location is free to proceed with whatever activity best suits its specific needs.

Eta Kappa Nu Recognition of Outstanding Young Electrical Engineers

James A. D'Arcy
RCA Astro-Electronics
East Windsor, N.J.

The 1984 Eta Kappa Nu Award Program to recognize outstanding young electrical engineers has begun, and the search for candidates within RCA is nearly completed. But there is still time to nominate, if you know of someone who deserves the award.

Since 1936, nearly 50 years ago, Eta Kappa Nu (Honorary Electrical Engineering Society) has recognized outstanding young electrical engineers on an annual basis. The purpose of this recognition is to "emphasize among electrical engineers that their service to mankind is manifested not only by achievements in purely technical affairs, but in a variety of other ways. It holds that an education based upon the acquisition of technical knowledge and the development of logical methods of thinking should fit the engineer to achieve substantial success in many lines of endeavor."

To be eligible for the 1984 Award, a person must meet the following criteria:

- Be less than 35 years old on May 1st;
- Have been graduated from an accredited baccalaureate program less than 10 years on May 1st; and
- Have an electrical engineering degree (BS, MS, or PhD) from an approved U.S. college or university.

Moreover, to be considered a serious candidate, a person must have made outstanding technical achievements and must have been involved significantly in non-technical activities. The technical achievements should be such that they could be recognized by a Technical Excellence award, an RCA Laboratories Achievement Award, or ideally, by a David Sarnoff Award. However, to have received one of these awards is not a requirement. The non-technical activities could include: activities on behalf of community, state, nation, or church; cultural interests and achievements; participation in professional societies; and so on.

In the recent past (about 10 years), about 50 percent of the winners had received an MS degree and most of the remaining winners had received a PhD degree prior to having been recognized. Before 1970, about 15 percent of the winners had received a BS degree, about 25 percent of the winners had received an MS degree, and about 60 percent had received a PhD degree prior to having been recognized. Additional statistics concerning this award are included in an article, "Outstanding Young Electrical Engineers," which is contained in the Feb. 1971 issue of *The Bridge* published by Eta Kappa Nu.

Other insights concerning the Award Program observed during the past 10 years could be of interest. For example, the age range of winners during this period is about 28 to 32 years old. These winners have had technical assignments, both in management and in nonmanagement roles. The winners' nontechnical activities have covered a wide spectrum, including: professional society involvement; involvement in community and church activities; and cultural achievements (music, art, language, and so on). It should be emphasized that the foregoing statistics and insights are not rules. If a young electrical engineer has been making outstanding technical contributions and seems to have a notable amount of nontechnical activities or interests (as described above), submission of a nomination should be considered seriously.

In this Award Program, there are several levels of recognition: winner; honorable mention; and finalist. Only one winner, the highest level of recognition, is chosen each year. Generally, one to three candidates are chosen for honorable mention. The winner and those receiving honorable mention are chosen by a Jury of Award from among a small group of finalists. Candidates who have passed the stiff initial screening are called finalists. Since 1981, those finalists who have never been recognized as winner, honorable mention, or finalist, have been recognized as finalists. To commemorate the recognition, each winner receives a certificate at an Award Banquet that is held in April of the succeeding year.

Since this Award Program is a national activity of Eta Kappa Nu, past winners have been associated with many different organizations throughout the United States. Most recently, the winners have been associated with the following organizations: IBM Corp.; RCA Corp.; Bell Laboratories; Cornell University; Westinghouse Electric Co.; Raytheon, and so on. Three of the winners have been associated with RCA: Morton H. Lewin (1966, formerly RCA Labs); George H. Heilmeier (1968, formerly RCA Labs); and John G. N. Henderson (1977, RCA Labs). Several RCA employees have received honorable mention and several have been recognized as finalists.

If you would like further information concerning this Award Program, for example, biographical sketches of past winners, contact Jim D'Arcy, RCA Astro-Electronics (TACNET 229-2359). If you are a member of Eta Kappa Nu, the RCA Technical Excellence Center (Princeton) would like to know. Please inform Gerry Moss (TACNET 226-2410) and include your Chapter, if possible.

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Reprint RE-29-4-TN

Paul E. Seeley

Technical Excellence: A motivational tool, or an exercise?

From the vantage point of 19 years of experience with Technical Excellence, here's a look at the program, Automated-Systems style

The telephone call to an engineer by the business unit chairman for Technical Excellence (TE), brought forth a response not atypical of many "grass-roots" engineering opinions. The chairman had been talking to an engineering candidate for service on the Technical Excellence Committee—the candidate's name had been submitted by a Section Manager to fill a vacancy.The candidate responded to the chairman: "You want me to serve on the TE Committee. Why should I? I see no indications that the Technical Excellence program has ever motivated engineers to do a better job. Prove to me that I am wrong. I am willing to listen!"

Thus started a discussion repeated many times before among managers, engineers and particularly those responsible for conducting and maintaining Technical Excellence programs for their business units.

Abstract: *A brief history of the Automated Systems Technical Excellence program introduces us to the present program and the methods being used to keep it effective as a promoter of engineering viability at the Burlington, Massachusetts facility. The author describes some results of engineering motivation studies and key lessons learned over the 19 years of the program's existence at Burlington.*

Final manuscript received May 31, 1984
Reprint RE-29-4-3

Raising the question

Basically the question is: "Is our program working and how do we measure its effects?" Having been associated directly with Technical Excellence since 1979, and as one involved in varying degrees in TE for its 19 years at Burlington, I am very familiar with these discussions.

Looking at motivation

The role of "tangible rewards" in motivation is the basis for TE activities. It is discussed in the context of the total motivation subject in the following paragraphs.

The motivating of engineers in a large corporation has been the subject of wide research and reporting. Maslow's theory (1954) postulated five general classes of basic needs—physiological, security, social, self-esteem, and self-actualization. They represent levels where the lowest level must be satisfied before the next higher level can be reached. Maslow's theoretical model addressed the general population; pertinent research[1] concerning engineers has further refined the basic understanding of motivation. The following is a list of eight psychological factors that apply to the motivation of engineers.

1. The view that people inherit most of their performance capabilities and are motivated only by reward and punishment has proven inadequate.
2. Every person has multiple needs. Though the specific forms those needs take are highly individualized, the basic needs themselves are shared by everyone.
3. The emergence of a need does not follow a specific rigid pattern.
4. A satisfied need is not a motivator of behavior. As one need is fulfilled, another need emerges.
5. It is not necessary to satisfy a "lower" need fully before a "higher" need may emerge and operate as a motivator.
6. There is no universal motivator for all people, nor is there a single motivating force for any one individual. Rather, the significance of each need varies from one individual to another and varies for the same individual from time to time.
7. There are individual differences in the most appropriate ways to satisfy the same need.
8. Motivation is internal to the individual. A person is not motivated by what people think he ought to have, but rather by what he himself wants.

Motivation can be stimulated or retarded through positive or negative factors. A recent study[2] concluded that negative factors (demotivators) have a great effect on motivation. The five most important demotivators that need to be eliminated or minimized are:

1. Arbitrary assignment of tasks without consultation or negotiation.

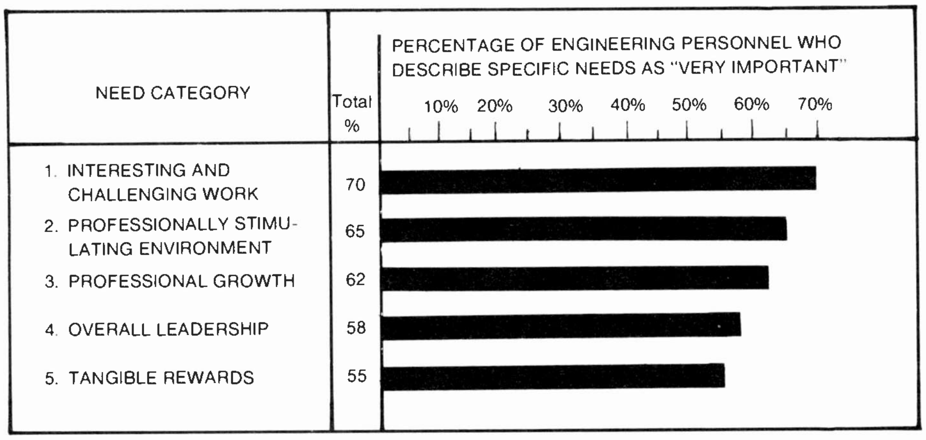

Fig. 1. *Five most important motivational categories as identified by engineering personnel.*

2. Lack of opportunity to exercise one's own expertise. Failure to give a person the opportunity to use his or her expertise leads to frustration and feelings of loss of self worth.
3. Inequitable distribution of tasks. Disproportionate workload assignments often lead to a feeling of being used or not being adequately involved in the decision-making process. This can result in a drop in productive output.
4. Failure of others to listen to or understand one's ideas: Not being heard is often given as a reason for being "turned-off."
5. Lack of clarity concerning project goals, the framework for accomplishing them, and the roles of the team members.

Previous studies agree that motivation is desirable and efforts to increase the motivational level seemed to work best when multiple approaches are used. The successful employment of motivational tools results in a more motivated engineer who is more productive.

Motivation studies conducted in the early 70's[3] and updated with additionalresearch have identified 16 categories of motivational factors. They range from "Interesting and Challenging Work" to "Open Communications" and "Minimum Changes."

The five most important motivational categories as identified by engineering personnel are shown in Figure 1.[4]

As Technical Excellence awards are in the category of TANGIBLE REWARDS of Figure 1, it is interesting to note that 55 percent of the engineering professionals surveyed rank tangible rewards as very important. (Tangible rewards are defined as financial rewards such as salary increases, as well as other rewards such as promotions, praise and recognition, better offices, and educational opportunities.)

As indicated, a subcategory of TANGIBLE REWARDS is "praise and recognition." TE programs, although they provide small gifts, are mainly aimed at "praise and recognition."

The importance of engineers being motivated through multiple positive reinforcements was formalized by RCA 19 years ago when they began the Technical Excellence program. RCA's history of Technical Excellence Awards has been and continues to be a major positive factor in motivating and inspiring engineers to continue meeting greater technological challenges.

Automated Systems starts TE

In 1965, Automated Systems (then known as Aerospace Systems Division) began its Technical Excellence Program. The idea was to have one group award and several individual awards each month. Also, the individual awards were made in several categories each month: Engineer of the Month, Draftsman of the Month, Technician of the Month, and so forth.

As this program developed, a number of problems surfaced, such as:

- High-technology assignments attracted more awards than the mainstream business, thus inhibiting widespread participation.
- Awards were made on a monthly schedule as a first priority rather than on merit as the primary emphasis.
- The initial momentum was difficult to sustain, and with time the program appeared to be losing enthusiasm.

Later, with experience, the TE program was restructured and most of the early shortcomings and out-of-balance activities (in terms of providing recognition opportunities to some and not others) were eliminated. Rather than elaborate on the interim trial-and-error steps during the evolutionary period, I will focus on the following topics covering present-day activities, observations, and their results.

Present Technical Excellence program

The present TE program is aimed at reviewing/selecting exemplary cases of extraordinary technical and professional achievement, and giving recognition and rewards in the cases identified.

Criteria for awards

By extraordinary achievement, we mean some or all of the following:

- Solutions were provided to difficult technical problems and were a major factor in a program's success as measured by: on-time and on-budget delivery; customer-acknowledged satisfaction, follow-on business opportunity generated, future cost-saving benefits generated.
- Professional results were accomplished that were of value on current and future programs and could be used effectively by others to increase output or to provide better products.
- The project output produced a patent application, or software of value.

Presentation of awards

The awards are given for individual achievement and team achievement. All TE awards are presented at an in-plant luncheon ceremony. The awards are presented by the Division Vice President and General Manager of Automated Systems working with the Chief Engineer and the Chairman of the TE Committee. The individual typically receives an engraved TE medallion and a technical book of his/her choice. The team member receives a certificate of TE accomplishment and a gift.

Figure 2 shows a typical individual TE Award at Burlington from the late sixties. Figure 3 is a present-day award made during the Fall of 1983. It was presented to Kenneth St. Pierre for his outstanding technical contributions in the design of a digital finite-impulse-response filter for the Simplified Test Equipment manufac-

Fig. 2. *A typical individual TE award at Burlington in the late sixties. Left to right: E. P. Tangney, H. J. Woll, J. M Anderson (recipient), I. K. Kessler.*

Fig. 3. *A TE award presented in the Fall of 1983. Left to right: A. T. Hospodor, K. J. St.Pierre (recipient), D. M. Priestley.*

tured by RCA and used for field maintenance of the new Bradley M1 Army tank.

Reactions by the technical staff

My personal observations of the program are as follows:

- I have never seen a case where a recipient did not appreciate receiving an award. Typical responses were: "There is more to the job than just the paycheck; management is not impersonal, but really does appreciate its staff and their contributions and is willing to demonstrate this."
- Communications were always improved between management/supervisor and recipients through the process of getting better acquainted at the luncheon. This improvement was usually a permanent one.
- The spouse was given an opportunity to get better acquainted with RCA personnel and the job activities and really seemed to appreciate the chance to be among the guests at the awards luncheon.

The need for multiple activities

Experience with the program has taught us that the TE achievement program should be an integrated part of a total plant activity that encourages professional creativity, productivity and continued education. Some examples from Burlington follow.

IQ. In addition to the Professional Recognition program, we have an IQ (Involvement in Quality) program for manufacturing personnel. (See article, T.I. Arnold, *RCA Engineer*, March/April 1984.)

Sigma Xi. We have the RCA Burlington Branch of the Scientific Research Society of America (Sigma Xi). The branch is operated as an after-hours club by its members, who currently number 44. Technical seminars, however, are open to all interested RCA employees.

Continued education. At Automated Systems all BS graduates in engineering hired since 1981 are working toward their MS. This is done via application and acceptance to the Automated-Systems Accelerated GSP (Graduate Study Program), or through an after-hours course of study at one of the several eastern Massachusetts engineering colleges or universities with night programs.

Lessons

Two examples of lessons learned are:

Teams. Team awards are, in most cases, more difficult to handle than individual awards, but are still well worth doing. The difficulty arises in two ways. One is the minor problem of the increased logistics of inviting the various representatives to the luncheon (teams are frequently made up of different disciplines of EE, ME, draftsmen, technicians, and so on). The second problem is more important: Which people make up the team? Does it include only the full time, key performers - no more, no less?

Quotas. It is best not to set number-of-awards budgets based on calendar periods. Our experience has shown that deserving individuals and teams should be considered at any time, and as frequently or infrequently as merited without setting quotas.

Annual recognition dinner

Each year there is a Professional Recognition Dinner. This is held at a restaurant as an evening function. Attending the

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Contact him at:
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Burlington, Mass.
TACNET: 326-3095

dinner are recipients who, in the previous twelve months, published or presented professional papers relating to their jobs, received patent filings or patent grants, earned advanced degrees in engineering or science from a college or university via after-hours or GSP continued education, and/or received an individual TE award.

Summary

In summarizing one finds that, notwithstanding its role in the category of TANGIBLE REWARDS, the question of whether the TE program is a motivator for professional excellence is best passed over for several broader considerations. Here are the fundamental, more important questions to be examined and answered:

- Are the outstanding achievers getting recognition by their peers and by management?
- Are the recipients getting something worthwhile out of the program including increased interest and pride in their jobs, as well as the awarding of a gift?
- Does the program promote communications and technical interchange?
- Is the program structured so that recent graduate engineers have equal chances to be awards recipients as senior designers?

At Automated Systems, we give a resounding affirmative response to each question.

Because our future, in part, depends on maintaining an effective TE program, we believe that the principles outlined here will enable us to continue to conduct a successful program at Automated Systems.

References

1. "Motivating Engineers: A Little Psychology Goes A Long Way," Machine Design, Oct. 16, 1975.
2. I. Federman, "Motivating and Demotivating," Electronic Engineering Times, March 16, 1981.
3. G. R. Gemmill and J. H. Thamhain, "The Effectiveness of Different Styles of Project Managers in Gaining Project Support," IEEE Transactions on Engineering Management, May 1973.
4. H. J. Thamhain, "Managing Engineers Effectively," IEEE Transactions on Engineering Management, Nov. 1983

Corporate Engineering Education Catalog released

Corporate Engineering Education (CEE) is now in its seventeenth year of delivering continuing engineering education programs to the RCA technical community using a "Tutored Video Instruction" delivery system. During this period over 24,000 course enrollments have been served; first from offices in Camden, then for nine years in Cherry Hill, and since June, 1983, from our new offices in the RCA Technical Excellence Center in Princeton.

While all our staff takes pride in our history, we look forward to the current and future challenges of maintaining and improving our service to the RCA technical community. For example, significant effort has been spent in recent years to improve video course production values. We invite you to try the newest RCA-produced course releases (E60: Television Engineering Fundamentals and MF22: Applied Robotics) and to compare them with earlier CEE courses (See Table I). We think you will find that significant strides have been made.

This summer the CEE Video Course/Videotape Library Catalog was sent to those on the *RCA Engineer* mailing list. This catalog contains 16 new video courses and a total of 73 video courses for use throughout RCA. The CEE Videotape Library has expanded from 69 listings in the last catalog to 135 listings in this catalog, a growth of 96 percent. With over 90 pages of catalog material, this publication is available free from Mary Pjura, TACNET: 226-2972.

Another major change in the nature of CEE catalog offerings is the increase in the number of purchased courses. During the past 6-7 years, the number of quality video course packages available from outside vendors has increased at an astounding rate. CEE has taken advantage of this new availability of outside courses with the result that more than one third (25 of 73) of the video courses in this catalog are now purchased courses.

In addition to the Video Course and Videotape Library services, CEE personnel have been involved for the past two years in the development of the National Technological University (NTU) concept. NTU offers the promise of convenient, high-quality master's degree programs and non-credit continuing engineering education programs delivered at the plant site by satellite. A full-page description of NTU appears in the catalog.

The CEE staff looks forward to another exciting year in partnership with RCA's technical community. We are your resource and we need your ongoing support and advice to be effective. The CEE Contact Guide is the place to start (Table II).

Table I. *What's new in the 1984-85 CEE Catalog?*

Sixteen new course packages have been added to CEE offerings since publication of the last (1982-83) catalog. Fourteen of these new courses are available as of June 1984. The remaining two (E60 and MF22) will be available in September 1984.

- **C10: Computers at Work**
  Designed to help the novice understand computer-based systems and their applications.
- **C46, C47: Ichbiah, Barnes, and Firth on Ada®,II**
  A two-course sequence presents the Ada programming language and modern software methodologies.
- **C75: Telecommunications and the Computer**
  Telecommunications links and their use in computer data transmission.
- **C76: Packet Switching Networks**
  On operation, tradeoffs, and design of packet switching networks.
- **C77: Local Area Networks**
  On planning and/or implementing an interactive system using a local area network.

- **D15: Applicon 2D-PCB Program**
  On the system commands and procedures available in the Applicon 2D-PCB package.
- **E17/EL17, E18/EL18: Digital Electronics I,II**
  A two-course sequence that presents analysis, design, and debugging of digital systems and circuits.
- **E55, E56: Plasma Deposition of Microelectronic Films in VLSI Processing I,II**
  A two-course sequence that presents the basic mechanisms of plasma disassociation of donor gases and the role of bias on the substrate where film growth occurs.
- **E60: Television Engineering Fundamentals**
  Presents concepts of basic television systems including TV signal transmission, color cameras, video recorders and emphasizing color receivers and monitors.
- **G10: Professional Engineer's Exam Refresher Course**
  Review of mathematics and basic engineering sciences to help prepare for the Fundamentals of Engineering Examination.
- **M21: Design of Experiments II**
  Conclusion to the two-course sequence (M20, M21) on the principles and techniques of experimental design.
- **ME10: Finite Element Methods in Engineering Mechanics**
  On the modeling and solving of structural problems using the finite element method.
- **MF22: Applied Robotics**
  RCA-produced course on the successful application of robots in the manufacturing environment.

Table II. *Your CEE contact guide.*

To inquire about:	*Contact:*	*Extension:*
Video Course Scheduling/Ordering Video Course Administration Procedures Video Course Certificates/Transcripts	Shirley Treherne	2227
Videotape Library Scheduling/Ordering	Mary Pjura	2972
Teaching Considerations Technical Content of Course Offerings	Rick Zang or Frank Burris	2131 2971
Educational Consultation	Frank Burris	2971
TV Studio Services	Marc Orton	2159
To request:		
Video Course Outlines Video Course Study Guide Previews	Shirley Treherne	2227
CEE Catalogs Videotape Library Catalog Supplement	Mary Pjura	2972
To submit:		
Ideas for New Courses Suggestions/Criticisms of Current Courses	Frank Burris or Rick Zang	2971 2131
New Tapes for Videotape Library	Rick Zang	2131

CEE mail should be addressed as follows:

Internal (RCA) Address: Princeton Labs—Roszel Road

Outside Address: RCA Technical Excellence Center, 13 Roszel Road
P.O. Box 432, Princeton, NJ 08540

Use telephone number (609) 734-(extension)
or TACNET 226-(extension)

H.B. Law

The shadow-mask color picture tube—How it began

At the end of September 1949, with color television at a critical developmental stage, RCA researchers working individually and together engaged in a no-holds-barred effort that led to technologies still in use today. Here's the behind the scenes story.

In 1950, RCA demonstrated the first practical color television picture tube using the principles devised by Dr. Harold B. Law. These principles are still in use today, a remarkable demonstration of their importance. Dr. Law died in April, but he left with us his insider's view of how the development came about, his initial thoughts, the trials and errors, and the thrill of final success. Published in 1976, Law's tale is more than just history: it's an inspiring picture of how inventions are made. For those who may not have ready access to the original, an excerpt is reprinted here, prepared by Edward W. Herold.*

Toward the end of September 1949, at RCA Laboratories, Princeton, New Jersey, selected members of the Technical Staff were asked to attend a special meeting. No reason was given and I could not help but wonder what it was all about. One of the main topics of interest at the Laboratories was RCA's ongoing objective to devise a system for broadcasting television pictures in color without making obsolete the million or more black-and-white receivers then in use. Therefore, I suspected it might have something to do with this subject.

Color television was at a critical stage. The Federal Communication Commission had called a series of hearings earlier in 1949 to discover whether or not it was possible to standardize on a color system within the 6-MHz channel then in use for black-and-white. The CBS group advocated a field-sequential system that they demonstrated by using a rotating filter-disk display. Because this system was not compatible with the black-and-white system, the transmitted pictures could not be received on the large number of receivers already in use, and that were being sold by RCA and others at a great rate. The RCA workers had devised a subcarrier color system which *was* compatible; that is, it produced good black-and-white pictures on existing receivers, and color pictures on experimental color receivers designed to demodulate the subcarrier. Unfortunately, existing projection-tube displays and a very complex direct-view display containing three orthogonal picture tubes whose pictures were combined by mirrors lacked convincing evidence of practicality. In summary, it appeared that, unless a direct-view color picture tube were developed, it was likely the country would have no choice but the CBS color system, and it would compete with black-and-white, rather than complement it.

We were told that RCA had decided to embark on an all-out no-holds-barred effort to develop a color-picture tube. Feasibility was to be shown in three months. There was to be no limit to expense, and any manpower that could contribute, anywhere in the company, would be made available. The task of coordinating and organizing the activity was assigned to Edward W. Herold.

When the meeting ended, the enormous importance to RCA and to the television industry of our successfully meeting this challenge was quite clear, but how it could be done was equally unclear. My close associate, Al Rose, prepared an internal report outlining all the previously suggested ways to make a color-picture tube, and I must say it wasn't very encouraging. There just didn't seem to be a really workable idea.

Before continuing with the story of what happened next, I want to go back to my work on color tubes that dates from 1946, since it shows the background that I had at the start of the crash program. In mid-1946 I learned of an idea of one of my colleagues, A. C. Schroeder, which prompted me to record the following in my notebook:

> It seems on thinking the matter over that Schroeder's idea for a three-color kinescope deserves a try. The idea referred to is one in which three guns scan a grill that serves to mask lines of different color phosphors from certain of the beams.†

* Adapted, by permission, from the *IEEE Transactions on Electron Devices (ED-23, July 1976). Published in slightly different form in the RCA Engineer*, Vol. 22, pp. 88-94, June/July 1976.

† Neither Schroeder nor I knew in 1946, or even long afterwards, of a related earlier invention by a German scientist, Werner Flechsig, which issued as a French patent in 1941.

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I then made several attempts to construct a screen, but with no success.

Two years elapsed before I tried again, this time by settling a screen through a grill. A sharp line pattern was obtained but with defects. It was then (1948) that I made the following entry in my notebook:

> It would be highly advantageous if the phosphor strips could be applied by a photographic process since it would be easy to get a good mask by ruling and etching glass and filling the grooves with opaque material. Such a process would accommodate itself to a curved faceplate.
>
> It may be possible to do the job by settling the phosphor in a photosensitive solution of gelatin, potassium dichromate and silicate binder. When the solution is poured off it would be light sensitive. Exposure would harden the gelatin and trap the phosphor while the unexposed portion would rinse away. The silicate binder might have to be omitted.
>
> Subsequent firing in the air would remove the gelatin and leave the phosphor. The second set of strips could then be applied.

I was not to become aware of the importance of this entry until some years later when it became the basis of phosphor deposition now used in all color-picture tubes.

It was early 1949 before I again returned to further color-tube experiments. I tried a structure consisting of thin metal vanes mounted perpendicular to the faceplate with phosphor on the sides of the vanes and on the faceplate between the vanes. With alternate vanes electrically tied together, the electron beam could be made to strike the sides of one set of vanes or of the other set, or go through to the glass for the third color, depending on the voltage applied. The voltage required between the sets of vanes to obtain a single color was excessive, so I started to design a three-gun system that avoided high-voltage switching to change color. Slot apertures between the vanes permitted each beam to see only one color in an application of the shadowing principle.

I also built three guns in a delta formation and put them into a 12-in. tube with a white screen so that I could look at the problem of keeping the spots together during deflection. The angle between the guns and the tube axis was about 2°, and each gun was independently mounted on a rod so the spots could initially be brought into coincidence at the center of the screen by warming up the glass.

When the opportunity came to go all out on the "crash program" to build a color tube, my mind again went back to the shadow-mask idea but this time to a different form of the Schroeder design in which the mask contained a hexagonal array of holes instead of a wire grill. The problem was: how can the positions, beyond the apertures where the electrons are going to strike, be precisely located; and how can one then place phosphor dots at exactly these locations in a practical and straightforward manner? Then all at once the thought occurred to me that, after deflection, the electrons travel in field-free space so their paths will be straight and can be simulated by light. Therefore, a light-sensitive material, such as a photographic plate, temporarily positioned in the same location as the faceplate, could record the phosphor-dot positions for a given color if a point light source were placed at the deflection center of the beam for that color. If a photographic plate were used, one could then print a photoresist pattern on thin metal foil such that the black spots or phosphor-dot locations would not be exposed and would develop out free of resist. Holes could then be etched through the foil where the phosphor dots should be, so the foil could be used as a settling mask. All that would be required in addition was to provide some way to locate the settling mask in the proper position on the faceplate. For this purpose, alignment holes in the mask frame could be used to record alignment marks on the photographic plate at the time of exposure.

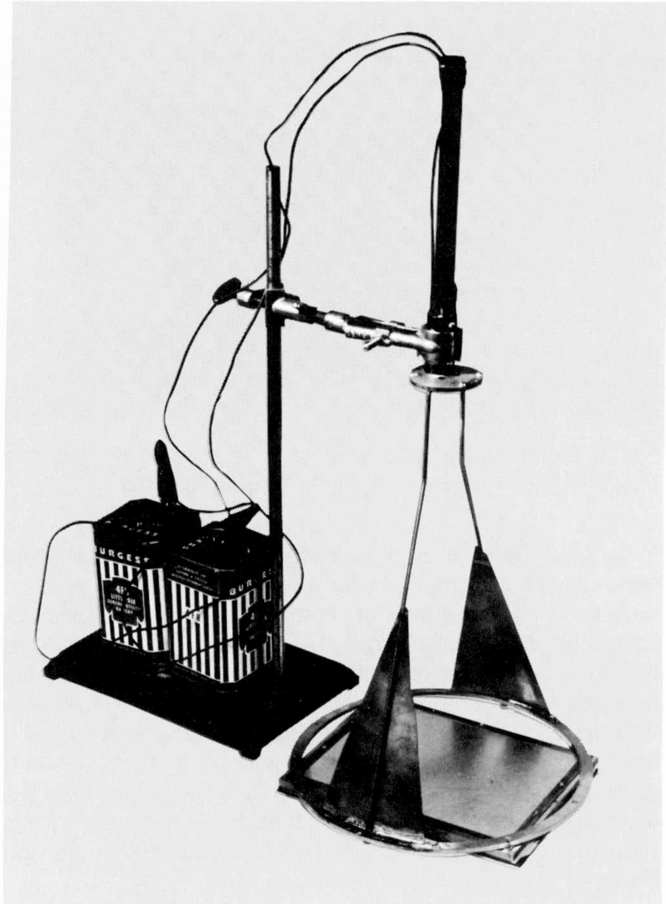

Fig. 1. *Lighthouse used in printing the first experimental shadow-mask color tube. A photosensitive film is located in the phosphor-screen plane. It is exposed from a point source in the lighthouse and through the shadow mask to locate the desired phosphor dot positions.*

I immediately began to design the tube geometry and to think about construction details. Since I had no thin metal with a hexagonal array of apertures for a mask, I decided to make the mask by etching. But first I needed the proper photographic pattern of dots, so I wound a wire grill on a frame of threaded rods and with the help of Tom Cook, our laboratory photographer, made a double contact print, the second exposure after rotating the grill 60°. A hexagonal array of diamond-shaped elements was produced, but Tom was able, by printing with an overexposure, to round off the sharp corners to produce a usable pattern. With this pattern I made the first thin metal masks.

In preparation for making the first phosphor screen, the step was to make exposures through the mask from three points mounted in such a position that the color centers would coincide with the center of deflection of the yoke when the yoke was placed in its normal position on the tube neck. In addition, it was necessary to have a means to determine the correct orientation of the three-gun cluster at the time it was being sealed in the tube neck. For this experiment the problem was solved by building a superstructure or "lighthouse," which was attached

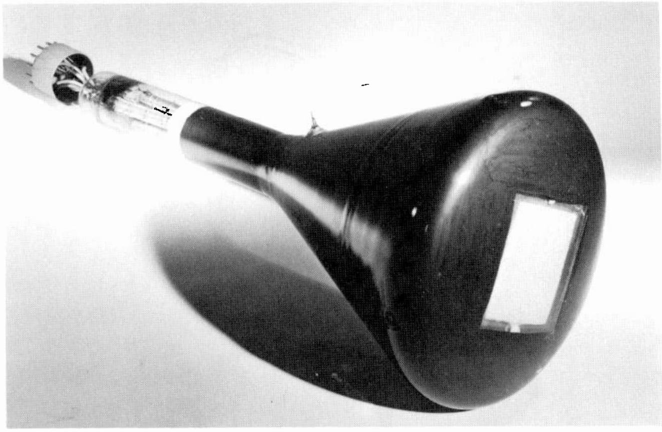

Fig. 2. *Experimental shadow-mask tube used to display color pictures on this type of color tube for the first time.*

to the mask-frame assembly and carried a small metal plate with three exposure apertures as shown in Fig. 1. Three exposures were made on three pieces of photographic film, after which the remaining steps were carried out according to plan; finally the lighthouse was removed after the mask-screen structure had been put in place in the tube. Three individual electron guns were sealed into the tube neck on tungsten rods, as described in the earlier experiment, and the tube put on a vacuum system to pump. Two guns gave enough emission to test but the third was inoperable. Nevertheless, it was a thrill to see the screen change from one color to another by simple adjustment of the grid biases.

The mask-screen structure was repeated and, after a couple of tries, a tube was produced in which red, green, and blue color fields could be produced and the grids could be modulated with video. At this point, about six weeks after the September meeting, the tube was turned over to L.E. Flory and his associates who had been assigned the circuit program for operating the tube. They used small permanent magnets to achieve coincidence of the deflected spots in the center of the screen and were able to show three-color pictures for the first time on a shadow-mask tube. I recall Les Flory being so pleased with the result that he declared we would be making color pictures the same way five years from now. It sounded like a rash statement then, but actually it has been more than twenty-five years and the shadow-mask tube is still the only one in use. Moreover, light exposure in a piece of equipment called a lighthouse is still used today in practicing the same basic procedure for locating the phosphor dot positions. A photograph of this first tube is shown in Fig. 2.

Of course, the inauguration of the RCA crash program led to many other projects within the company. A full description of accomplishments of these and other projects at RCA plants in Lancaster, Pennsylvania, and Harrison, New Jersey, will be found in a series of eleven papers published in the special Color Television Issue of the *Proceedings of the IRE*[1], but the status of the projects of RCA Laboratories as of two months after the September meeting are contained in notes made by Ed Herold at the time. He wrote, in part, as follows:

> A group from Harrison, another group from Lancaster, and a somewhat larger group from RCA Laboratories at Princeton, was shown a number of color reproducer projects at Princeton . . .
>
> One of the demonstrations showed a color picture on a single tube reproducer using 150 sets of three-color phosphor lines and a single electron gun . . . A 150-line, noninterlaced, scanning raster was used, accurately aligned with the ruled phosphor line sets. The picture was approximately 4-1/2 inches by 6 inches . . . and was quite excellent and showed about 300 lines horizontal resolution and good color fidelity . . .
>
> A second demonstration showed . . . a single-gun tube using the shadow-mask direction screen (see below). This tube was demonstrated with a television black-and-white broadcast picture, which could be shown in any one of three colors by rotating a yoke around the neck of the tube.
>
> A three-gun tube was demonstrated that employed a shadow-mask screen aligned with tri-color phosphor dots. This tube produced a color picture approximately 4 inches by 5 inches with good rendition of colors, and adequate brightness. The color picture appeared to be well registered and converged at the center of the picture, and fair registry was obtained out to the edges. Either simultaneous or dot-multiplexed signals could be employed. Because of the small number of dots employed, resolution was not high but the future possibilities of this method seemed clearly demonstrated.
>
> Still another demonstration showed a demountable form of reflected-beam tube in which the colors were switched by manual adjustment of the voltage on the transparent conducting coating. A monoscope test pattern was employed and could be shown in any one of the three colors.

The results described, after only two months of intensive work, were so encouraging that doubts and gloomy forecasts were forgotten.

In my case, I decided to make the shadow-mask tube with a larger screen size and found that the mask had to be stretched tightly over a frame to obtain geometric stability. The settling masks were more difficult to make and use, and the assembly techniques were very crude for the accuracy needed. However, Ed Herold and many others were convinced of the promise of the shadow-mask tube and the "lighthouse" technology for making it. My own efforts were soon swamped by an avalanche of others helping in many ways with the objective of making a tube with 12-inch diagonal picture size.

At the FCC, the showdown was still ahead over which color system would be approved by virtue of the type of standards to be adopted, so that efforts were redoubled to produce the best tubes possible for an upcoming demonstration.

Early in February 1950, another internal company demonstration was held which, in the perspective of the time, was described in Ed Herold's notes as follows:

> A large group of visitors from Lancaster, and from Harrison were shown a series of demonstrations on Saturday, February 11, 1950, at RCA Laboratories, Princeton . . . By the time of this demonstration, 16-inch metal envelopes had been employed for some of the types and a silk-screening technique had been worked out for making line-screen tubes and shadow-mask dot-screen tubes . . . Substantial progress had also been made on the reflected-beam type of tube, which was made in a sealed-off version . . .
>
> A 9-inch by 12-inch picture using the shadow-mask direction screen and a single electron gun operated from a standard RCA dot multiplex signal was demonstrated and shown to have good color fidelity with fair picture brightness. A three-gun form of shadow-mask tube was also demonstrated and showed a picture that was also considered to be generally excellent at the time. The reflected beam tube was operated, using a 7-1/2-inch diameter screen with a picture having approximately 150 to 200 lines resolution, with good fidelity and complete freedom from the registration or convergence problem . . . A two-color tube using grid control was demonstrated, but was somewhat low in brightness. Black-and-white pictures as

well as color reproductions were shown on all these types of tube.

The line-screen tube was shown in operation with an automatically registered scanning raster but no picture was shown.

Continuing, we learn of further developments:

> Work was started on a receiver for the three-gun type of shadow-mask tube and a second receiver for the one-gun type. In each case, a standard 16-inch black-and-white receiver was used and the additional tubes and circuits added for the color kinescope so as to convert the receivers. In the case of the three-gun type, it was decided to use a cathode-sampling circuit and every effort was made to use a sufficient number of tubes and components to permit a high quality picture reproduction. Separate high-voltage supplies were used, capable of delivering about 13 kv for the early test. The finished receiver used 19 additional tubes over those originally in the black-and-white receiver.
>
> The receiver for the single-gun shadow-mask color tube, on the other hand, was designed so as to introduce the fewest number of tubes and the simplest of components. It was found possible to make this receiver with only ten additional tubes over the black-and-white chassis . . .
>
> On March 23, 1950, an informal demonstration was given to the Federal Communications Commission . . . On March 29, a public demonstration was made, which received major attention in the press . . . .

One succinct trade-press comment comes from the *Television Digest* after the March 29 demonstration:

> Tri-color tube has what it takes: RCA shot the works with its tri-color tube demonstrations this week, got full reaction it was looking for—not only from more FCC members and several score newsmen, but from fifty patent licensees who came to see for themselves.
>
> So impressed was just about everybody by remarkable performance, that it looks now as if RCA deliberately restrained its predemonstration enthusiasm to gain full impact. "Now we're getting somewhere," was essence of comment, especially among manufacturers. Previously, solidly sold on compatibility and fairly well sold on RCA's system, many seemed ready to go all the way with RCA now that they've seen normal-looking, compact receivers (no "grand pianos") giving decent pictures.
>
> Adoption of either CBS or CTI, by themselves, can now be ruled out unequivocally. Their only chances, particularly those of CBS, lie in multiple standards permitting virtually any 6-Mc system . . . .

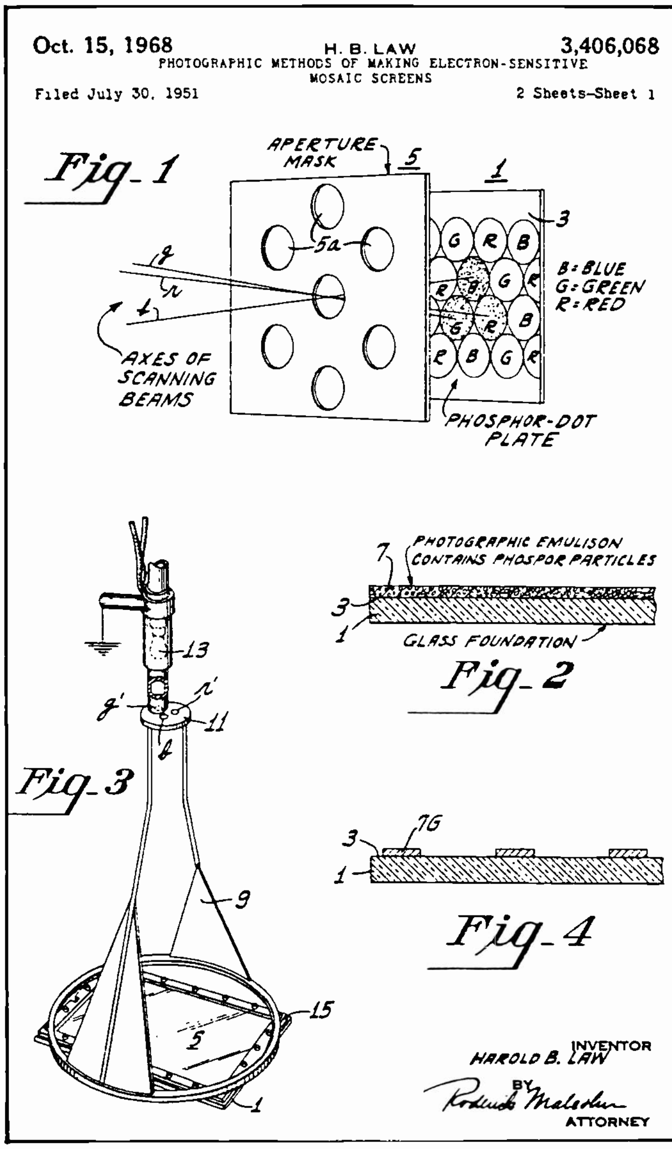

Fig. 3. *The 1948 notebook entry on photodeposition of phosphors led to this important patent, issued in 1968. The "lighthouse" shown is covered by U.S. 2,625,734, issued in 1953.*

Although color broadcasting standards remained in doubt for a long period of time, there was no doubt about the utility of the shadow-mask tube, because it was suitable for either the CBS or RCA system. The major problem was how to mass produce the tube at a reasonable cost. Having to process a photographic plate and make a silk screen for each tube was expensive. The solution seemed to be traditional mass-production techniques making use of interchangeable parts. Progress was being made toward interchangeable masks, but it was accompanied by an enhanced appreciation of the geometric distortions that can be produced when the mask is mounted on a frame under highly stressed conditions.

In the midst of the struggle for mass production at RCA, a new technical development was announced at CBS-Hytron and later published[2] Instead of using a flat mask and an internal screen plate, the mask was spherically curved and mounted close to the similarly curved faceplate of the tube. Phosphor was applied by means of the lighthouse to directly expose a photosensitive binder containing the phosphor on the inside of the faceplate. The exposed portion remained and the unexposed portion could be washed off. A repeat of the process made it possible to successfully print all three primary color phosphors.* Clearly it was not an interchangeable system, but it didn't have to be. I was convinced of the approach's merit, but it was an important decision for RCA.

Within a short time, RCA Lancaster put together a curved-mask tube using photosensitive binder for phosphor deposition and confirmed the considerable advantages inherent in the system. One of the most obvious advantages to the viewer is the display of the picture on the tube face as in black-and-white picture tubes rather than on an internal screen. RCA adopted the system which essentially opened a new era in the practical

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* As was seen from the quotation from my 1948 notebook above, I had already proposed depositing phosphor in a photosensitive binder and suggested that it would work on a curved plate. A patent was applied for in my name by RCA on the process. Although I was first to conceive the invention, an interference was declared with another inventor. After extended litigation, I prevailed and was granted patent No. 3,406,068 in 1968 (Fig. 3).

manufacture of the shadow-mask color tube and marked the end of the early development period.

Many of my colleagues and I continued on in color-tube work as a career. What followed were years of frustration at the slow progress of color television in the marketplace. How could color sets be sold when color telecasts were few and far between? Who would be willing to pay for programs in color when there were only a sprinkling of color sets among all the television sets in use? To top it off, color sets were expensive, and there was occasional publicity about work in progress on new color tubes that promised to be less complicated and cheaper than the shadow-mask color tube—both fostering the notion of waiting until color was "perfected" before buying a set. However, successful commercialization of another type of color-tube display did not materialize. This was true partly because of continuing successful efforts to improve the performance and reduce the cost of the shadow-mask system and partly because this success, in a performance as well as a business sense, provided a rapidly moving target for any potential competing system. From crude beginnings, the tube design and manufacturing processes today have been so developed and refined that the system constitutes perhaps the most sophisticated collection of high-technology procedures that is to be found anywhere in the mass production of such a bulky product. Some of these technical developments have been documented[3] and the history of color-tube development brought up to date[4,5], but it is a continuing story as improvements in performance and reductions in costs are still being made.

It is hard to believe that those first few experiments could have led to a device that has reached a cumulative production of over 100 million units worldwide[5] It should now be abundantly clear, however, that although I performed the experiments, the basic design of the color system and tube were already there, and my colleagues both here and worldwide have carried out a Herculean task, including the making of many ingenious inventions, to get us where we are today. Also, a key factor that cannot be too strongly emphasized was the vision and determination of RCA Chairman General David Sarnoff, who provided the challenge, opportunity, and resources for this major effort. Without his leadership, color television, as we know it, would at least have been delayed.

The late **Harold B. Law** retired in 1976 as Staff Adviser, Materials Research Laboratory, RCA Laboratories, Princeton, N.J. He received the BS in liberal arts and the BS in education in 1934 from Kent State University. He received the MS and PhD in physics from Ohio State in 1936 and 1941. Dr. Law joined RCA, Camden, in 1941 and in 1942 transferred to RCA Laboratories. He became a Fellow of the Technical Staff in 1960 and from 1962 to 1975 was Director of the Materials and Display Device Laboratory, a laboratory affiliated with the Electronic Components and Devices Division. Upon joining RCA, Dr. Law first worked on television camera tubes and then on color television display tubes.

References

1. Color Television Issue. *Proceedings IRE*, Vol. 39 (October 1951).
2. N.F. Fyler, W.E. Rowe, and C.W. Cain, "The CBS-Colortron: A Color Picture Tube of Advanced Design," *Proceedings IRE*, Vol. 42, pp. 326-223 (1954).
3. A. M. Morrell, *et al*, *Color Television Picture Tubes*, Academic Press, New York (1974).
4. E. W. Herold, "History and Development of the Color Picture Tube," *Proceedings, Society for Information Display*, Vol. 15, No. 4, pp. 141-149, Fourth Quarter (1974).
5. E. W. Herold, "A History of Color-Television Displays," *Proceedings IEEE*, Vol. 64, pp. 1331-1338 (Sept. 1976)

J. Conklin

MCC: Investment in the future

This private-sector joint research and development venture, which includes RCA, aims to maintain U.S. technological pre-eminence in microelectronics and computers.

Back in the 1920s, when waggish aphorisms were in vogue, one member of the famed Algonquin roundtable called the oboe "an ill wind that nobody blows good." There has been similar talk more recently about technology transfer between companies. Examples of unsuccessful attempts to transfer even simple technology abound. And, it must be said, these attempts are seized upon as evidence that technology should be created in-house and not acquired. No one reading this is guilty of that attitude, of course. We're talking bad guys here.

Abstract: *Microelectronics and Computer Technology Corporation (MCC) is a private sector joint research and development venture created to help maintain U.S. technological preeminence in microelectronics and computers. RCA is one of 15 companies who are "shareholders" in MCC. Each shareholder participates in at least one of MCC's four technology programs for a minimum of three years, and contributes outstanding scientists and engineers to these programs. MCC will hold title to all resulting knowledge and patents, and will license them to the shareholders participating in these programs. This paper explores the opportunities and perils in transferring MCC's technology into RCA effectively.*

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Since we're all good guys, we will want to know about a major investment RCA is making and how, since this does involve technology transfer, we can make the most of it. The investment is in the Microelectronics and Computer Technology Corporation (MCC) (see sidebar), and if MCC succeeds, the technology will be crucial to RCA's future competitiveness in several vital areas. The issue is how we can best benefit from creating on our side the means for successfully capturing MCC technology in those places where RCA will need it.

Recently, in helping MCC study technology transfer from its point of view, we uncovered a piece of research done by people at the Massachusetts Institute of Technology that was aimed at discovering the most important factors in successful technology transfer. It will probably be no surprise to you to learn that these were, in order of importance: positive management attitude, internal entrepreneurship, timing, and funding.[1]

Makes sense, right? If the boss doesn't want it, it probably won't happen. Another way to state the case is, if the boss sneezes NIH (Not Invented Here), everybody else will come down with NIH pneumonia. The boss can't "make it happen" alone, but can surely *keep* something from happening.

"MCC always will be focused on taking that [pure] research and turning it into application. We are the critical link in the process of commercializing technology."
—Adm. Bobby Ray Inman
President and Chief Executive, MCC
(from a June 1, 1984 *Electronic Business* article)

"Internal entrepreneurmanship" is another way of saying that the new technology has to have an in-house champion, a "White Knight" to fight for it. It helps if the champion is a respected senior technical guru, but that's not essential if the champion is competent, convinced, and willing to make a case in front of tough audiences. Younger technical people should seek to be champions, in fact, given that they have the knowledge and confidence in their own judgment to back their play. It is good for the company and for the individual if they succeed, and good even if they don't.

What is MCC?

Microelectronics and Computer Technology Corporation (MCC) is a multicorporate research venture based in Austin, Texas. Its mission is to concentrate scarce financial and intellectual resources on developing the fundamental technologies of the next generation of computers, thus maintaining U.S. technological preeminence in the international microelectronics and computer marketplace. But MCC will not market products — rather, its technologies will be transferred to its member companies for development into products and services of their own conception and design, for competition in markets of their own choice.

At present, MCC is owned by 18 American microelectronics and computer companies: Advanced Micro Devices, Allied, BMC Industries, Control Data, Digital Equipment, Eastman Kodak, Gould Electronics, Harris, Lockheed, Honeywell, Martin Marietta Aerospace, Mostek, Motorola, National Semiconductor, NCR, RCA, Rockwell, and Sperry. RCA is a member of two of MCC's four major research programs (each company must belong to at least one program). These two are: the Software Technology Program, a seven-year program to develop new methodologies and tools that improve both productivity and software quality by at least an order of magnitude; and the CAD/VLSI Program, which is an eight-year program to improve computer-aided design technology and to develop an integrated set of tools that will have particular application to complex systems and the very complex VLSI chips from which they will be built.

The other two programs are Packaging, whose goal is to advance the state-of-the-art in semiconductor packaging and interconnect technology, especially to achieve automatic assembly at the circuit and system levels; and the Advanced Computer Architecture program, which consists of the following four "sub-programs": Parallel Processing, Database System Management, Human Factors Technology, and Artificial Intelligence/Knowledge-Based Systems.

Each member company sends a Technical Liaison to each of the programs to which it belongs. The liaison's job is to oversee the transfer of MCC-developed technologies into the company. The company may also send "assigned representatives" to work as members of the program's technical staff.

—Jeff Conklin

Someone once said that in life, timing is everything. There's more to that quote, but we won't dwell on it. As a business, though, we have to be conscious that technology timing is not necessarily a driving force. It is market timing that is significant. A super technology for which there is no market is better off on the shelf. The trick is to know the market and competing technologies well enough to know when to pull it down from the shelf and begin using it in products.

Finally, the research results say that it costs money to transfer technology, in ways that are obvious (look, for example, at license fees) and perhaps not so obvious (travel and communication costs, for instance). If the essence of management is to avoid surprises, then technology transfer depends upon anticipating the total cost structure. Obviously, for technology transfer to be managed in a business-like way, there has to be an organizational responsibility, there must be a plan, a commitment of resources, a driver, and of course a high level of motivation, although not necessarily in that order.

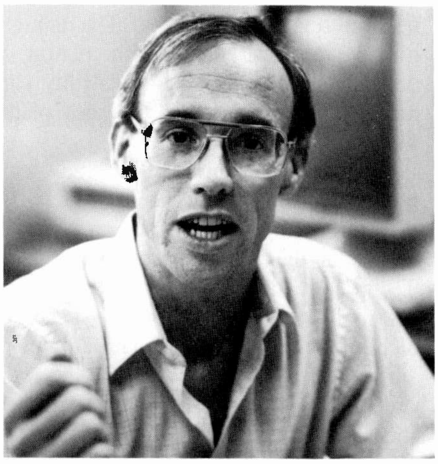
MCC is preparing a set of technology-transfer guidelines for internal use and also for use by the shareholder companies. These guidelines will suggest things to be done on both sides to make technology transfer successful. One of the key notions is early involvement on the part of the recipient. Thus, even though MCC is a long-range program, it is not too soon to begin to think about the possibilities, and find ways to become involved. I'll be glad to help.

Acknowledgment

My thanks to Dick Hill, Honeywell Liaison Representative, for his contribution to this article.

References

1. A. Gerstenfeld and P. Berger, "From Basic Research to Applications: A Model of Effective Technology Transfer Mechanisms," *Office of Naval Research Report*, ONR contract NOOO-82C-0484 (August 1982).

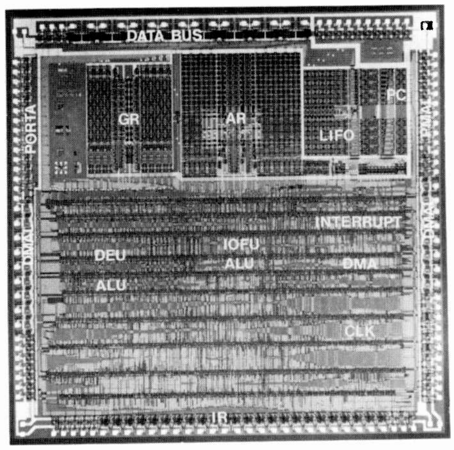


Jeff Conklin has a PhD in Computer Science, specializing in the Artificial Intelligence (AI) field of natural language processing — the study of software systems that generate and understand English. After managing the AI Laboratory at the Advanced Technology Laboratories in Camden (Fall, 1983), Dr. Conklin relocated to the MCC in Austin, Texas (Spring, 1984), where he is RCA's liaison representative to the software technology program. At MCC he is focusing on the area of software engineering — the scientific study of the engineering of large, complex computer programs.

Contact him at:
MCC
Phone: 512-343-0860

P. W. Ramondetta

ATMAC-II—A fast microprocessor



The instruction set, the architecture, and the technology form a high-performance VLSI chip for a variety of signal-processing and control applications.

ATMAC-II is a 16-bit VLSI signal processor intended for very high-speed and low-power applications. Implemented in RCA's 3-μm complementary silicon-on-sapphire CMOS/SOS technology and featuring such architectural features as pipelining and functional concurrency, ATMAC-II is ideally suited for real-time applications in speech processing, telecommunication-modem processing, digital filtering, and spectrum analysis.

Performance is achieved through the combined use of the CMOS/SOS technology and ATMAC-II's pipelined-parallel architecture. The 3-μm technology supports a typical design-oscillator frequency of 16.7 MHz. This translates to performance levels of 3 to 4 MIPS (million instructions per second). With ATMAC-II's pipelining and functional concurrencies considered, effective performance levels as high as 20 MOPS (million operations per second) are achievable.

Abstract: *ATMAC-II is a 16-bit VLSI signal processor that resulted from a team effort at the Government Systems Division's Advanced Technology Laboratories in Camden, N.J. It features a highly parallel, pipelined architecture implemented in 3-μm CMOS/SOS technology that means, ultimately, performance levels of 3 to 4 million instructions per second and effective performance levels as high as 20 million operations per second. This article describes the architecture, the programming, the process technology, the implementation, and the design and simulation process. Extensive use was made of RCA's Computer-Aided Design/Design Automation System (CADDAS). ATMAC-II is an attractive candidate for military, high-performance, remote-site, signal-processing applications.*

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Figure 1 illustrates an ATMAC-II system in which a single ATMAC-II chip is functioning with separate 64K program and data memories (128K total), a coprocessor, a generic 16-bit multiplier-accumulator, an input/output (I/O) controller, and I/O devices.

Functional concurrency is facilitated by ATMAC-II's pinout and packaging approach. The 132-pin leadless hermetic chip carrier (LHCC) permits ATMAC-II to support two separate 16-bit data-memory and program-memory address buses. Consequently, a full 64K words are directly and simultaneously addressable for each memory. A separate 16-bit bidirectional multiplexed data bus allows 16-bit operands to be passed to a hardware-multiplier-accumulator (HMA) or coprocessor early in each instruction cycle, while a second 16-bit operand is simultaneously passed to these devices via a separate 16-bit operand port. During the later portion of each instruction cycle, the data bus is also available for data-memory operations. Finally, a separate 24-bit program memory data bus permits extensive instruction-field usage for horizontal (concurrent) programming.

The ATMAC-II instruction set supports over 150 separate operations, many of which can be executed simultaneously during a single (240-ns) instruction cycle. This instruction set contains a complete complement of generalized instructions such as arithmetics, logicals, conditional branches, and immediates. In addition, highly specialized features such as Low Power Idle (LPI), stretched programmable I/O cycles, program-memory read and write (for verifying memory contents), sorting instructions, and enhanced software multiply-and-divide instructions are also implemented. For real-time signal-processing applications, the ATMAC-II instruction set provides twelve specialized hardware-multiply instructions. An industry-standard hardware-multiply-accumulator (HMA) CMOS chip interfaces directly to ATMAC-II and provides it with single-cycle hardware multiply-accumulate capabilities. For more specialized tasks, ATMAC-II supports coprocessors that can be designed to work from a reserved set of sixteen operation (op) codes.

Architecture

Figure 2 illustrates the ATMAC-II chip's architecture. This structure permits many operations to be performed in parallel. Conceptually, the ATMAC-II chip can be thought of as two parallel units—the data execution unit (DEU) and the instruction and operand fetch unit (IOFU). If an

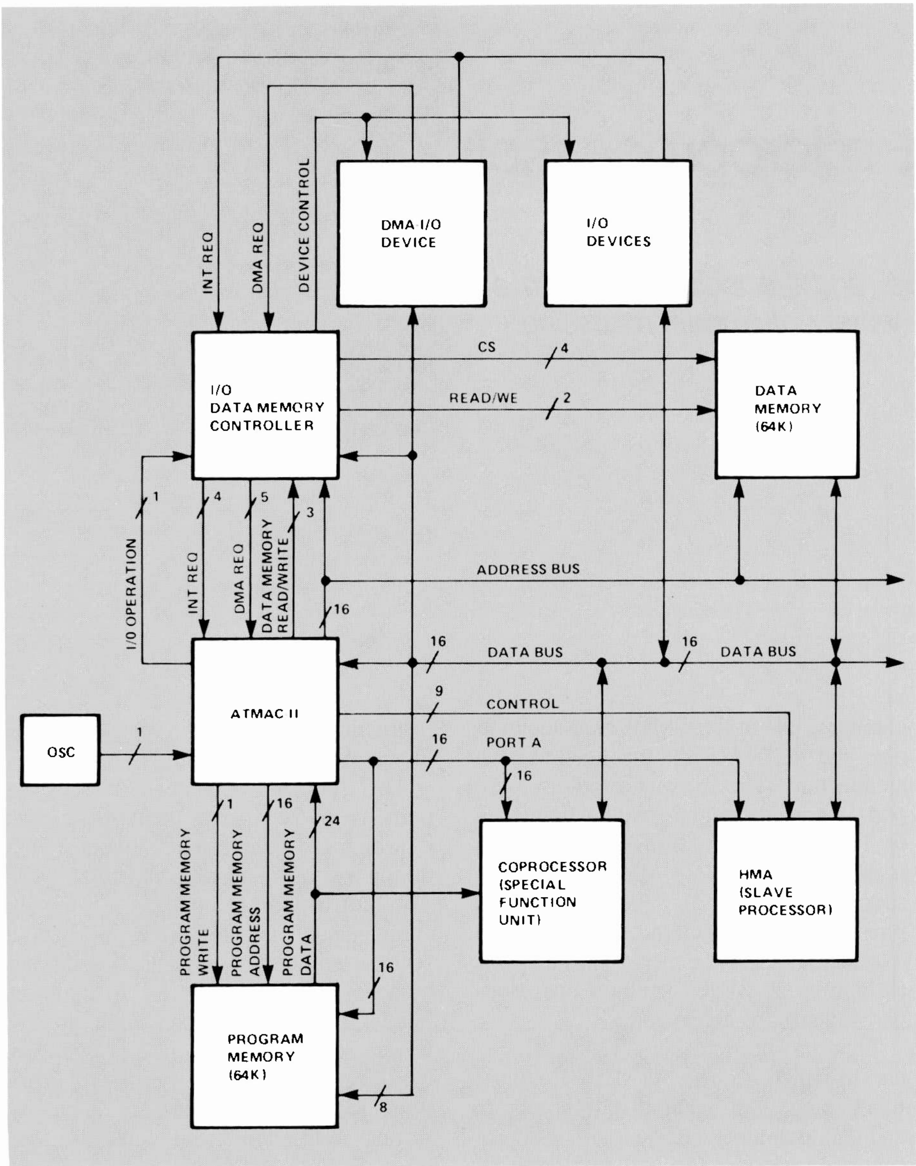

Fig. 1. *ATMAC-II system.*

HMA and a user-defined coprocessor chip were included, then the ATMAC-II system would grow to four separate parallel units.

Data Execution Unit

The DEU performs 16-bit arithmetic and and logic operations on data. All the operations performed in this unit have operands taken from either the general register stack, immediate operand (from the instruction word), a hardwired constant, or the program-memory verify latch. The operations are register-to-register oriented; results can be stored in selected general registers, indirect address registers, or sent off-chip to data memory or I/O devices. Key architectural features of the DEU include a quad-port general register stack, which is 10 words deep by 16 bits wide, a flexible hardwired arithmetic and logic unit, and a 16-bit bidirectional internal data bus for communications. Separate write ports to the general register stack permit the DEU to perform and store arithmetic operations in parallel with the reading of data from the external bus. The source of this data could be from data memory or I/O devices.

Instruction and operand fetch unit

The IOFU develops the 16-bit addresses for instructions from program memory and operands from data memory. All program-memory addresses are taken directly from the program counter, immediate operand (from the instruction word), or the last-in, first-out (LIFO) stack. All data-memory addresses are extracted from the indirect address-register stack or the immediate operand (from the instruction word).

Key architectural features of the IOFU include a quad-port address-register stack, which is 13 words deep by 16 bits wide. Two of the 13 stack addresses are only 12 bits wide and serve as iteration counters. They incorporate self-decrementing circuitry for increased functional concurrency during program looping operations. In addition, the IOFU has its own 16-bit arithmetic unit to update addresses used for data memory. For instruction fetching, a separate self-incrementing 16-bit program counter and an 8-word-deep LIFO stack are included.

Finally, the IOFU portion of ATMAC-II features a four-level vectored interrupt system, a DMA support controller, an I/O-address-space detector (for memory-mapped I/O), a programmable instruction-cycle stretcher, and a system-clock generator.

Pipelining and concurrency

As a direct result of ATMAC-II's pinout, the fetch and execute operations are performed simultaneously, hence giving two levels of pipelining. Moreover, because separate program-memory address and data buses are used, multiplexing is unnecessary. This results in reduced external support circuitry as well as improved cycle times.

The separate DEU and IOFU provide for a significant degree of functional concurrency. When we examine each unit by itself, we see further operational parallelisms. Specifically, the DEU can perform arithmetic/logical operations while simultaneously loading (reading) a full 16-bit operand from data memory. Alternatively, the results of an arithmetical/logical operation can also be simultaneously stored (written) to data memory, as well as stored in a general register. In either case, the performance of these parallel/simultaneous operations does not increase instruction execution time. The advantages of these parallelisms will be illustrated in assembly code later.

An examination of the IOFU's operation reveals additional parallelisms. Specifically, while the DEU is performing arithmetic/logical and data memory operations, the IOFU will be generating and updating the data-memory and program-memory addresses. With its own 16-bit arithmetic unit, the IOFU can simultaneously supply the present data-memory address and modify it for the next data-

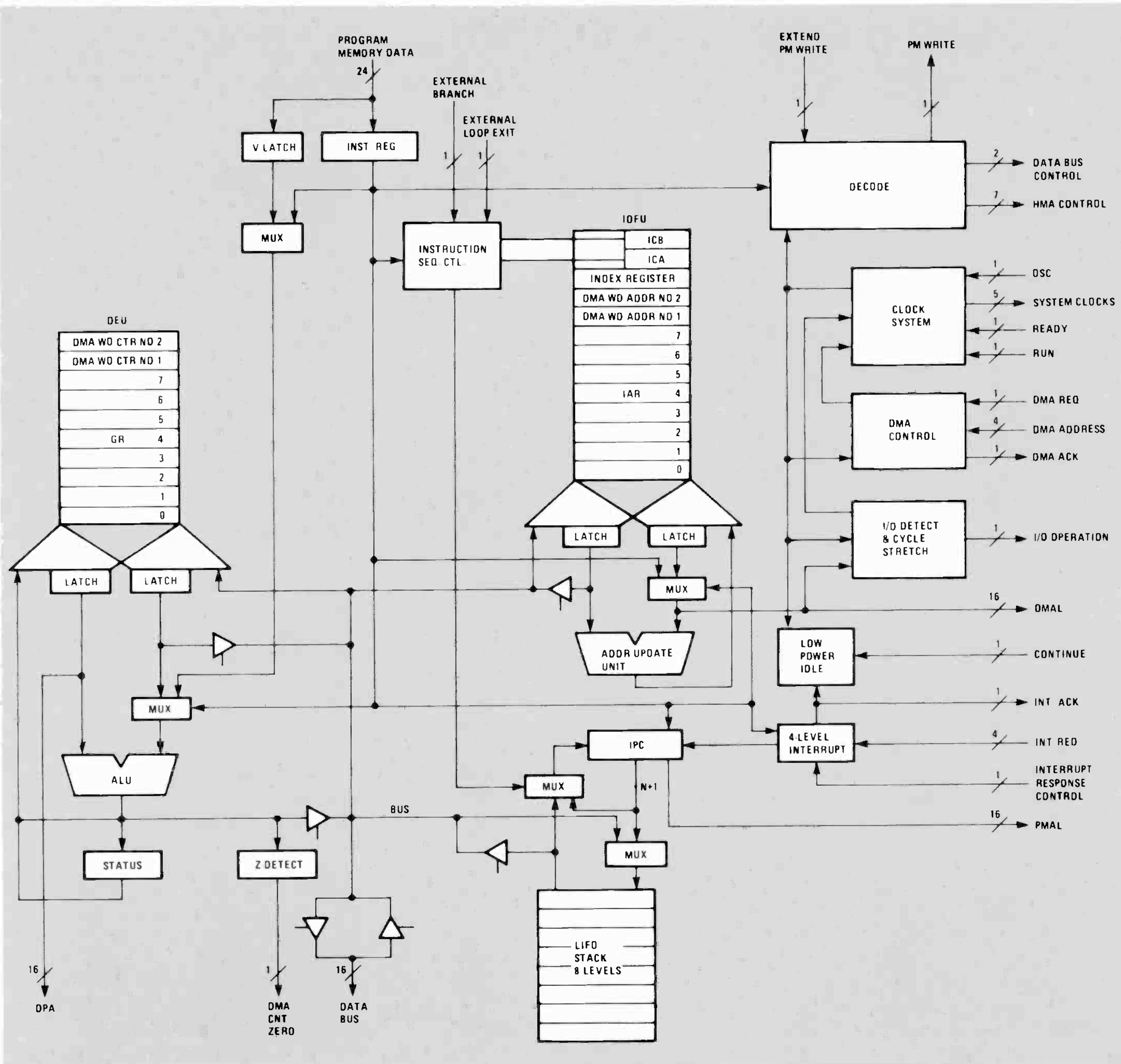

Fig. 2. *ATMAC-II chip architecture.*

memory operation. This modification can be an increment, decrement, or index operation. In addition, because the address-register stack incorporates self-decrementing iteration counters, loop-control operations can also be performed simultaneously with data-memory-address-register updates. As with the concurrent DEU operations, these parallel/simultaneous operations can be performed without an increase in instruction-execution time.

Although not physically part of the ATMAC-II chip, a separate coprocessor (SFU or special function unit) can further expand available concurrencies. For example, a special hardware-divide unit could be designed to operate from ATMAC-II's reserved instruction set. This unit would augment the DEU's functional capabilities, be able to read (or write to) data memory, or perhaps generate its own data-memory address.

ATMAC-II does support a hardware-multiplier-accumulator (HMA) function. Commercial CMOS 16 × 16 multiplier-accumulators* interface directly to ATMAC-II without the need for external support circuitry. An expanded view of the ATMAC-II and HMA interface is shown in Fig. 3. During HMA instructions (ATMAC-II has dedicated HMA op-codes), concurrencies are also possible. Depending on data-bus use, concurrent data-memory operations are also possible with both the optional SFU or HMA hardware.

Programming

The format of the ATMAC-II 24-bit instruction field is shown in Fig. 4; it sug-

** Examples of compatible CMOS parts are Analog Devices ADSP-1010KD, TRW TMC-2010, Rockwell 31416. An example of a compatible TTL part is TRW TDC 1010J.*

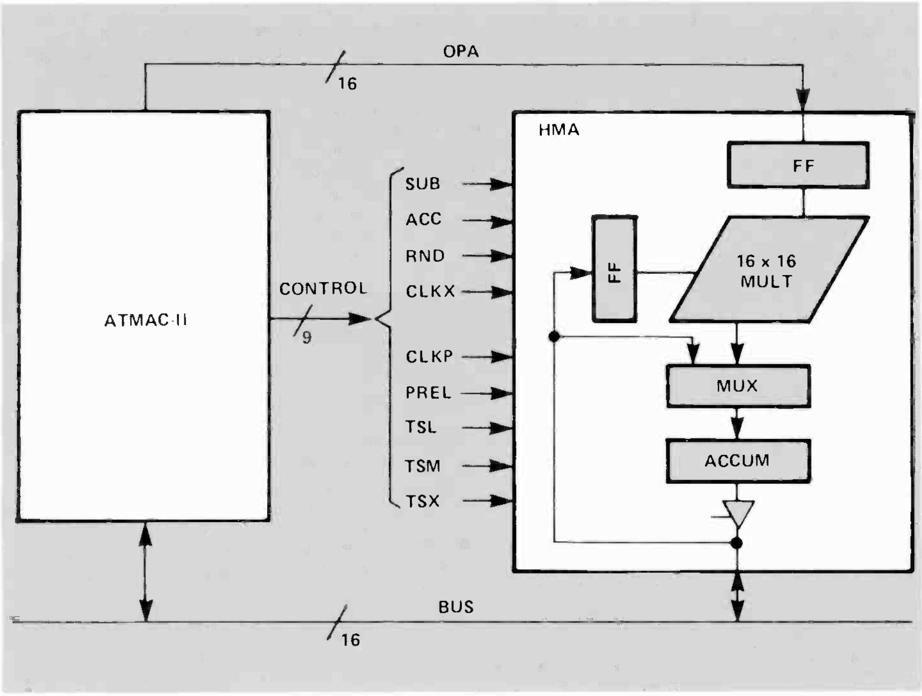

Fig. 3. *ATMAC-II and HMA interface.*

gests the horizontally programmed nature of the architecture. Some of the concurrencies available to the ATMAC-II programmer are presented in Table I. The first example in this table presents the one extreme in which only a fetch and arithmetic operation are performed during the instruction cycle. The sixth example illustrates the other extreme in which an HMA operation is performed in parallel with a data-memory read (or write), an address update, an iteration-counter update, and a fetch operation. For those critical real-time applications, in which high throughput is mandatory, careful programming at the assembly language level can result in the performance of as many as five operations per instruction cycle without increasing cycle time. For example, consider the simple case where the microcomputer must perform the accumulation of *N* elements of a vector stored in contiguous locations of data memory with the symbolic address "ADDR" pointing to the first element.[1] Figure 5 contains an ATMAC-II assembly-language coding that performs this function. Statement 4 of Fig. 5 makes maximum use of the ATMAC-II's concurrencies. Specifically, the following five operations are performed when statement 4 is executed:

1. ADD GA1,GA2 — Addition of GA1 and GA2
2. LD GA2, IA1 — Data-memory read and load of GA2
3. Decrement iteration counter — ICB
4. Increment data-memory address register — IA1
5. Determine and fetch next instruction.

Although it is not always possible to reach this degree of concurrency, parallel operations are almost always possible. For example, the inner loop of a complex Fast-Fourier-Transform butterfly would typically average three concurrencies per instruction.

Support software available for ATMAC-II includes a cross assembler, linking loader, monitor, simulator, and hardware diagnostics. To take advantage of application software developed for the

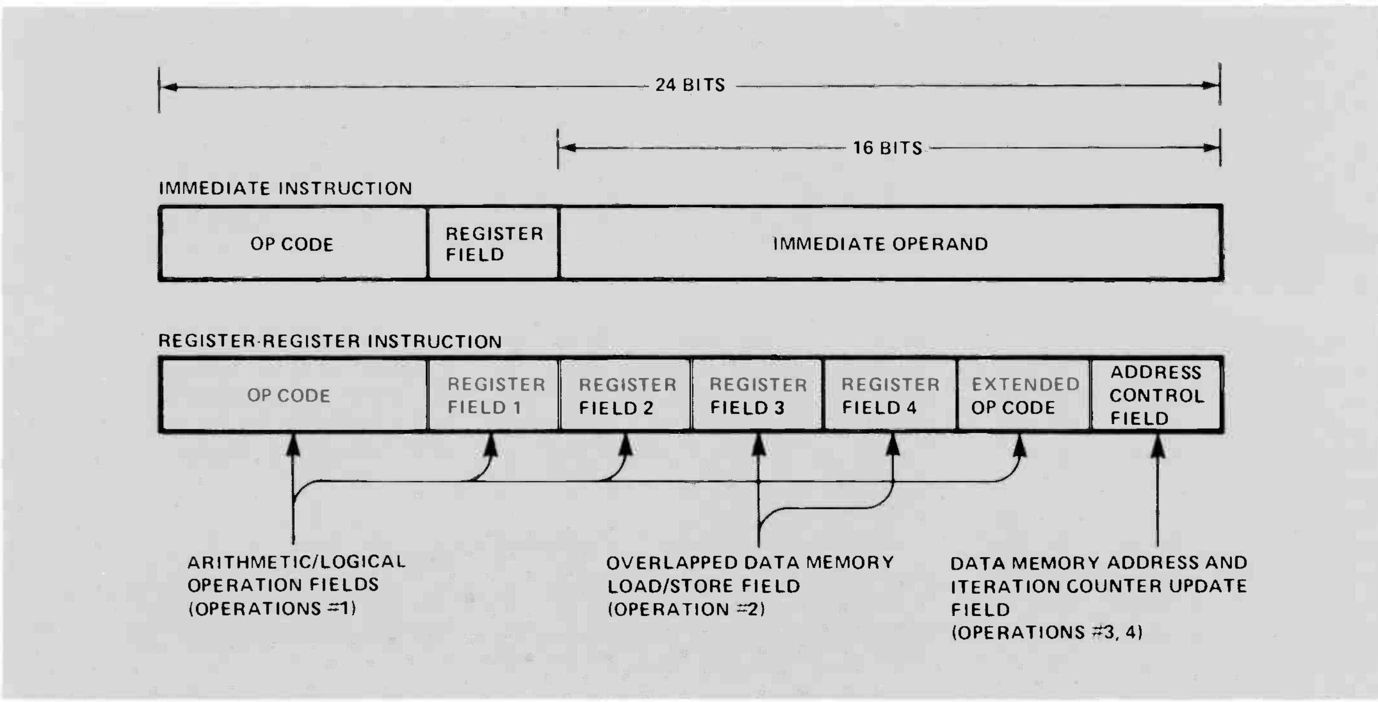

Fig. 4. *ATMAC-II instruction word.*

original byte-expandable ATMAC, an ATMAC to ATMAC-II Assembly Code Translator is also available.

Technology

The first ATMAC-IIs were fabricated with RCA's CSOS-III process. The gate lengths were drawn to 3 μm. The gate material, which is also a second level of interconnect, is polysilicon with a typical resistivity of 20 ohms/square.

Actual measurements are indicating less than 3-ns on-chip stage delays. This translates to basic oscillator frequencies of 20 MHz (instruction execution times of 200 ns) for our sample parts. System integration is ongoing; actual system performance has yet to be measured.

Designed with fully static 5-V CMOS circuitry, ATMAC-II achieves a standby power dissipation of 5 mW when executing the LPI instruction. Dynamic power dissipation is controlled by the CV^2f component and is less than 10 mW/MHz. With a 20-MHz oscillator, this dissipation translates to less than 200 mW.

Future performance enhancements can concentrate on improving the RC interconnect and transistor delays. This can be done by the use of polycide gate material (5 ohms/square) and narrower gate lengths. Polycide can be introduced in the present design with no mask changes, while gate-length reductions can be easily introduced on one mask level (poly) by changing a single path-length definition. Chip size can be reduced by shrinking the mask set, since future SOS processes (SOS-IV) will support the tightened geometries.

Implementation

ATMAC-II is implemented with a combined standard-cell/handcrafted approach. The regular nature of the three register stacks encouraged their implementation with a handcrafted layout design. ATMAC-II's remaining logic, being somewhat more random, was implemented using an existing 3-μm standard-cell family. The chip was assembled using RCA's CADDAS VLSI design automation system. The chip is shown at the beginning of this article. All major blocks are labeled. The handcrafted stacks (at the top of the chip) and the standard cells (arranged in horizontal rows) are quite apparent. It is also evident that the chip size is virtually pin-limited with the 132 I/O and power pins. The chip measures 360 × 353 mils and contains 20,500 devices

Table I. *Examples of allowable ATMAC-II pipelining and functional concurrencies.*

EXAMPLE		Operation #1	Operation #2	Operation #3	Operation #4
	Instruction fetch	Instruction type	Data-memory load/store	Data-memory address update	Iteration counter update
1	*	A			
2	*	A	X		
3	*	A	X	X	
4	*	A	X	X	X
5	*	S	#	X	X
6	*	H	#	X	X

Fixed Instruction Cycle

* indicates pipelined operation

X indicates available concurrencies

\# indicates conditional concurrencies based on data bus utilization

A indicates Arithmetic Instruction

S indicates SFU Instruction

H indicates HMA Instruction

General Register Assignments:

GA1 Register for accumulating the sum

GA2 Scratch register used for holding each sequential vector element

Indirect Address Register Assignment:

IA1 Indirect Address Register containing the data memory address of the next vector element to be used.

Statement number	Instruction	Comment on instruction
1	LDIAI IA1, ADDR,	Load IAR1 with vector initial address, ADDR.
2	LDF2I, GA1, O; LD GA2, IA1; AUTP1	Zero-out GA1 to start accumulation; load first element of vector into GA2 from data memory addressed by IA1; auto-increment by +1 for next computation.
3	LDIBI ICB; = N-1;	Load ICB or IB4 with vector-loop-length, minus 1 (this action automatically pushes the IPC stack with the next address for iterative loop linkage)
4	ADD GA1, GA2; LD GA2, IA1; RNBP1	Adds GA2 to GA1 to perform accumulation; loads new vector element into GA2 from data memory addressed by IA1 for next computation; increments by +1 for the next computation and controls loop dwell time for N iterations

Fig. 5. *Accumulation of N-element vector element*

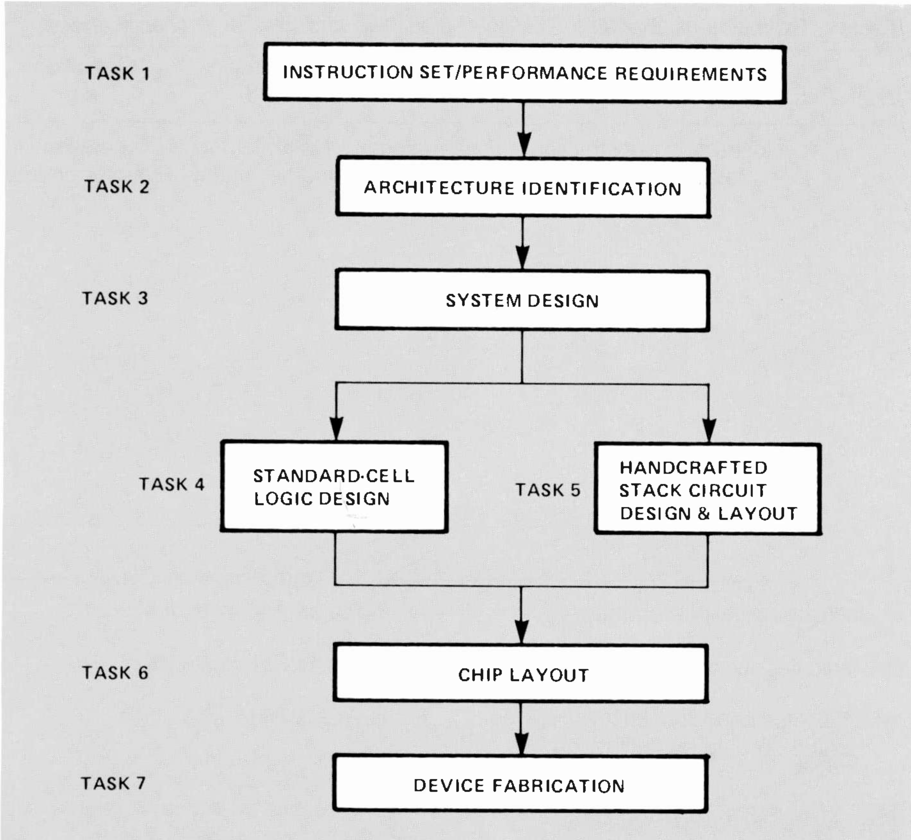

Fig. 6. *The ATMAC-II design approach.*

(9,600 of which are in the handcrafted stacks).

Design approach and implementation

The design of the ATMAC-II signal-processor chip started with the identification of an instruction set/architecture that was targeted for a number of RCA applications; chip performance levels as well as chip availability and, hence, design time were critically important.

Figure 6 shows the design approach taken to implement the ATMAC-II integrated circuit. Not shown in Fig. 6 is the technology identification process, which was performed in parallel with Tasks 1 and 2. Performance requirements (originally estimated at less than 3 ns per stage), power requirements (minimum power for battery operation), and high device counts (originally estimated at 18,000 transistors) led to our choice, in 1983-84, of the in-house 3-μm CMOS/SOS process. The requirements for chip availability, targeted for system power-up within fifteen months of initial instruction set identification, demanded a heavy reliance on in-house VLSI design automation methodology.

Design automation tools

The design approach made extensive use of RCA's Computer-Aided Design/Design Automation System (CADDAS). This integrated system ties the design process, the simulation process, and the layout process together. One pivotal advantage in using this system is the tight, software-controlled, 1:1 correspondence between the simulated function and the final chip artwork. The basic elements of this system as they apply to the ATMAC-II design are:

- CDB (Common Data Base) — A formatted method of describing functional blocks and their interconnections
- TESTGEN — A functional gate-level simulator
- MP2D — A placement-and-routing program for standard cells and nonstandard macros
- ENLAVE — An artwork topology and connectivity checking program that also checks for a 1:1 functional-to-pattern correspondence
- LOGCEK — A program that compares the MP2D output to the CDB net list
- CRITIC — A layout design-rule checking program
- CADDAS Translation Routines — Programs that permit date conversion between the CDB and any CADDAS software tool (that is, TESTGEN and MP2D).

Figure 7 illustrates the procedural relationship between these tools and the CDB.

Design approach

The "flow-chart method"[2] was used to translate the original programmer's external model (instruction set and register complement) into the internal hardware implementation (Fig. 6, Tasks 1 and 2). A combination of pseudo code and flow charts were developed for each instruction. These served to identify exactly how each operation of each instruction was performed. In effect, internal hardware use and availability were identified for each instruction. This procedure was particularly important in view of the ATMAC-II instruction set's parallelisms and concurrencies. During the flow-charting process, various contentions for internal ATMAC-II resources (the internal data bus, LIFO stack, and so on) were identified and resolved. In some cases, the original instruction set had to be revised to ease chip implementation. A clear hardware-oriented architectural block diagram of ATMAC-II resulted from this process.

With the hardware blocks and their internal/external interconnections identified, chip-floor planning, system timing, and logic design were initiated. Estimates of each block's performance, device count, physical size, and location on-chip were developed. Internal timing, instruction lengths, layout approach, and floor plan were all influenced during this process (Fig. 6, Task 3).

As a first cut, ATMAC-II was broken into four basic design modules; these included the stack designs, the DEU design, the IOFU design, and the CLOCK/CONTROL design. The regular logic such as the stacks would be designed with the higher-density handcrafted-layout approach. The other three modules (DEU, IOFU, and CLOCK) would be designed with an existing 3-μm CMOS/SOS standard-cell family. This approach had the advantage of minimizing design time and manpower requirements while keeping chip size down. Moreover, implementing the control logic, the ALUs, and high-speed clock circuitry in standard cells would permit design changes to be easily introduced. In parallel with the chip-im-

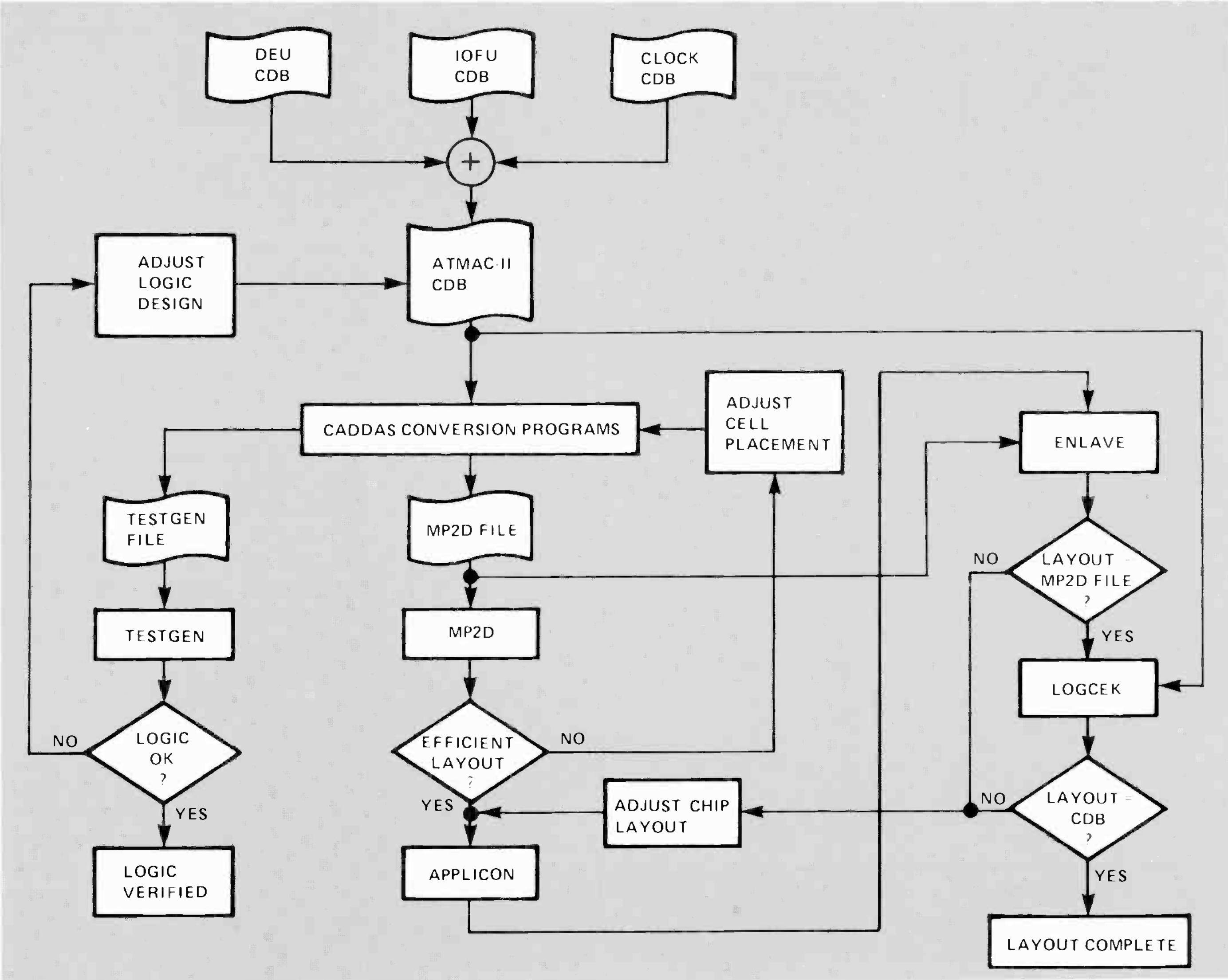

Fig. 7. *A CADDAS design procedure.*

plementation effort, a separate software group was simulating the instruction set; design changes resulting from their effort would clearly be a possibility.

With approaches identified, the handcrafted layout of the stacks began (Task 5). Logic design of the DEU, IOFU, and high-speed clock-control-logic modules began in parallel (Task 4). To encourage communication between designers, all layout and logic design were performed in the same "room." This approach fostered effective communications between engineers that resulted in a similarly good interface between their separate designs.

The CDB was used to describe the functionality and interconnections of each design module. Specifically, the three ATMAC-II handcrafted stacks (General Register, Address Register, and PC/LIFO) were described using the CADDAS macro facility. All other logic was described in terms of the 3-μm, standard-cell family's existing macro base.

The uniqueness of our approach was that each of ATMAC-II's subsystems was designed, simulated, and debugged separately using CADDAS. Most important, once the separate designs were verified, their CDB files were frozen. Signals (wires) common to two or more modules were given global mnemonic names, while signals within modules were given unique numeric names. At the end of this phase of the chip's design, three separate debugged CDB files existed, one for each of the three logic modules.

Layout

To assemble the chip, the three CDB files were merged into one file (Fig. 8). Because care was taken to preserve the integrity of the data base from the start of the project, each standard cell and macro mapped directly to a physical pattern. This direct-mapping feature enabled layout to commence with minimal chance of error. Although MP2D could automatically place patterns (functions), all elements were manually placed to keep track of critical paths. That layout program, MP2D, was run iteratively. After each run the layout was examined for efficiency (compactness, for example) and critical timing, then placement adjustments were made and the program was run again.

If an element (cell or macro) was overlooked or accidentally placed twice, the CADDAS software would detect a discrepancy between the merged CDB file (which is the desired design) and the layout. Moreover, because all connections between modules were done by MP2D, interconnection errors were unlikely to

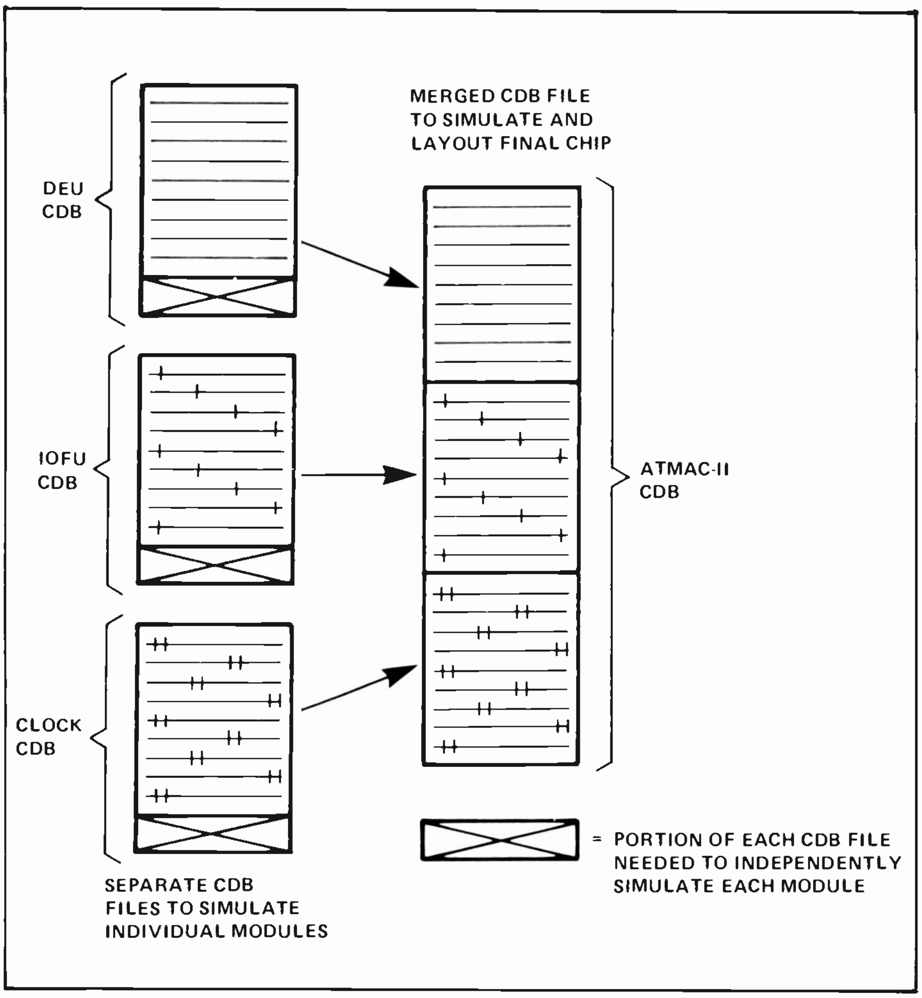

Fig. 8. *CDB file handling.*

occur. Final touchup errors introduced during the Applicon work would be checked with the ENLAVE, LOGCEK, and CRITIC software.

Simulation

In parallel with the placement effort, the merged CDB file was also used as the basis for the chip's final functional simulation. Errors detected during simulation were immediately corrected in the merged CDB file. These errors were generally interface errors between the separately designed modules. Once corrected, the merged CDB file served as the starting point for the next MP2D and TESTGEN runs.

Because ATMAC-II contained nearly 7000 logical elements, it was necessary to compress the simulator's output. Figure 9 is a sample of this compressed output. Rather than examining waveforms, the "state" of the machine (as represented by several hundred selected nodes) was printed out after each clock cycle. Register stack states were printed out in a graphically mapped format. This proved to be very efficient since the contents of all registers, the state of the internal data bus, control signals, and so on, could be observed at the end of each instruction. It would have been extremely inefficient to look at that many signals in a waveform format.

Design time

The final assembly of the chip layout was performed totally under program control. The time from the first checkplot to the final MP2D run was less than 3 months. Final "touchup" was performed on the Applicon and was primarily for enhancing performance. The time on the Applicon was less than 3 weeks.

The software and the systems groups were working in parallel with the ATMAC-II chip's hardware design effort. All design schedules converged on the first working samples of the ATMAC-II chip. Because the ATMAC-II project is targeted for a number of RCA applications, a timely delivery of a working chip was extremely important. Failure to deliver working samples would interfere with both software and system development.

In light of these schedule realities, the chip-design methodology was targeted for maximizing the probability of getting working parts on the first try. Failure to achieve this would cost all facets of the ATMAC-II project at least 10 weeks in schedule slippage.

The CADDAS VLSI Design Automation system must be credited with helping to achieve these goals. Indeed, CADDAS served its purpose — it enabled the rapid and reliable development of a 16-bit VLSI signal processor. ATMAC-II parts are available for limited production systems. Other projects in the future could conceivably use CADDAS to guarantee the first VLSI samples, while allowing a delayed, but parallel, semi-handcrafted effort to develop the high-production versions of the same design.

Conclusions

The ATMAC-II signal processor features a highly parallel, pipelined, 16-bit architecture implemented in the 3-μm CMOS/-SOS technology. Together, ATMAC-II's instruction set, architecture, and technology form a high-performance processor that is adaptable to a variety of signal-processing/control applications. Its built-in interface to a commercial multiplier-accumulator chip provides the user with 300-ns hardware multiply-accumulate capabilities, while ATMAC-II's 16 reserved coprocessor instructions allow a user to further enhance performance by implementing — directly in hardware — functions unique to the application.

The CMOS/SOS technology supports ATMAC-II's 16.7-MHz oscillator (240-ns instruction times), 5-mW standby power, and less than 167-mW dynamic power. Considering the CMOS/SOS technology's other natural advantages, such as its relative insensitivity to operating temperatures and voltages and its natural radiation hardness, the CADDAS-designed ATMAC-II becomes a particularly attractive candidate for military, high-performance, remote-site, signal-processing applications.

Acknowledgments

The ATMAC-II chip's successful development was the result of a team effort.

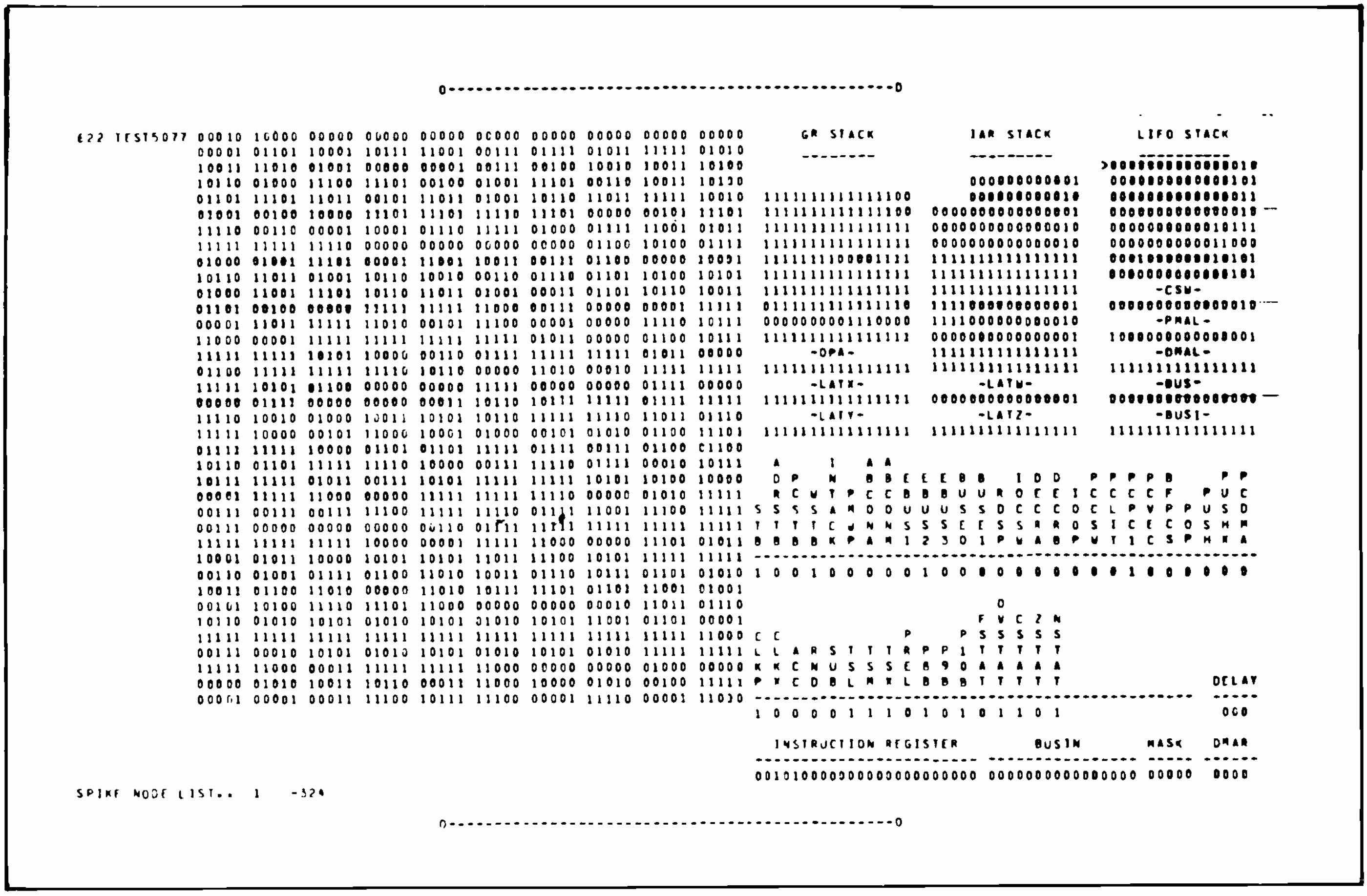

Fig. 9. *Compressed TESTGEN output.*

Other members of the ATMAC-II team were G. Caracciolo (ATL), W. Helbig (ATL), R. Shedd (ATL), W. Boyd (ATL), F. Bertino (ATL), C. Lovelace (GSD), and B. McNellis (GSD). The author is particularly indebted to them for their contributions in the areas of programming, design automation, instruction-set development, layout, and system design.

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References

1. A. F. Cornish, "A Microprocessor Architecture for Digital Signal Processing," IEEE Workshop on Microprocessors in Military and Industrial Systems, Johns Hopkins University Applied Physics Laboratory, Laurel, Md., January 1980.
2. N. Tredinnick, "How to Flow Chart for Hardware," *IEEE Computer*, December 1981.

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R. J. Butler/R. H. Edmondson

NBC Ku-band satellite — A progress report

The new NBC satellite network is a celestial switch — the inputs to the switch are the feeds to the uplinks and the outputs are the feeds to the affiliates.

Early in the 1960s, the networks had made preliminary studies of the technical capabilities provided by satellites, but were at that time not in a position to make the transition from land lines to the untested "celestial" technology. Although the networks used satellite feeds during the 1960s and 1970s for the collection of programming, the opportune moment for full distribution by satellites had not yet arrived. Many factors, both technical and economic, needed to fall into place before satellites for the commercial networks could be a reality.

In 1981, NBC began in earnest to re-evaluate the technical developments within the satellite industry. This was prompted by a deterioration in the service provided by the existing terrestrial system. Divestiture of AT&T was scheduled for 1984. Anticipated economic and service problems resulting from this split up were further justification for an in-depth study of satellite potential.

Abstract: *The history and the planning effort leading to NBC's satellite distribution system for network television are described. The Ku-band is being used. The entire system of 180 ground stations should be operational next January. The system will offer a more efficient and economical way to distribute the television signal. The Satellite Network Management System (SNMS) that NBC developed jointly with Comsat General provides central control of traffic through control points known as "Skypath Control" in Burbank and in New York. The system will mean better pictures and better traffic control.*

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Satellite system feasibility

The study first identified those problems in the conventional system that a satellite system might solve. Available satellite performance specifications were collected and matched with earth-station performance criteria. System models were developed to test operational needs and probable system costs. Eventually, a clear picture emerged as to what the system problems were and what kind of a satellite system might overcome them.

Listed in order of importance are the main failures of the terrestrial network distribution system.

1. NBC does not manage its own distribution.
2. The system must be manually operated by a third party.
3. Quality is degraded by the number of series elements in the distribution path.
4. The capacity of the system is limited to one program at a time to each affiliate.
5. The 1950 standards used to develop the distribution system are obsolete, and therefore resulted in technical limitations.
6. The cost of the system, even without improvement, is expected to nearly double in the next 10 years.

NBC solicited its affiliated stations as part of the background study to ascertain how many were already using satellite programming. In addition, the industry was asked to respond to a Request For Information supplied by NBC. This Request For Information had as its central theme a call for system specifications that could overcome what we knew to be the problems of the present terrestrial system.

Choosing a contractor

Thirteen manufacturers were solicited to provide information relative to the project, either as a general contractor or as a subcontractor. NBC, after careful review of the responses, decided it did not want the general-contractor job, and that the best business arrangement would be one where a single general contractor provided the total service. Total service would include the satellite space segment, the full complement of earth stations, nationwide maintenance, and the development of a computerized management system that NBC would operate.

Eventually, the potential general contractors were reduced to three: AT&T with a C-band system, and RCA Americom and the Comsat General Corporation with K-band systems. Nine months of specification writing and intensive negotiations finally resulted in the selection of Comsat General as the general contractor.

Ku-band and the Dalsat study

Two of the finalists had recommended the Ku-band as the appropriate radio frequency spectrum to use for network distribution. These recommendations were backed by thorough computer analysis of

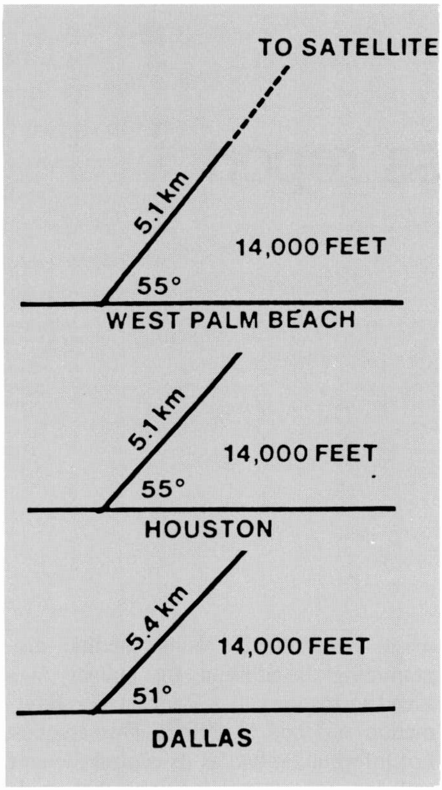


Fig. 1. *Path lengths vulnerable to rain.*

the rain attenuation that might be expected at any receiving site across the country. Yet, others in the industry had made their preference for C-band clear. NBC decided to verify the Ku-band computer projection by actually testing availability at sites in the U.S. that were subject to heavy rainfall rates (Fig. 1). This study was conducted by an independent contractor named Dalsat, located in Plano, Texas. The study, although using only three-meter antennas and low-powered SBS satellites (S.B.S. stands for Satellite Business Systems and is a consortium of three major companies — IBM, Aetna Life Insurance and Comsat General), gave an insight into why we believe the fears about rain voiced by others were an incorrect interpretation of the facts.

The Dalsat study highlights the fact that rainfall can only affect the vulnerable path, and the satellite-vulnerable path is much shorter than existing 11- and 12-GHz terrestrial microwave paths. The shorter satellite path provides higher availabilities than terrestrial experience would have indicated (Fig. 2). Further, Dalsat's data would indicate that heavy rainfall cells had diameters that were only a fraction of the vulnerable path length. In any event, the Dalsat tests and our performances to date on 22 stations scattered across the country confirm the accuracy of the computer projections supplied by the contractors.

The choice of Ku-band

The choice of Ku-band by NBC reflects our original concerns about the existing system. If the receiving earth station could not be located on the affiliates' premises, a third party might be required to carry the signal from the off-premise site back to the station. This situation would be both costly and undesirable. Ku-band, with its smaller, highly directional antennas, provides the means to achieve colocation. The higher power of the Ku-band satellite transponder and the choice of an appropriate-sized primary antenna at each site provide the margin necessary to give an availability of 0.9999.

AT&T, who had also been in the running right up to the end, not only did not offer Ku-band, but they would not allow real-time management of the system. Their offer would share earth stations with contracting users and they would be the traffic manager. This, although an efficient way to organize an off-premise site, surely would leave NBC with what it believed to be the one most significant shortcoming of the present terrestrial system, namely, loss of real-time management control of the system.

The needs for any American commercial network vary greatly, but one consistent requirement is that the network changes drastically on weekends as compared to weekdays. This results from the broad sports coverage that each network provides to its audience.

In NBC's case four paths through a satellite are required on weekdays: one for East Coast release, one for delayed release, one for West Coast release and a fourth for news, sectional commercials, or closed circuits. A possible fifth path is for unforeseen events. The situation changes drastically on weekends, since at least five additional paths are needed to carry the simultaneous sporting events that will be delivered to regional networks around the country.

This peak demand on weekends really gave Comsat General the edge on the final negotiations. Comsat General had proposed SBS Ku-band satellites as their space segment. The SBS satellites were primarily used for wide-band data distribution. The traffic on the satellite transponders would be high during the week and light on weekends. This allowed Comsat to offer the five additional weekend transponders at an attractive occasional rate.

RCA, however, could offer higher-powered transponders on their satellites, to be launched in the latter part of 1985. The deal was signed on October 16, 1983. To begin with, the NBC system will use SBS satellites, but a migration of the weekday traffic to the higher-powered transponders on RCA satellites is planned in mid-1986.

Implementation

The full Ku-band system will be in operation by January 1985 (Fig. 3). To date, 22 receive-only (RO) stations, two transmit-receive (TR) fixed earth stations, and four transportables have been put in place. By January 1, 1985, 170 RO and eight TR stations will be in operation. Two more transportables will complete our present complement of four, making a total of six units. Both NBC New York and NBC Burbank will have a master earth station, each capable of eight protected uplinks and 12 protected downlinks. Each of the ROs in the system will have four receivers, providing up to four simultaneous services to our affiliates.

Key to the efficient use of the satellite transponders and the earth-station receivers is the Satellite Network Management System, SNMS. Its function is to control uplink and downlink switching on a real-time basis. The SNMS controls and monitors the entire system via what is termed SCPC (single channel per carrier). Wide-band transponders provide ample room for these carriers to share the available frequency space (Fig. 4). The use of separate carriers, rather than subcarriers, further allows control-and-status SCPC signals to originate at points other than the main video and audio uplink point. The two SCPC channels provide both outbound control and inbound status to the master station, and the use of two transponders with the SCPC capability makes the control channel outbound redundant.

The "four-nines" (0.9999) availability provided by our contract with Comsat General guarantees less than 53 minutes per year below system-performance specifications. Equipment failures or rain fades cannot combine to lower this availability without substantial penalty to the contractor. Total system design provides redundant equipment throughout. Automatic protection circuitry replace defective equipment and report the failures to

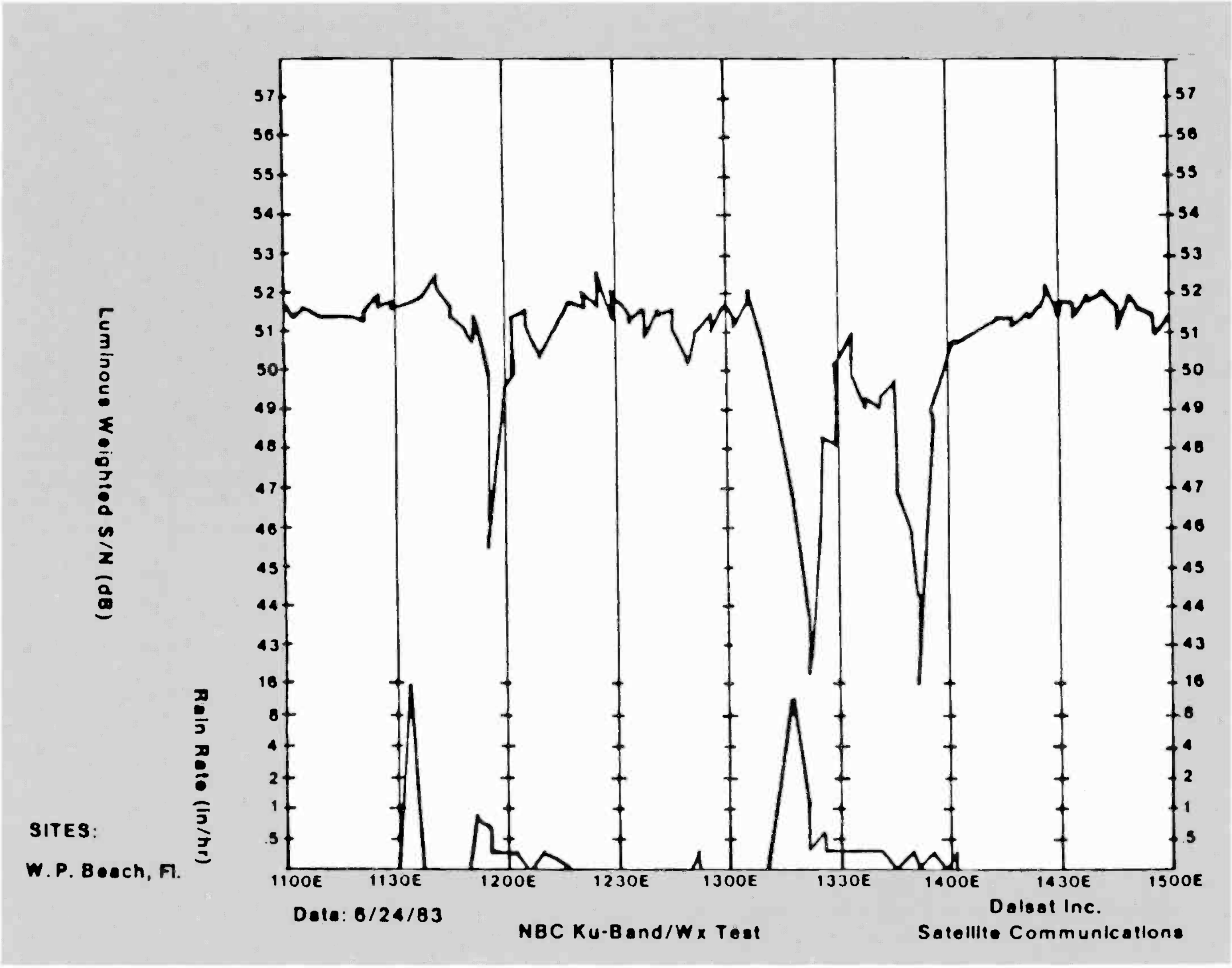


Fig. 2. *The shorter vulnerable path of satellites means that rainfall affects their availability less than it does the availability of existing 11- and 12-GHz terrestial paths.*

the SNMS. The SNMS can poll the entire system for a health-status report in 10 seconds. Management of the satellite network on a real-time basis requires high data rates between the master station and the 170 ROs. Without real-time status return via satellite, switching flexibility would be limited, as it is presently in the terrestrial system.

Conceptually, the NBC satellite network is a celestial switch. The inputs to the switch are the feeds to the uplinks. The outputs from the switch are the feeds to the affiliates. There are 44 potential inputs to the switch scattered across the country and 760 outputs of the switch also located at different points across the country.

The celestial program distribution system that has now been detailed in its design and operational philosophy is, of course, integrated with the ongoing television network operation.

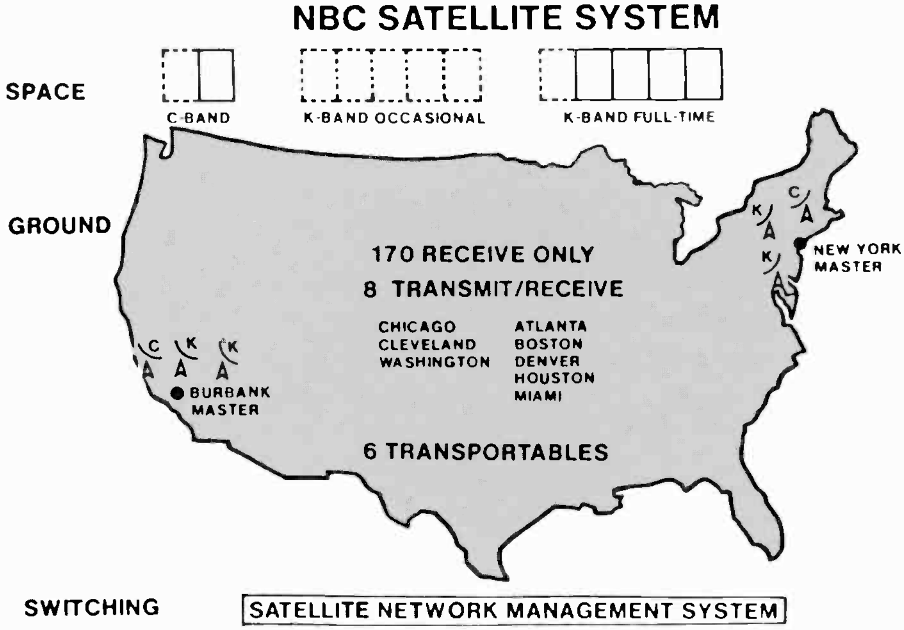


Fig. 3. *The complete Ku-band system.*

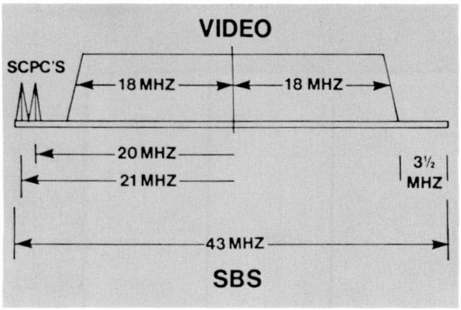


Fig. 4. *Wideband transponders provide ample frequency space for carriers.*

Historical operation

Historically, NBC feeds its affiliates from both the East and West coasts through automated-release control centers — "Switching Centrals." Burbank Switching Central supports the Pacific time zone and provides a network "feed" that is tailored to the three-hour difference between both coasts. When the present modernization of Burbank Switching Central is completed, NBC will be able to simultaneously feed up to six different sequences of programs on both coasts at once. In contrast, a terrestrial network distribution system tends to isolate the operations on each coast. A satellite television system offers the opportunity to unify the operations (Fig. 5).

Both Switching Centrals are supported by a set of automation computers and a large array of technical facilities (Table I).

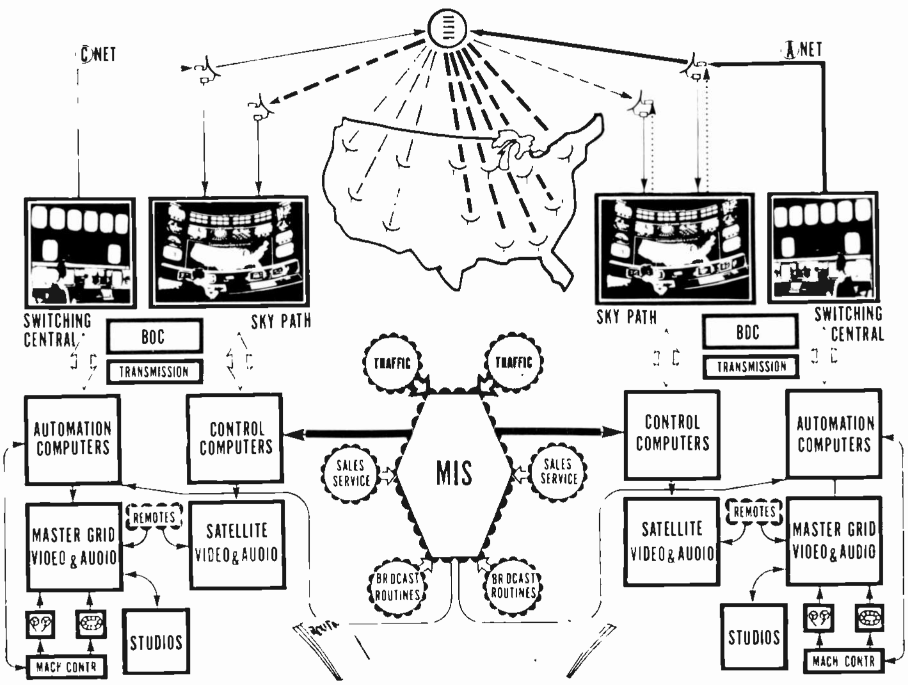


Fig. 5. *A satellite television system would unify the coast-to-coast television network.*

The automation computers not only control the "master grid," a large video and audio routing switcher, but also start the various machines required to support the daily "routine."

The television network operation may be better understood with the following brief explanations of the supporting subsystems shown in Figure 5.

Broadcast Operations Control

Broadcast Operations Control (BOC) is the on-site management position for the daily overall supervision and control of network operation. The Transmission section provides the technical interface to the common carriers. It certifies all incoming and outgoing feeds as well as in-plant circuits. BOC and Transmission are both lo-

Table I. *Skypath control point components and major functions.*

Components

- Skypath monitors
- Network and special "feed" monitors
- Configuration and status monitors
- Data-entry keyboards
- Manual override control panels
- Remote control and facilities assignment
- Test and diagnostics
- Voice communications
- Skypath control computers

Control functions

- Obtain "configuration-and-control schedules" from MIS
- Download earth station SNMS control systems with:
- Downlink-switching schedules
- Uplink-switching schedules
- Data-base edits
- New software (Updates and enhancements)
- Edit "day-of-air" configuration-and-control schedules
- Manual override for emergencies
- Assign control of earth stations and skypaths to Switching Central computers and studio-control rooms
- Certify quality of incoming feeds
- Route incoming feeds to master grid

Status functions

- Skypath monitoring
- Network feeds monitoring
- Present-configuration display
- Next-configuration and time-of-change display
- Future-configurations and time-of-change display
- Earth-station status display
- Display and log major outages and status-of-repair actions

cated immediately adjacent to Switching Central to permit effective coordination. Because Skypath Control will provide nationwide monitoring and control of the network, it is essential that it be located near both the BOC and Switching Central.

Management Information Systems

To support fully our "day-of-air" requirements, many other organizations within NBC play significant roles. The Sales Service and Broadcast Routines organizations, on both coasts, use the Management Information Systems (MIS) computers to jointly produce an automated "routine sheet." An electronic version of the "routines" is loaded into the automation computers for the following day's operation.

Traffic

Skypath, the major control point of the system, however, provides what we believe is the closest replica of video and audio monitoring that can be achieved (Fig. 6). Skypath, by design, can receive all transponders active in the system. The program routines of all services provided to all affiliates are also locally stored in the Skypath computers. Each affiliate, via its status report, confirms the correctness of Skypath's locally stored routines. With this information at hand, Skypath video and audio switchers can duplicate the output continuity for any of the 760 outputs of the network system.

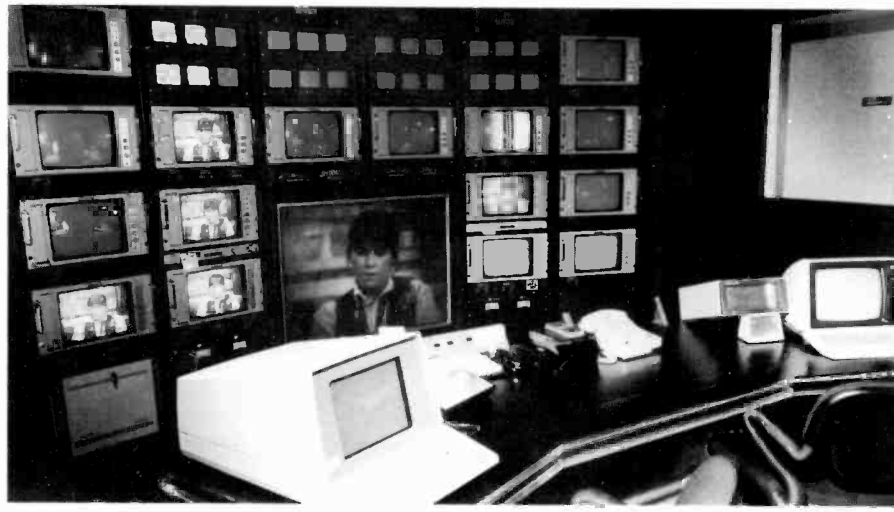


Fig. 6. *New York Skypath Control room.*

Skypath Control computers

As noted previously, each earth station will be controlled by a computer system called Satellite Network Management System (SNMS). The SNMS System (Fig. 7) is composed of a pair of redundant computers that act upon commands received from Skypath Control and report the status of the equipment.

Antenna pointing, receiver tuning, and video-audio switching are some of the functions that Skypath Control will be able to perform. Four TV receivers provide for a fully protected network feed and one or two simultaneous secondary feeds.

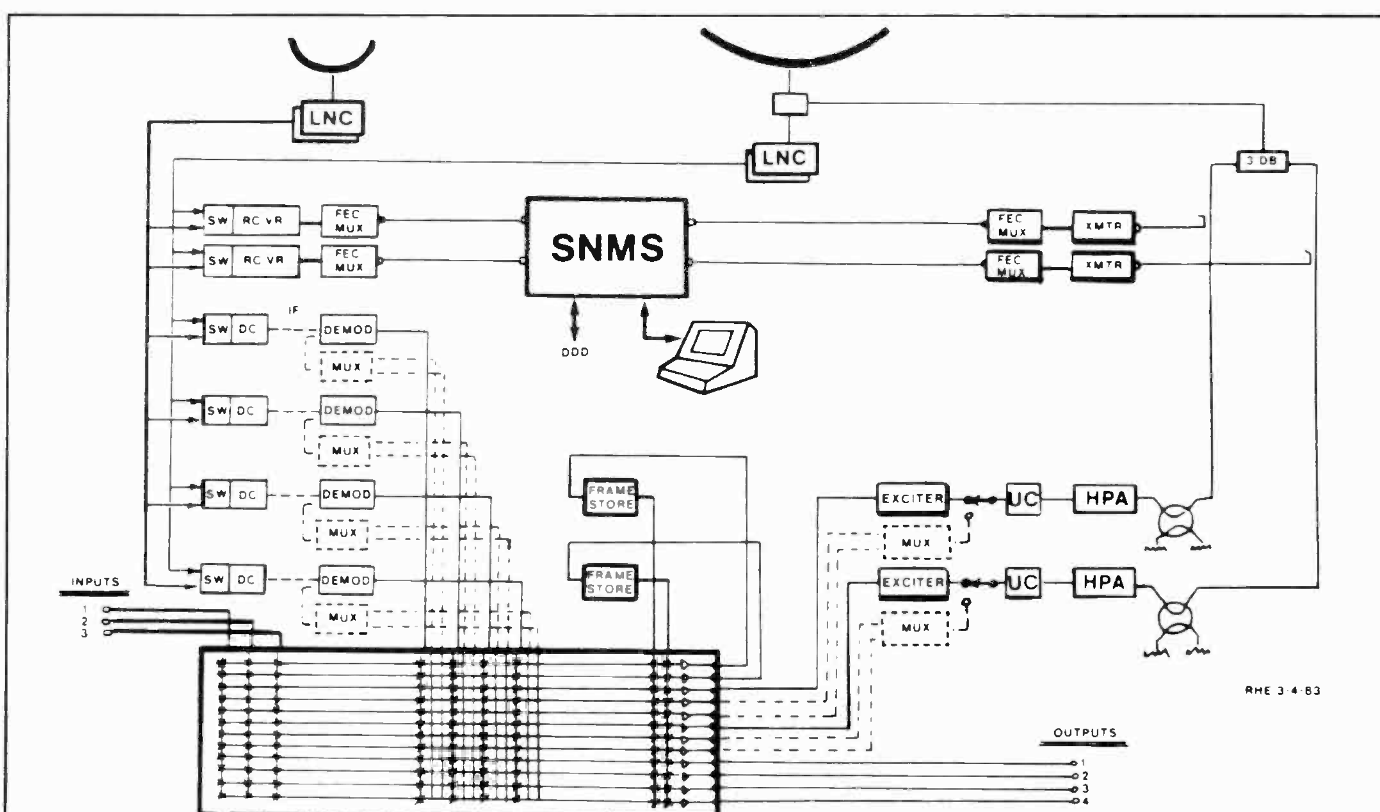


Fig. 7. *Transmit/receive earth station block diagram.*

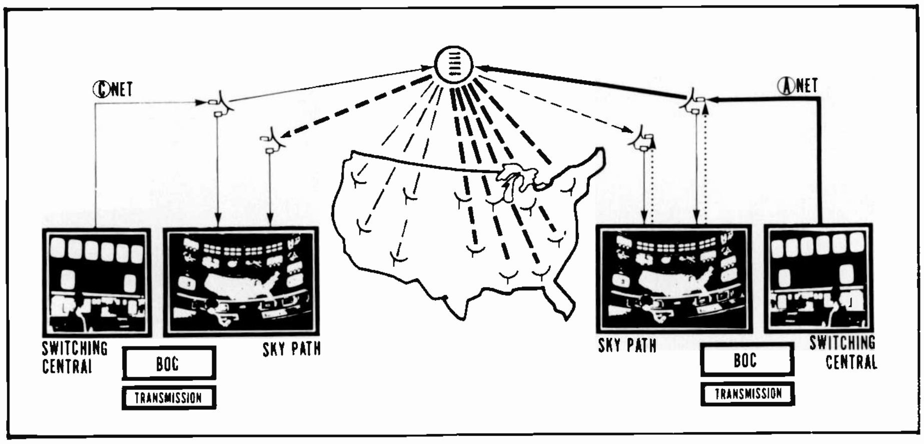


Fig. 8. *Nationwide SNMS control and monitoring available on both coasts.*

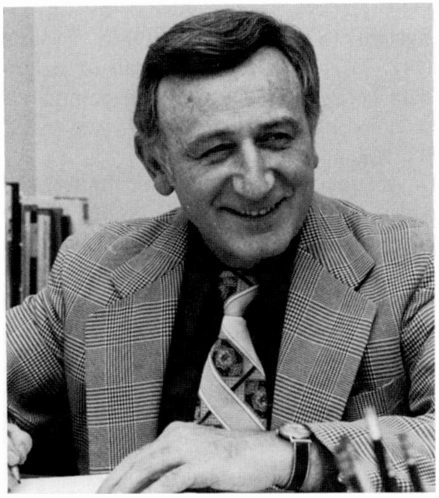
Some earth stations will be able to transmit as well as receive. Dual transmitters provide for one fully protected transmission or two simultaneous unprotected transmissions. Transmitter tuning, waveguide switching, and "on-off" control of transmissions can be controlled by Skypath Control. Uplink transmissions can occur simultaneously with incoming feeds. Effective use of uplink switching and receiver tuning, in various combinations, provides a substantial level of operational flexibility.

Normally, New York feeds the "A" network and Burbank the "C" network. Since the feeds are available nationwide, Skypath Control and BOC on each coast can monitor the total network (Fig. 8). Uplink switching permits the same group of affiliates to receive their network feed from a different location. In this case Burbank could feed both the "A" and "C" networks.

A third network feed can easily be configured by assigning a Switching Central channel to a Skypath and transmitting commands to the desired affiliates to tune to the new Skypath. In this case, New York could feed the "B" network to the Central time zone. A remote broadcast can directly feed a desired group of affiliates. Both New York and Burbank can monitor and tape the feeds as required.

Conclusion

All of the pieces of the system are coming together as planned. Our signal quality at the earth stations is better than our expectations. There is, however, a lot to be done.



Robert J. Butler studied electrical engineering at New York University and joined the RCA Service Company in 1947. He was transferred to the National Broadcasting Company in 1952, and has since worked in all phases of color studio development. Mr. Butler was appointed Project Engineer in the NBC Engineering Planning and Equipment Development Group in 1966. He was named Director of the group in 1969. He served as Director, Technical Development until 1981. He was then named Director, Engineering Planning for Broadcast Operations. In April 1984 he was appointed Chief Engineer, Satellite Network.

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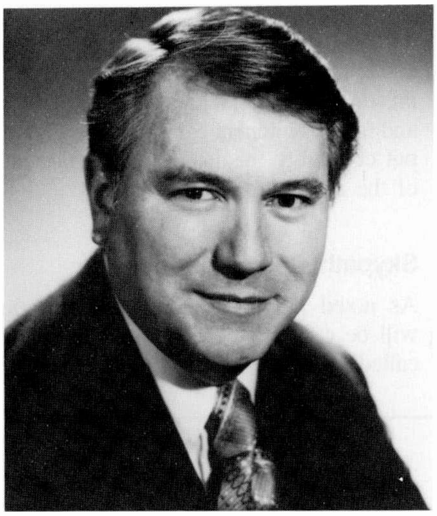

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Special issue of *RCA Review* on reliability

RCA Review is a technical journal published quarterly by RCA Laboratories in conjunction with the subsidiaries and divisions of RCA Corporation. The June 1984 issue contains seven invited papers on various aspects of the reliability of electronic components and systems. They are directed primarily toward specialists concerned with the effects of design and manufacturing technology on electronic device and equipment reliability. Included are articles on reliability of integrated circuits ranging from plastic-encapsulated ICs for commercial applications to high-reliability ICs for military and aerospace systems. The last paper in the issue discusses techniques for attaining high reliability in a satellite communications electronic system requiring a 10-year design life.

The topics in this issue represent a small fraction of the total RCA effort on improving the reliability of products, but the principles and approaches employed in these projects are applicable across the full range of RCA's areas of interest.

A one-year subscription to RCA Review costs $12.00 and back issues are $5.00 (employees get a 20 percent discount); reprints of individual papers are generally available from the authors.

Contents, June 1984

P.W. DeBaylo

Quality and service: The keys to our future

Continuous attention to the improvement of quality and customer-oriented services are fundamental elements of growth and long-term business success.

Communications is considered to be one of the world's foremost growth industries. RCA Americom has demonstrated its ability to compete in this marketplace based on the quality and cost-effectiveness of its services and has certainly realized some of this industry's great potential.

In reality, there is no such thing as a growth industry; rather there are companies organized and operated to create and capitalize on growth opportunities. Industries in which people assume they are riding a growth escalator invariably descend into stagnation. Companies cannot merely survive or maintain the "status quo." As Will Rogers once said, "Even if you're on the right track, you'll get run over if you just sit there." As in the organic world, there is only growth and decay, and growth is what businesses are all about.[1]

Abstract: *RCA Americom has earned its present position as the preeminent communications satellite carrier in the United States. However, increasing numbers of competitors have created an abundance of transponders and are selling diversified, state-of-the-art systems. We cannot rest on our laurels, but instead must focus on improving quality and service to sustain us against the dedication of those who wish to be first. This challenge is being met head-on through marketing efforts aimed at better understanding our customers' needs, and via programs to increase the quality of services and operational productivity. As a result, we can expect continued increases in market share, improved performance, and lower costs.*

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For the last ten years RCA Americom has met the needs of the satellite communications market through advanced communications engineering and operational techniques that make efficient use of satellite and terrestrial facilities. In proper balance, operational procedures and tools (such as RCA Americom's Network Monitoring and Control Center, the computerized Customer Service Center, and the Hekimian and Marconi performance measurement systems) were installed to maintain and improve service quality during this period of rapid expansion (Table I).

Now, as new satellite carriers enter the marketplace, we must seek to avoid complacency. Markets requiring the use of Ku-band spacecraft and other advanced technologies must be developed, and we must work even harder to keep ahead of what appears to be stiff competition.

Two essential elements must be considered when dealing with competition: price and quality. Price helps "sell" customers the first time; quality of service will assure that they continue to "buy." The combination of the two is the value of our service to the customer. The challenge then, is to continue to provide improved service while maintaining low costs. Quality and productivity go hand-in-hand; if you improve quality, then increased productivity will naturally follow.

Customer orientation

Successful companies realize that business is a customer-satisfying process (Table II). They know that the customer de-

Table I. *Communications facility growth.* *RCA Americom (formerly RCA Globcom) entered the satellite-communications field in the early 1970s, first providing communications services in December 1973 via leased Anik II transponders and small earth stations in Valley Forge, Pa. and Pt. Reyes, Calif. RCA Americom's first owned spacecraft, designed and built by RCA Astro-Electronics, was launched in December 1975. Since then, growth of our system has been dramatic and continuous.*

	1978	1981	1984
Spacecraft	2	3	5
Microwave Links	6	6	13
Central Offices	6	8	14
Earth Stations	17	31	48
TV Receive Only (Customer owned)	500	4000	9000

termines the requirements although he may not be able to state them precisely or quantitatively. The customer judges the results, based on criteria that may or may not have been defined up front, and the customer always gets what he wants—from you or from your competition.

Well-managed companies are customer-driven. In high-technology industries, such as ours, it is tempting to be too scientific or too engineering oriented. This appears acceptable in the short run, since new frontiers virtually assure a healthy market share. However, if you do not discover what the customers' needs really are, the market will dissolve.

Continuous contact with the customer will provide insights that direct the company.[2] Successful marketing demands a constant search for opportunities to apply existing technical and service know-how to the creation of customer-satisfying uses.

Good quality is good business[3]

Every customer wants high service quality. Quality is a customer's total perception of the service rendered—from the reliability of the equipments used, to the level of marketing support. Potential customers' procurement decisions are based, at least in part, on how well they rank your quality in relationship to that of your competitors. Surprisingly, your price—relative to your competition—has little effect in this decision; absolute price (that is, the magnitude) is of course important.

The Strategic Planning Institute in Cambridge Mass. manages a database called PIMS (Profit Impact on Market Share).[4] This collection of financial and qualitative data, from over 200 affiliated companies representing some 2000 businesses, allows analysis of a business' expected ROI (Return On Investment) by studying some 30 factors and ratios. These factors capture about 70 percent of the expected ROI variability. One index, relative quality, is your quality compared to that of your three top competitors, from the perspective of the customer. It includes intrinsic characteristics and any associated services (installation, billing, technical support, and so on), but does not include the customer's perception of price. Relative quality is the third most important contributor to the total ROI (approximately 9 percent), the highest contributor being investment intensity (19 to 20 percent), followed by relative market-share (15 percent). Despite this, many companies do not know their relative quality position or, if they do, do not consider it during the strategic planning process.

Table II. ***Some prominent customers serviced by RCA Americom.*** *Today, RCA Americom controls five in-orbit C-band spacecraft serving video, audio, voice, and data customers in the government and the commercial spheres. Services extend throughout the contiguous United States, Alaska, Hawaii, Puerto Rico, Greenland, the Caribbean, Panama, and to various overseas military bases via Intelsat International Gateway stations.*

Government:	NASA, DOD, NOAA/NESS, US Senate, VOA, AFRTS, GSA.
Private Line:	GTE/Sprint, MCI, Western Union, RCA Global Communications, U.S. Telephone Communications, Securities IND Automation, Teltec Savings Comm., Network I Inc., Fundamental Brokers, Lexitel Inc., Starnet, Mobil, Texaco, J. C. Penny, Holiday Inn, Pan Am, USTS, GE, IBM, Saks Fifth Ave.
TV:	NBC, CBS, ABC, HBO, Showtime, CNN, ESPN, Reuters, Warner Bros., WTBS, USA.
Digital Audio:	NBC, CBS, ABC, RKO.

RCA Americom's quality approach

Quality and service are the responsibilities of everyone at RCA Americom. Beginning with the initial customer contact by marketing, proceeding through engineering design and service implementation, and culminating with actual operational support, the customers' expectations must be kept in focus. To accomplish this, a formalized service-quality program was inaugurated in mid-1977, the objectives of which were simple: to get management and all employees to consider quality as a leading part of their operation; to assist them to do their job better; and to target programs of quality improvement through defect prevention. For the first time, in 1984, quality objectives have been incorporated into RCA Americom's strategic plan.

RCA Americom's quality program spans both the spacecraft and terrestrial portions of the communications service. Quality systems and procedures have been tailored to RCA Americom's specific needs and businesses, and influence the design, development, procurement, implementation, test, and operational processes.

Service performance measurement systems define and focus on areas requiring corrective action, for the benefit of top management. Active management participation in solving the problems of the "system" make the achievement of customer satisfaction possible.[5]

The remaining sections of this paper exemplify RCA Americom's integrated service quality program. Though not comprehensive, it illustrates the excellence achieved by the entire technical staff at RCA Americom in its vigilant efforts to make quality an integral part of RCA Americom's business.

Procurement quality

RCA Americom's business growth is capital intensive. Large quantities of high-value equipments and facilities are installed at remote locations in support of a diversity of services. Thus, it is essential that the quality of procured goods be assured.

As a user of equipment, Reliability and Quality Assurance (R&QA) cannot exercise direct control over equipment quality in the traditional sense. Since RCA Americom buys from a multitude of suppliers where the dollar value at any one vendor is small, most vendors are reluctant to accept additional quality control constraints. RCA Americom puts emphasis on the assurance aspect of quality rather than the control; R&QA works closely with suppliers, becoming familiar with their organization, manufacturing capabilities, and practices. Cooperatively, the mutual goal of high quality at low cost can be achieved.

In concert with Engineering and Purchasing, clear and unified requirements are specified to our suppliers. Some are tailored to the individual equipments or vendors based on our previous experience. Compliance is monitored during in-plant acceptance testing and in-field operations. This becomes the basis of our vendor-rating system.

Vendor qualification is achieved via surveys of the quality of product or service, supplier facilities, manufacturing

Fig. 1. ***RCA Americom's Customer Service Center (CSC)*** *is staffed Monday through Friday from 8:00 A.M. to 8:00 P.M. to accept trouble calls from RCA Americom's customers. The CSC functions are handled via the New York CTO, after hours. (Foreground left,* ***Nina Zeccardo,*** *right* ***Ellen Arnold,*** *background left,* ***Leslie Ortiz,*** *right* ***Karen Miller.****)*

capabilities, and quality assurance practices. Considered as well are price competitiveness, compliance with requirements, timeliness in delivery, and field support. A qualified vendors list is maintained and adjusted periodically based on actual performance.

Customer Service Center

When RCA Americom was established as a separate entity within the corporation in 1976, company management recognized that a prime requisite for success was the establishment of a dedicated customer-interface group within the Technical Operations activity.

The primary responsibility assigned to this function—the CSC (Customer Service Center) —is contact with a customer at the beginning, during, and at the end of a service problem. This customer contact is intended to demonstrate to the customer that RCA Americom cares about the service it provides.

The customer first sees this care when experiencing trouble. The customer reports the trouble to the company on a WATS-line telephone that is answered by a customer-service representative in the CSC. In a courteous manner the customer-service representative quickly and knowledgeably extracts the necessary trouble information from the customer, gives a trouble ticket number as a receipt, and promises to contact the customer soon with a trouble status.

The customer will again see this care when the CSC fulfills the company's call-back commitment: 100 percent of the customers will receive a status report on their reported troubles, and 95 percent of these reports will be made within two hours of the customer's report.

The CSC also calls to obtain the customer's verification that the trouble has cleared and that the customer accepts the circuit as operational.

During the last seven and one-half years, customers (through surveys and other methods) have complimented the CSC on its dedication and professionalism. The CSC also serves as an "operations tool"—its second priority. CSC is charged with the responsibility for headquarter's control of trouble-clearing activities at field locations throughout the company.

Upon receipt of a trouble, CSC enters the trouble-reported data into the computer and telecommunicates the data to a field-location CTO (Central Telecommunications Office). Using the computer, the CSC monitors the trouble data entered by the CTO during the troubleshooting process to detect format or data errors. The CSC is also part of the trouble-escalation procedure, and is the agency used for contacting headquarters personnel.

The CSC is the focal point for all queries on uncleared and recently cleared troubles, and serves Marketing, Operations, Engineering, Reliability and Quality Assurance, customers, and so on, in this regard.

Trouble-call management (TCM)

In 1978, it became apparent that the manual trouble-reporting mechanism, used by RCA Americom since its inception, could not accommodate the expected increased volume of trouble associated with growth projections. Accordingly, the RCA Americom quality group designed a computerized system that would replace the current "paper" trouble ticket issued by the CSC . Management Systems and Services transferred the design into software code and coordinated the system implementation.

Initially, the CSC received the trouble from the customer, extracted the necessary trouble information, gave the customer a trouble-ticket number as a receipt, and then referred the trouble by telephone call to a CTO. Thereafter, the CSC periodically contacted the CTO to receive and record the various trouble actions taken to clear the trouble. The CSC also called the CTO to remind them to escalate a trouble referred to telco (telephone company) to a higher level in accordance with the established telco escalation policy. By the time the first phase of automation was ready, the CSC had grown to a staff of six customer service representatives, and virtually all of the CSC time (and much of the CTO technicians' time) was used to verbally extract and record the trouble data on paper tickets.

When the troubles were cleared, the paper tickets were sent to R&QA where the trouble data was reviewed for accuracy (that is, inspected) and manually recorded in journals. The data was summarized, compiled and reported monthly, showing the performance trends of the company's service system-wide, by CTO, and by telco.

Table III. ***Trouble-call management (TCM)****—Improved customer quality by elimination of error.*

- Automated trouble routing
- Automated ticket management
- Visibility of action taken
- Increased technician/CSC efficiency
- Automated outage credits
- Escalation-required prompter
- Automated trouble analysis

Practical aspects in predicting service availability

Service availability is one of the more important quantifiable measures of quality. It influences company revenues, by way of influencing customer credits, maintenance, manning, and logistic support. Availability (designated in the adjacent table as A) has vital importance on the way we design, implement, and operate our service networks.

Traditional methods of calculating system availability were discussed previously.[6] These methods, however, describe only inherent failure mechanisms of equipment and their associated repair. Real-life operating conditions prevail, often offsetting our expectations.

To arrive at a model much closer to actual conditions, numerical coefficients were introduced that modify the generic availability based on actual performance history. Seven major factors were established and probabilities of occurrence were assigned to them on a statistical basis. The product of these factors and the generic availability yields a more realistic prediction of service performance.

Real-world Availability Coefficients

A1: Equipment failures not modeled
- Remote/control/alarms
- Levels
- Cables/connections

A2: Purchased services
- Telephone lines
- Commercial power

A3: Customer-induced troubles

A4: Human factors
- Error
- Training

A5: Logistics
- Spares
- Preventive maintenance

A6: Procedural
- Quick fixes
- Fault isolation

A7: Weather

A system = A generic x A1 x A2 x...x A7

TCM is a computerized system whose prime focus is to provide efficient trouble management and correction in RCA Americom's growing system (Table III). In October 1981, Phase I of TCM became operational. The CSC became semi-automatic in that each customer-service representative had a video terminal to enter the trouble information from the customer and from the CTOs. In November 1982, Phase II was activated. Virtually all of the R&QA reports were prepared automatically by computer. Computer-generated history files replaced the manual recording in journals, making the data available to everyone.

By the end of 1983, Phase III of TCM was completed, and all CTOs had video terminals and printers that enabled the CTO to automatically receive the trouble ticket and input the trouble data directly into the computer. The CTO now has the responsibility for data integrity, with R&QA performing an auditing and training function. The CSC still accepts the initial complaint, keeps the customer informed as to the troubleshooting status, and monitors the quality of the data inputted by the CTOs. The customer is the main beneficiary of this three-phased automation.

CTO Manager's report

The CTO Manager's Report is an operational tool used for the location of problem areas in the RCA Americom system. The data is provided by technicians via the TCM. Field management uses this information in conjunction with headquarters staff to isolate and correct problem areas.

Summarized TCM information is stored in FOCUS databases, processed using an IBM PC. Non-TCM acquired information is added to the summarized files and statistical analyses are performed.

The report is issued monthly. Each CTO manager receives a one-page report on how the system performed and a one-page report on their CTO's performance in the same key areas. The report contains data on the number and type of maintenance actions, and gives in-depth analyses of those troubles directly attributed to the CTO. This document reports on how timely and efficient the CTO was in clearing troubles versus company standards. It also flags those circuits that have had more than one trouble in a 30-day period. Backup data supporting the results shown in the one-page report provide a tool for the manager to isolate problems in the CTO. A monthly review by representatives of different Technical Operations activities follows and action items are generated to correct any weak areas.

A Chronic Circuit Report is also provided to CTO field operations. This report identifies those circuits that have, over a period of time, performed below RCA Americom's quality standards. CTO Operations give special attention to these circuits, and initiate special testing as required. Results are monitored by R&QA and performance is reviewed periodically for recurrences.

Test and monitoring systems

RCA Americom uses many different automated testing, monitoring and control systems to assure that the various components in its satellite communications system are operating at their optimum performance levels. These systems include: an Alston traffic monitor; a Hekimian remote test system; various computer-controlled test facilities; remote status-monitoring and control systems; and a Network Monitoring and Control Center.

The Alston monitor is a traffic-activity reporting system, used to automatically detect voice-grade circuits that are always busy or that show very short connect times. Circuits exhibiting these characteristics are suspected to be defective and are subjected to further testing and corrective maintenance, if necessary.

The Hekimian test system allows unattended, off-hour testing of voice-grade services. It performs full end-to-end testing of each circuit and can isolate performance problems to an individual piece of equipment. This allows us to adjust or replace equipments that are not meeting performance requirements. In many cases corrective action is performed before the customer has noticed a problem, greatly contributing to his overall satisfaction. For one large customer this sytem finds up to 90 percent of the troubles before they are reported. The Hekimian test system is also being used to perform fault isolation of troubles reported by the customer, allowing rapid referral to the fault location (for example, the subscriber's office, the local telephone facility, or an RCA Americom facility), thereby greatly reducing service restoral time.

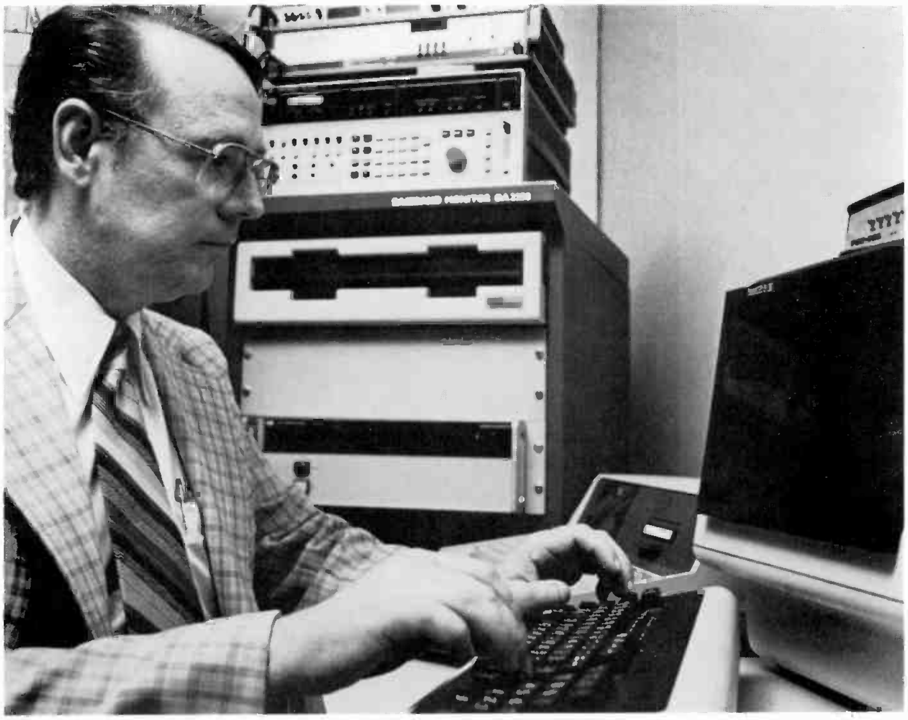

Fig. 2. *A baseband monitoring system, controlled from RCA Americom's headquarters, measures the performance of the multiplex communications traffic. (Demonstrated by* ***Tom Baruta,*** *Engineer.)*

Fig. 3. *A Hekimian Test System allows remote, after-hours testing (by* ***Pete Byrnes,*** *Technician) of intermachine trunks and other voice-grade services. Trouble tickets are issued to the CSC on suspect circuits for trouble verification and resolution.*

System-performance monitoring of our multiplexed traffic is conducted at baseband at the earth station and CTO locations. Accurate frequency and level control is a prerequisite for satisfactory system performance. Testing is performed with the aid of a Marconi test system and other computer-controlled test equipments. These systems support routine testing as well as troubleshooting of known or suspected failures. Again, the objectives are to detect problems before they become severe enough to cause customer complaints and to aid in isolating a problem and initiating corrective maintenance action as rapidly as possible.

Since it is not cost-effective to man all of our earth station and microwave sites on a continuous basis, RCA Americom has extensive remote monitoring and control systems located at our Vernon Valley Earth Station (for commercial systems) and at our Goddard Earth Station (for government systems).

Remote locations automatically switch to backup redundant units in the event of a failure and report equipment-status changes to the central monitoring and control locations. The control centers are able to remotely command equipment reconfigurations and dispatch technicians to the remote site for restoration of functional redundancy as rapidly as possible.

The Network Monitoring Center (NMC) located in Vernon Valley, N.J., is manned on a 24-hour basis, and can monitor all video and audio programs transmitted by RCA Americom's facilities. In addition, the system has the ability to monitor incoming microwave signals, enhancing the NMC's ability to isolate trouble spots.

The NMC houses an extensive inventory of test and control equipment, including waveform monitors, vector scopes, spectrum analyzers, VU and peak-level meters, and video monitors. Audio and video test signals can also be originated, giving NMC the ability to quickly detect and fault-isolate a problem. This ensures rapid trouble correction and the best service to our video and audio customers.

Conclusions

Quality must be an integral part of RCA Americom's business planning process to assure our success in a world of increasing competitive strength. Looking outwardly, we must understand our competitive quality position and recognize what effects the improvement of customer-perceived quality will have on our market share and profitability. Looking inwardly we must find the areas where we are paying dearly for error, and must streamline the "system" to increase overall quality and productivity, resulting in reduced expenses.

Through all of this, we must not lose focus on the customer—understanding their needs, designing to meet them, and providing operational tools that strive to continually improve upon the service we offer them. Quality- and service-oriented management, dynamic, outlooking, and "hungry," will solidify our place in the future.

Acknowledgments

Service quality is assured through the synergistic efforts of all the people in all the departments and activities at RCA Americom. This paper is dedicated to their accomplishments. Special thanks is given to J. Christopher, whose active support of RCA Americom's quality thinking resulted in the creation of many of the programs described herein.

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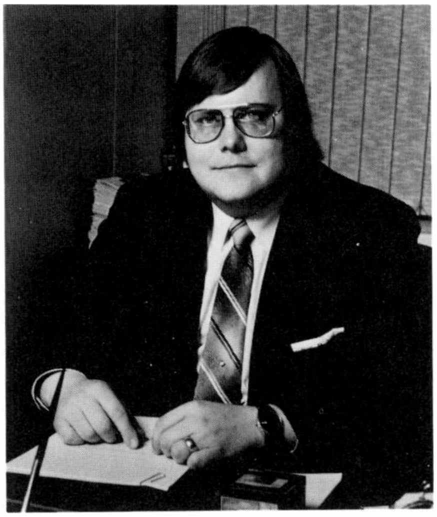

References

1. Levitt, Theodore, "Marketing Myopia," *Harvard Business Review*, Vol. 53, No. 5, pp 26-48 (Sept.-Oct. 1975).
2. Peters, Thomas J., "Putting Excellence Into Management," *Business Week*, (July 21, 1980).
3. Pollack, R., Introductory remarks, *RCA Engineer*, Vol. 25, No. 4, p. 2 (Dec. 1979/Jan. 1980).
4. Strategic Planning, an American Management Association Course, Number 2526-89, January 1984.
5. DeBaylo P.W., "Design, Measurement and Achievement of a High Level of Service Availability in A Domestic Satellite Communications Network," *AIAA 9th Communication Satellite Systems Conference*, CP-821, pp. 405-412 (Mar. 1982).
6. Schreier, S.S., and DeBaylo, P.W., "Quality Assurance: Measurement and Action," *RCA Engineer* Vol. 25, No. 4, pp 41-46 (Dec. 1979/Jan. 1980).

S. I. Alexander

Just-in-Time: A plan for productivity gains

The Just-in-Time manufacturing concept encompasses an operations strategy that is outlined here. It's working at other U.S. corporations.

Just-in-Time (JIT), the subject of an "Engineer's Notebook" article in the Mar./Apr. 1984 *RCA Engineer*, has many aspects that interrelate. Some of the benefits of JIT are also prerequisites—for example, quality. Improved quality is a major benefit of JIT, but it is also necessary for quality to be at some minimum level before JIT can be effective. With some minimum level of quality, JIT can begin to be introduced. Quality improves, which in turn leads to a greater use of JIT concepts. Maybe another way to explain this is to say that JIT is a continuum of self-improvement. This philosophy (Table I) of continuous improvement applies to several of the elements of JIT.

Definition

Just-in-Time is an operations philosophy, an operations strategy; it is not a system. The most basic definition of the JIT goal is this:

> Produce only the minimum necessary units, in the smallest possible production-run quantities, at the latest possible time, with the objective of achieving plus-or-minus zero performance to schedule.

Abstract: *The Just-in-Time operations philosophy is elaborated. JIT is more than an inventory program, and all elements of this program to increase manufacturing productivity are presented in this article. Moreover, a sidebar details some of the many Just-in-Time success stories of major companies that have implemented this strategy.*

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Just-in-Time prescribes no single methodology or technique. It simply establishes the goal, the means to achieve this goal, and the self-evaluation standard for the measurement of success. The target is the minimization of waste of all types in manufacturing processes in order to have factories function without inventory, which compensates for the problems not yet solved.

What JIT is not

JIT is frequently misunderstood, partly because it is so new. Many people and many businesses are just now gaining some understanding of these concepts. Most of what is written on this subject is superficial or only covers one aspect of JIT, such as kanban or Just-in-Time vendor deliveries. It is difficult to find one article that integrates all the elements of JIT, that gives the reader a comprehensive understanding of what is involved.

JIT is not simply an inventory program. Inventory reductions are by-products of the productivity gains realized. These inventory reductions then, in turn, generate additional productivity gains.

JIT is not initially a program for suppliers. Still, this is what many think JIT means: Have suppliers located close to the factory and make frequent deliveries just before the part is needed on the production line. This is a part of JIT, but relatively only a small part, and usually becomes part of a program down the road somewhere. Only after JIT is operational internally are we ready to work with suppliers for Just-in-Time deliveries. If we *only* push inventories to suppliers' warehouses, we have missed the point.

JIT is not a fad. In many ways, it is a development of basics. And it is proving to be of major benefit to many companies with business problems similar to RCA's. JIT is not a materials management or purchasing project. Although most industry JIT projects were begun in materials functions, the concepts also encompass Industrial Engineering, Design Engineering, Manufacturing Engineering, Data Processing, Quality and Reliability Assurance, and Finance.

JIT is not a cultural phenomenon. It is true that the beginnings of JIT come to us from Japan and that *parts* of JIT involve a management style not common in many U.S. companies. However, most of JIT can be viewed as a winning combination of neglected American ideas rather than an import of something distinctly Japanese.

JIT is not a program to displace Material Requirements Planning (MRP). More accurately, it is a marriage to existing systems. MRP is still needed to translate a forecast into a material requirements plan, to create a Master Production Schedule, to do capacity planning, to monitor bills of material, to schedule vendor material, and so on. If JIT replaces any part of MRP, it is in the shop-floor control area—the execution of the schedule on the factory floor. MRP does the planning, JIT does the execution.

Table I. *Production philosophy—Traditional versus Just-in-Time*

Element	*Traditional*	*Just-in-Time*
• Inventory	An asset. Protects against forecast errors, machine problems, late vendor deliveries More is "safer".	A liability. Every effort must be extended to do away with it
• Lot sizes	Formulas. Always revising the optimum Lot size with some formula based on the cost of inventories and the cost setup.	Immediate needs only. A minimum replenishment quantity is desired for both manufactured and purchased parts.
• Setups	Low priority. Maximum output is the usual goal. Rarely does similar thought and effort go into achieving quick changeover.	Make them insignificant. Requires either extremely rapid changeover to minimize impact on production, or availability of extra machines already setup. Fast changeover permits small lot sizes to be practical, and allows a wide variety of parts to be made frequently.
• Queues	Necessary investment. Queues permit succeeding operations to continue in the event of a problem with the feeding operation.	Eliminate them. When problems occur, identify the causes and correct. The correction process is aided when queues are small. If queues are small, it exposes the need to identify and fix the cause.
• Production	Strategy: Stability—long production runs so that need to rebalance seldom occurs.	Strategy: Flexibility—rebalance often to match output to demand.
• Line balance	Balance to line rate.	Balance to demand rate
• Mixed Models	Run mixed models where labor content is similar from model-to-model	Strive for mixed-model production, even in subassembly and fabrication
• Plant Layout	Linear lines.	U-shaped or parallel lines
• Asssembly line	Applied in labor-intensive final assembly	Applied even to capital-intensive subassembly and fabrication work
• Quality	Plan to run at fixed rate; send quality problems offline	Slow or stop for quality problems; speed up when quality is right
	Tolerate some scrap. We usually track what the actual scrap has been and develop formulas for predicting it.	Zero defects. If quality is not 100%, production is in jeopaardy.
• Workers	Assume fixed labor assignments	Flexible labor: Move to the current need
	Management by edict. New Systems are installed in spite of workers, not thanks to the workers. Then we concentrate on measurements to determine whether or not they're doing it.	Management by consensus. Changes are not made until consensus is reached, whether or not some arm twisting is involved. Vital ingredient of "ownership" is achieved.
• Equipment maintenance	As required. But not critical because we have queues available.	Constant and Effective. Breakdowns must be minimal.
• Capital equipment	Buy "supermachines" and keep them busy	Make (or buy) small machines; add more copies as needed
• Material handling	Conveyerized material movement	Stop stations or close together
• Lead time	The longer the better. Most foreman and buyers want more lead time, not less	Keep them short. This simplifies the job of marketing, purchasing, and manufacturing, because it reduces the need for expediting.

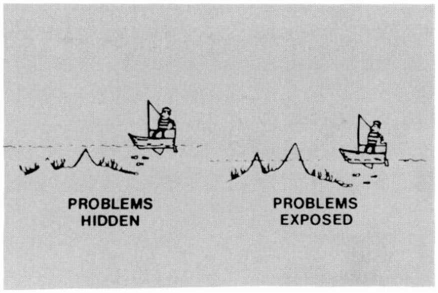

Fig. 1. *Inventory as a facilitator of the identification of problems.*

Finally, JIT is not a panacea for poor management. It doesn't cover up, it exposes. It takes a lot of hard work, and users have to be prepared to crash and burn once in a while. And, it's necessary to have management that will encourage some prudent risk taking and permit some failure.

Elements of JIT

Now that we have some understanding of what JIT is *not*, let's concentrate on what it is. Although there is no single specific technique or methodology accompanying it, practitioners are identifying many elements of JIT.

Reduced inventory

In JIT terms, inventory is a misdirected comfort index. The whole question of inventory is approached from a different standpoint—"Why have any at all?" instead of the historical "How much and when?" View inventory as a liability, not an asset, even though that may be the financial definition. Inventory only compensates for the problems not yet solved. This is an important concept—inventory reduction becomes a "facilitator" of the identification of problems.

Take a look at the reasons for inventory: quality problems, setup time, long cycle times, improper scheduling, inadequate information systems, complexity versus simplicity, old habits and attitudes. In this sense, inventory is one yardstick of how good a total management job is being done.

It is not unusual to discover that many different deviations or combinations of these problems have been lumped together, so that they appear to everyone as a single, insolvable situation. The "real" problems are revealed through the inspiration provided by the extra pressure from reducing the inventory. With layers of inventory slowly peeled away, concentration can then be focused on attacking the most visible evidence of unsolved problems.

An analogy is to view inventory as the water level in a pond with a rocky bottom (Fig. 1). The rocks represent problems. As the water level goes down, invariably at the worst possible time, the problems are suddenly and unexpectedly exposed. It is better to force the water level down on purpose, expose the problems and fix them in a controlled fashion, before they cause trouble.

Let's look at this in a typical plant situation. Many plant environments are characterized by large quantities of Work-in-Process (WIP) inventory between work stations, between a subassembly department and the final assembly line, or in a central stockroom waiting to be called to the factory floor. A production worker starts work on a lot of material that is usually large and typically has spent time sitting idle. A defective part is found that won't work properly. What is the easiest thing to do? Since there is a big pile of these parts, the worker tosses the defective part into a scrap or rework bin and grabs another. There are enough good parts to keep busy so why complain about defectives? But the department or person responsible for the bad parts rarely gets timely and accurate feedback. As a result, the real problem never gets defined or fixed.

Contrast this with the other extreme. Say that a worker makes one piece and hands it to a second worker whose job is to join another piece to it, but the second worker can't make them fit because the first worker made a defective part. The second worker wants to meet his quota and doesn't like being stopped, so he lets the first worker know about it right away. The first worker's reactions are predictable. He tries not to foul up again, and tries to root out the problem that caused the defective part. So this reduction of inventory facilitated reduced production time, reduced wasted materials, the identification of and solution of problems, and an improvement in quality.

Elimination of waste

In JIT terms, waste is defined as anything that does not add value to the product. Some examples of waste are the time parts spend in a queue, scrap or defective parts, excess material handling, overly complex scheduling systems, over-production or production sooner than required, and so on. JIT emphasizes the reduction or complete elimination of these wastes.

Short production cycle

Another fundamental element or characteristic is that the total production time or total cycle time is markedly reduced. This might be the core element of JIT. It is by doing all the things it takes to achieve a short production cycle that many of the benefits are realized. Reductions of the production cycle by one or two orders of magnitude are not uncommon.

Having a short production period permits the factory to produce only at the market mix and rate of demand, without producing unsold inventory. It might even be possible to reach the point where the production cycle time is less than the delivery time or lead time demanded by the customer. Think of the customer-service and inventory implications of that.

We can wait longer to commit the factory to a final assembly schedule. So there is a higher likelihood that the factory will produce on time what the customer wants, and a lower likelihood that the factory will produce what is no longer needed. Small lot sizes, short setup times, and a balanced or synchronized line and plant layout, all contribute to shortening total production time. The ultimate objective is to make each day what is sold each day.

Small lot sizes. Small lot production means making a little of everything often—even if this means mixed-model production. The auto industry is moving further in this direction—building Oldsmobiles, Pontiacs, and Buicks interspersed on a single assembly line. Why do this? First, to achieve a dramatic reduction of manufacturing cycle time. Estimates show that in many plants, 95 percent of the time that a part is in the factory it is either being transported or in queue. And large lot sizes are a big part of the reason for this.

With small lot sizes, feedback of quality or other problems is faster. The factory has more flexibility to react to fluctuation of demands, which results in faster market response. And finally, small lot sizes mean reduced inventory.

In Fig. 2, the top section indicates the process that normally determines what lot size is produced at a given production station. The calculations may not be actually made, but generally this is the thought process. A production time of 1.24 minutes looks better than 3.4 minutes, but consider the impact of this decision on the time it takes one part to get through the total production cycle.

This example assumes two operations, with an actual processing time of one minute for each operation. With a lot size of 1000, the first operation takes 1000 minutes. Then the lot is moved to the second operation, where another 1000 minutes is consumed for a total production time of 2000 minutes or 33.3 hours. If the lot size instead is 100, the same production sequence takes only 200 minutes or 3.3 hours. In this example there are only two operations. The effect on total production time is even more dramatic, of course, if there are more than two operations. There is also a capacity implication. If large lots are made now and not needed, capacity may have been lost for something that is needed.

This can be illustrated with another water-flow analogy. The top picture in Fig. 4 has a rocky bottom representing lots of inventory, large lot sizes, and many hidden problems. If a drop of water goes over the top it will roll around in those big pools for quite awhile before it comes out the other end; indeed it may never come out. In contrast, note the bottom picture in Fig. 4. Here the flow is smooth and fast.

Short setup times. Short setup times are an important element of JIT. Many successful users view this as a good entry point into the JIT cycle. Setup times must be low for small lot production to work. If setup times are low, the whole basis of large economic lot size disappears. This requires a change in thinking. Generally, setup costs are accepted as a given, then lot size is determined. With JIT there is great emphasis on significantly reducing setup time as a way to shorten the production period (cycle time), to provide the flexibility to respond to fluctuations of demand, to increase machine use and to reduce inventory as a by-product. And one of the best things about short setup times is that some dramatic results can be achieved with low implementation costs. To make a big dent in setup times is not as formidable a task as it initially appears.

Setup reduction elements. The first step is to recognize the elements of the setup that are external (work that can be done in advance with the machine still running) and those that are internal (work that must be done with the machine stopped). External elements then are completed before the machine is stopped. Examples include prior accumulation of any materials, tools, or fixtures that will be needed during setup; or making sure setup personnel are ready to go immediately upon machine shutdown. This may sound too simple to be true, but many companies have reduced setup time by 30 to 50 percent by this approach alone. And this step requires almost no investment.

The next step is to practice, review the methodology, and start to change some of the work from internal setup to external setup. One example is a die-casting mold that requires several trial shots to heat the mold before good parts can be produced. The solution is to preheat the mold outside of the press so no trial shots are required. Internal setup is moved to external setup.

As a final step, eliminate adjustments by using standard tools or spacers, locator pins, quick release clamps instead of threads, an injection-mold cooling-water manifold instead of individual water connections, and so on. This step usually requires an investment in new or modified tooling.

There is another point about setups—the emphasis on "efficiency," as typically defined, causes personnel to participate, ultimately, in inefficiency. The foreman wants to maximize the standard

SMALL LOT PRODUCTION

SET UP OR CHANGEOVER TIME	ACTUAL PROCESSING TIME	LOT SIZE	OVERALL PROCESSING TIME PER PIECE
4 HRS	1 MIN	100	$1 \text{ MIN} + \frac{4 \text{ HRS} \times 60 \text{ MIN}}{100} = 3.4 \text{ MIN}$
4 HRS	1 MIN	1000	$1 \text{ MIN} + \frac{4 \text{ HRS} \times 60 \text{ MIN}}{1000} = 1.24 \text{ MIN}$

TOTAL PRODUCTION TIME COMPARISON ASSUMING TWO OPERATIONS WITH ACTUAL PROCESSING TIME ONE MINUTE EACH:

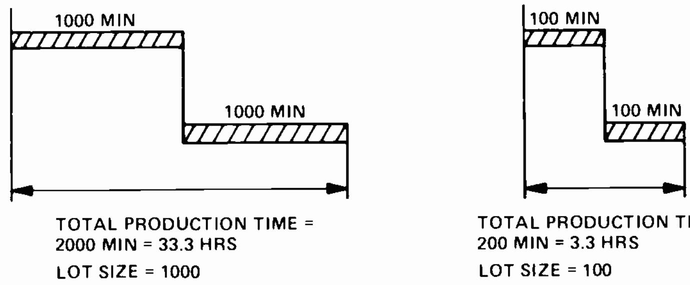

Fig. 2. *Effect of lot size on total production time.*

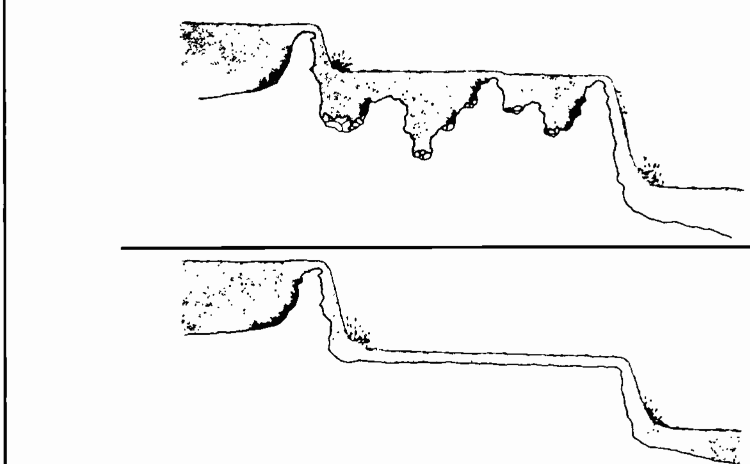

Fig. 3. *Analogy of water flow to material flow in production.*

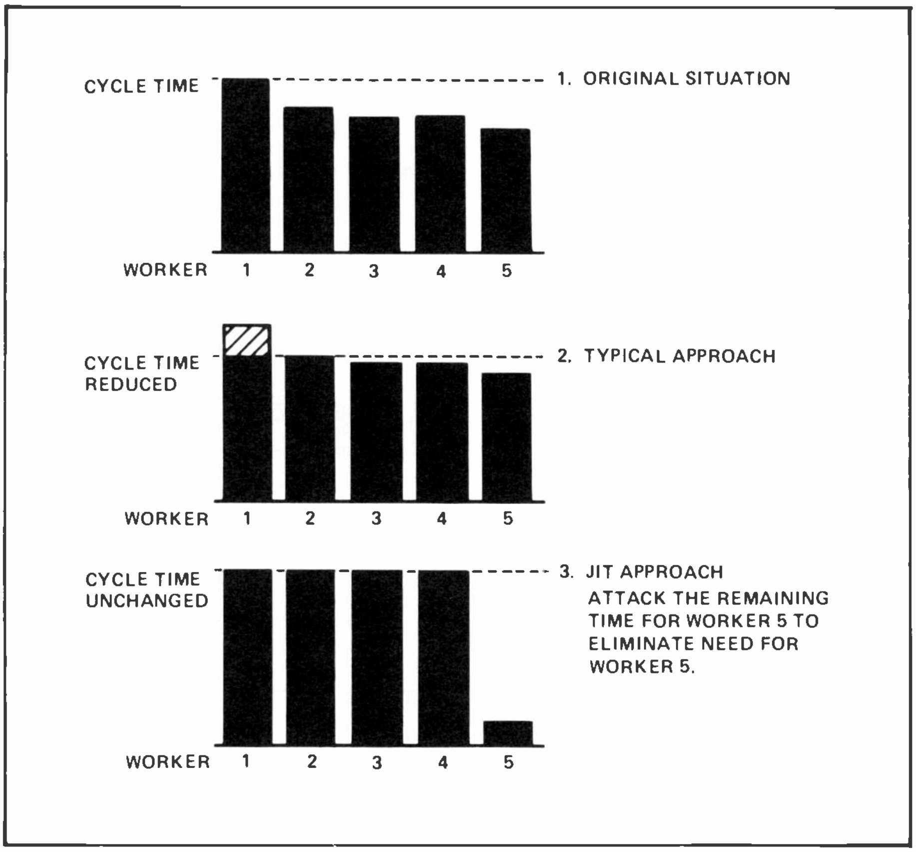

Fig. 4. *Balance to line rate (not necessarily to shorten time at any given operation).*

hours earned, he wants to keep the equipment running as long as possible. Even if setup time is part of the standard, no parts are made while the equipment is being set up. The way to maximize standard hours is to avoid setups—run as long as possible. By inference this places a high cost on setup time and encourages supervisors to produce as much as possible, even if the product is not needed. "Efficiency" goes up but the factory is encouraged to do "gravy jobs" first, to run as much as possible of the parts in which there is the highest ratio of potential standard hours to earn versus actual hours worked. These may not be the parts most needed at that time by the rest of the production line. What all this means is that there may be some change required in cost accounting rules or in the way people's performances are measured.

Balanced line. The production line is a complex assemblage of workers, supervisors, material, machines, handling devices, and a host of constraints and potential problems. The intent here is not to expound on how to re-engineer the whole manufacturing process, nor does the author pretend to be an expert in this area, but rather an attempt will be made to convey how line balancing and plant layout are treated in a JIT production strategy.

We're talking about line balancing from initial parts prep, through subassembly, to final assembly—not just within a final assembly line where U.S. industry typically concentrates effort. A balanced line means that each workstation has a cycle time equivalent to the cycle time of the next downstream station, all synchronized to the rate of final product off the end of the line. And the rate off the end of the line is ideally equal to the market rate of demand. This doesn't mean that the run rate of all machines is necessarily equal. It means that if the capacity of a machine is high, unnecessary production is not permitted. The machine might run 15 minutes and rest for 10 minutes. Large-capacity machines are paced by lower-capacity machines. This is referred to in JIT terms as synchronization of production. Put another way, if one operation takes parts from a preceding operation in large increments and in a random manner with regard to timing and quantity, then the preceding process would need surplus workers, equipment or inventory. And if this operation is near the end of the production process, it can really cause a snowballing effect on operations at the beginning of the process.

Line balancing is certainly nothing new to most U.S. manufacturing operations. Most U.S. plants divide production line tasks into equal portions, with each portion being assigned to a different machine or worker so that ideally each machine's or worker's task takes the same time. Final assembly lines make units one at a time, generally with no inventory buffers between successive operations. JIT takes this line balancing and one-piece flow, or at least small lot sizes, back through subassembly and into parts prep so that, to the extent possible, the entire production process is a continuous balanced flow. Figure 4 illustrates part of this difference in the line-balancing approach.

The original situation shows a major imbalance with Worker Number 1. A typical approach might be to cut time from Worker Number 1 and add this time to the remaining workers so that overall cycle time is reduced. However, if the original cycle time of the total line is good enough, if it is already matched to cycle time of subsequent downstream operations, the JIT approach would be to balance Workers 1, 2, 3, and 4 to the original cycle time, and then attack the remaining time for Worker Number 5, with a view toward eliminating the need for this worker. The important thing to realize here is that balancing is done to the cycle time required by the rest of the operations. It is not done to simply increase output. The priority is to cut inventory between operations, not so much to shorten the actual processing time at any given operation.

Plant layout. Plant layout is also important for reducing total production time. With setup times reduced, lot sizes smaller, one-piece flow introduced where possible, and mixed-model production instituted, material flow becomes an issue. Therefore, we must look at plant layout. Now, before you panic and think that Day One of a JIT program would require a massive plant layout change, realize that this is down the road a ways. Lots of improvements can be made, and must be made, before this point is reached. But some discussion of this is necessary for a full understanding of JIT.

The concept usually associated with JIT plant layout is called Group Technology as seen in Fig. 5. Rather than have large and separate departments each with some specialty—that is, machining, painting, heat treating, and so on—Group Technology means a group of dissimilar machines set up so that all of them can be running the same or similar products at once and with very little transport distance between them, physically lining up processes that are normally done in sequence. In the bottom of Fig. 5 large lots of material are moving back and forth from one department to another, creating lots of waiting time and lots of priority questions regarding which lot gets processed next. In the top of Fig. 5, several smaller lines are set up. Except for the heat-treating department, these lines are dedicated to one product or a small group of products. Thus the material movement between departments and the queue time is reduced. Productivity goes up and work-in-process inventory comes down dramatically. If you think about it, this is often how an expeditor works—hand-carrying parts from one department to another, breaking immediately into the production operation. With Group Technology this becomes the normal flow.

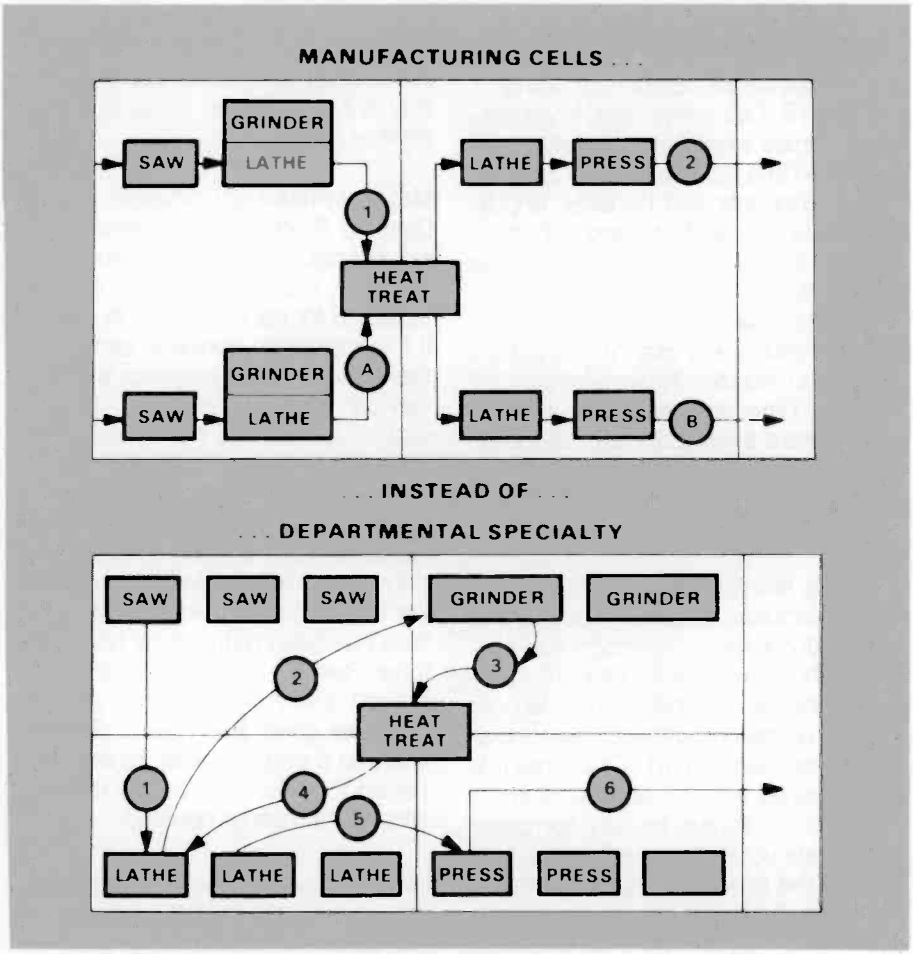

Fig. 5. *Group technology as a plant layout concept.*

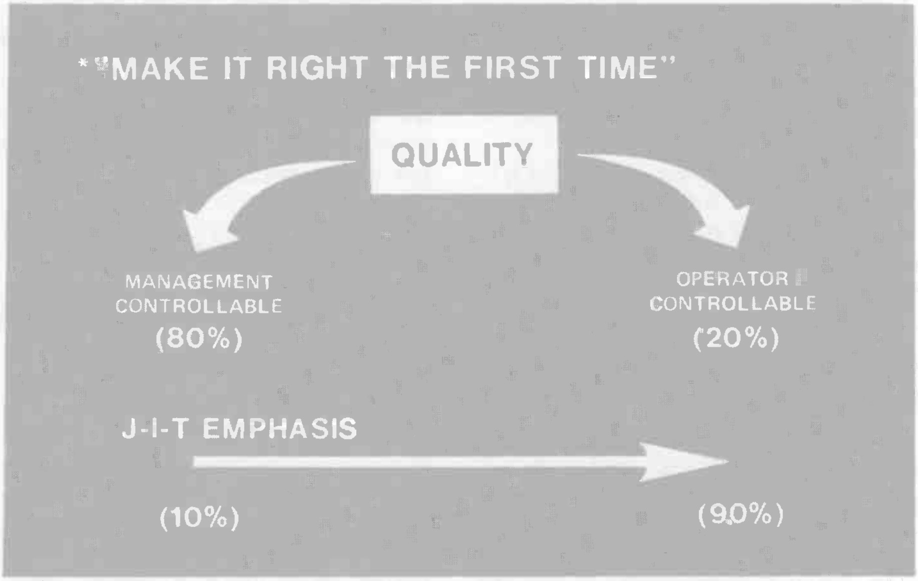

Fig. 6. *Make it possible for the worker to be responsible for quality.*

Total quality control

Total quality control means a lot of things. First, the emphasis is on defect prevention rather than defect detection. JIT will greatly improve quality, but quality must be good at the outset. In fact, many use improved quality as the entry point to a JIT program.

Statistical process-control techniques are used with the emphasis on the quality of the process as well as quality of the product. Fail-safe production techniques are achieved by designing the product or the assembly technique so that it is impossible to do wrong—the square peg in a round hole concept. Problems are made visible and get fast feedback with automatic machine shutoffs, warning lights, and so on. Problems are also made visible by low inventory and the constant pressure that the line won't run if everything isn't right. Every part is needed. Take judgment out of the inspection process. The more these techniques are used, the closer one achieves effective 100-percent inspection but not as a separate offline operation.

Employee involvement is stressed. The worker is encouraged to be responsible for the quality of production and is given tools and a situation that make him capable of producing parts to specifications. Management provides the necessary work aids and supports the workers in their endeavor to avoid producing poor-quality products. It becomes a way of life that bad parts never pass from one operation to the next in the manufacturing cycle. There is a habit or philosophy of continuous improvement. Previous programs—we all remember "Zero Defects"—were different than what we're talking about here. They didn't change the way we operated. Mostly, they were just slogan campaigns. Figure 6 illustrates this importance of worker involvement and the constant emphasis under JIT for the pro-

Just-in-Time success stories

What are other companies doing with JIT? Two years ago, involved companies were trying to define Just-in-Time, to understand Just-in-Time concepts and benefits, and to evaluate Just-in-Time applicability. Within the past year there has been a significant transformation. Today, these companies are reporting dramatic results and planning a continued and broader implementation of Just-in-Time. Awareness of and the movement toward the Just-in-Time management philosophy as a major tool for improved productivity, quality and profitability are spreading rapidly.

As a result of either visiting the manufacturing facilities, meeting with the individuals, or hearing them present their experience with JIT, the following list has been compiled of some of the companies making major investments in JIT. Of course it is recognized that the degree of improvement shown for any company depends upon how inefficient it was when the program began. However, in almost every example these improvement figures were taken from a base of performance that certainly was acceptable. Most of these companies were already sophisticated in materials and manufacturing systems. Hard facts prove that this strategy is successful in these businesses.

Motorola has a JIT program in their Discrete Products Wafer Manufacturing Area. Minimum, and more importantly, maximum queues are established for each production station. If this maximum queue is exceeded, the operator at the previous workstation can produce no more. On several occasions this has meant a complete shutdown of wafer starts—but why start them if you can't use them? Preventive maintenance is given a higher priority—it is done at the scheduled time even in the face of backlog. As a result, cycle time has been reduced by half. Customer service has significantly improved and the percentage of "hot lots" has gone way down. Yields went up 6 percent. And, all this happened in a 9-month period during which total output doubled.

Hewlett-Packard has Corporate attention focused on a JIT program. In computer manufacturing areas, work-in-process inventory was reduced from 6 or 7 days to 1.3 days over nine months. Space requirements were cut 50 percent! HP's belief that these results will continue is backed up by their business plan. Their history and previous 5-year plan called for the building of a 200 million square foot facility each year. As a result of JIT, the plan is now to achieve additional capacity needs with existing facilities. As David Taylor, Materials Manager for the Greeley Division says, "Results of the program are extremely dramatic—50-percent reductions in inventory and space, huge gains in productivity as quality and productivity problems are solved, simplified systems that allow material to 'flow' rather than batch up per traditional MRP techniques, less material-handling equipment and personnel required as material flows from receiving directly to production lines, fewer master schedulers with elimination of work orders."

IBM is another computer manufacturer that is involved with JIT. It is significant that both IBM and Hewlett-Packard have made a JIT commitment even though not yet seriously threatened like the automotive companies.

Black and Decker, within the past year, reduced finished goods inven-

duction worker to be more responsible for quality.

Let's look again at the elements of JIT. We talked about inventory, short setup times, total quality control, and small lot sizes. Just a few words about the other elements.

Short-term schedule stability/predictability

Some short-term schedule stability is required at least for total production output. This does not mean, however, that there is no flexibility to respond to last-minute small changes in demand or mix. This frozen schedule subject is one that causes lots of people to say "no way" and to bring up examples of the volatility of Marketing demands. There is a hump to get over in the beginning, but the important thing to remember is that with a greatly shortened production cycle, the schedule can be frozen and the factory will still do a better job in meeting customer demands. "Short terms" become a few weeks instead of a few months.

Multifunction workers

Multifunction workers help line balancing and factory flexibility, but are not a prerequisite.

Preventive maintenance

A regularly scheduled preventive maintenance program is important. With inventories tighter, unexpected breakdowns become more costly. And we're not only talking about major equipment breakdowns, but anything that causes a variation in performance.

Emphasis on simplicity

There is an overriding emphasis on simplicity—whether it be product design, production equipment design, or something as ordinary as a computer printout.

Supplier networks

Just-in-Time deliveries are not the first steps of a pilot program even though these are the most talked about aspects of JIT. It is important first to get our own house in order, to provide the stability that will make Just-in-Time deliveries a contributor and not a problem. And the real intent is not to have suppliers make Just-in-Time deliveries from their own enlarged inventory, but to have these suppliers adopt JIT in their own factories. The place to start with suppliers is quality improvement and schedule predictability followed by Just-in-Time deliveries.

JIT companies almost invariably move toward fewer, stronger suppliers, and they move toward long-term relationships and earlier involvement in the design process, which tends both to take cost out tory by 50 percent. Their goal is 65 percent. WIP inventory is down by 15 to 20 percent. The goal is 50 percent. Line rejects are down 38 percent. Manpower in the production area is down 20%. Setup costs were reduced 800%! Albert Wordsworth, Vice President of Manufacturing for the Consumer Products Division, sums it up this way. "The benefits are simply productivity. Increased productivity, less waste, and lower costs are the major benefits to strive for in producing high-quality product in a Just-In-Time environment."

Toyota requires only 36 hours of cycle time from the time an engine block casting is poured to the time a finished car rolls off the assembly line. In 300 thousand square feet Toyota builds the same number of cars that Ford requires 900 thousand square feet to build. And the people required is one-fourth of that for Ford.

Harley Davidson, in the past ten years, has gone from the comfortable position of having 100 percent of the heavyweight motorcycle business to having to fight for survival. As Thomas Gelb, Vice President Operations, and an absolute disciple of JIT, puts it, "We finally concluded that the competitive edge (of our competitors) was achieved through a truly different approach using improved and more efficient manufacturing techniques—today more commonly known as 'Just-In-Time' production. Implementation of these Just-in-Time operating principles is the vehicle Harley-Davidson is using to regain its competitive position." Since late 1982, setup time has been reduced from 3 days to 4 hours and with minimum dollar expenditure. WIP inventory is down 70 percent and housekeeping and reject rate have improved dramatically. The break-even point was reduced by 32 percent during 1982 alone.

General Electric was exposed to Just-in-Time as a result of their discussions in 1980 with Toyota on the possibility of exchanging management information. They began a small pilot at one location in 1981. The results were so encouraging that there are plans for expanding the number of projects to eight major GE locations. By December 1983 there were nearly 40 active projects. Five people at the Corporate level are involved full time with Just-in-Time.

RCA Records has had a Productivity Through Quality Improvement Program underway for about one year. Although not locally labeled "Just-In-Time," the program embodies many of the JIT concepts. The sustained effort has produced a 40-percent reduction in record scrap and in cassette-duplication/assembly defects. Customer service, as measured by response time and raw-material inventory turnover rate, has improved considerably. Devendra Mishra, Director, Manufacturing and Distribution Operations, says "Our business is the pursuit of excellence in manufacturing. We have established a culture around employee involvement and feel that productivity improvement is a way of life for everyone. The momentum of our program is picking up and more benefits will be forthcoming."

A final note about success stories...in a relatively short period, productivity in these companies has increased dramatically, at least in the pilot areas. Nothing has come on the manufacturing scene in the last 50 years that introduced as great an improvement for as many companies in so short a time.

and build reliability in by matching the part closely to the vendor's manufacturing capability. This does not suggest arbitrary sole sourcing or the reduction of competition.

Pull system

A pull system tells workers what quantity to produce and when to produce it. In a conventional production-control system, which is by way of contrast known as a push system, the production of parts takes place according to a given schedule planned in advance for each operation. Because of the time required to issue an updated schedule, inventory is normally carried between operations to absorb trouble and demand changes. With a pull system, the subsequent process withdraws parts from the preceding process. This preceding process then takes this withdrawal as an authorization or a schedule to produce more parts. Thus, the production only of parts truly needed is achieved.

A short editorial here to clarify terms:

The word "kanban" is used so much in conjunction with JIT that something has to be said but not much time will be spent on it. JIT encompasses all of the "elements" that we talked about. Kanban is nothing but a simplified controlling system or an execution system. Kanban is not the essence of JIT. It is a means to instruct workers when to make or move parts and how many to make or move. Typically, when parts are needed, a kanban, which literally means card, is passed to the preceding, upstream workstation. The kanban is the authorization for that workstation to produce parts. No kanban means no production.

JIT encompasses all of the "elements" that we talked about. Each of these elements is an improvement by itself. It is not necessary for all these elements to be tied together before you see results.

Just-in-Time is not a "once-and-done" project. Rather it is the basis for a dynamic process of continuous improvement. Just-in-Time is a journey, not a destination. This is graphically illustrated in Fig. 7.

Reduced inventory will force the identification of problems. As these problems are solved, inventory can be reduced further, pointing out additional problems to be solved.

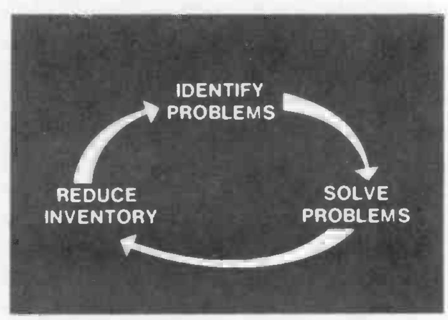

Fig. 7. *A continuum of self-improvement.*

Where JIT is not appropriate

Just-in-Time principles are most frequently applied in a repetitive manufacturing environment, where there is some semblance of continuous-flow production. There are manufacturing environments where JIT is not applicable—custom orders with custom engineering—where each product is substantially unique and manufactured in small quantities. Substantially unique does not mean a product with many options or variations. Automobile manufacturers, of course, are faced with an enormous variation of end-product and are making major commitments to JIT.

Products at the edge of the state-of-the-art, that are characterized by very low yields and great yield variability, are not JIT candidates. This does not mean the entire semiconductor industry. It might mean the start-up phase of a submicron program, though.

Where batch control is necessary for quality control, for example in pharmaceutical manufacture, JIT is difficult to implement.

It would also be difficult in a business characterized by a small number of customers and random arrival of orders. With JIT there must be some predictability of demand.

And finally, project manufacturing does not lend itself to JIT. For example, a nuclear power plant contractor would not adopt JIT. Even within these exceptions, however, it should be recognized that almost any manufacturing environment contains portions of the production process where JIT could be applied.

Benefits of Just-in-Time

The benefits of Just-in-Time are significant. They include reduced lead time and reduced manufacturing cycle time—a competitive advantage in a faster response to the marketplace. And, the problems of inaccurate forecasting are reduced because the critical horizon, within which forecasting is particularly important, is reduced. This leads to improved customer service.

Moreover, reduced idle inventory means positive cash flow and return-on-investment benefits. The amount of money required for inventory is significant. A good portion of this money can be freed for other purposes if inventory can be reduced. There is more to this, of course, than just inventory savings. As was said earlier, inventory levels become an indicator of the degree to which the production process itself has become flexible and free of breakdowns and rework. The financial impact of that is enormous, even if not explicitly identified as a separate item in financial statements.

Reduced material handling can be expected with delivery to the point of use within the plant, and from work center to work center instead of from work center to stockroom to work center.

Increased visibility to management (and workers) of production status and production problems. Higher quality means decreased manufacturing costs, reduced rework and scrap problems, decreased warranty costs, a competitive advantage. Reduced capital requirements result because critical or bottleneck machines are more efficiently used.

Reduced space is a significant item. Several companies have been able to cancel plans for new brick and mortar as a result of a JIT program. Reductions of 50 percent are typical. Productivity is the bottom line of JIT—whether it is productivity of people, machines, material, or capital dollars. Increases of 30 percent in labor productivity are typical of those companies practicing JIT concepts.

How does RCA get started

RCA can also benefit from use of the JIT philosophy. The following steps might be useful in getting started:

- Initiate pilot program.
- Designate team (5-10 people) with various disciplines represented.
- Educate through books, videotapes, presentations. Specifics are available. A reading list appears at the end of this article.
- Select measurement parameters and establish baseline.
- Select pilot product and limited number of elements of JIT.
- Involve employees, and explain the program to all indirect and direct employees that will be associated with pilot.
- Implement. Don't study it to death. Implementation cannot be planned in detail, because it is impossible to foresee in detail the problems that will occur.
- Continue management support and involvement.

As was said earlier, a JIT project encompasses many functional areas. Because of this broad approach required, there is a need for top management understanding of, and top management commitment to, a Just-in-Time program. Implementation is bottom up but the go signal, and continued support, have to come from the top.

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References

S. Shingo, Study of *"TOYOTA" Production Systems from Industrial Engineering Viewpoint Japan Management Association, (1981)*

Y. Monden, *Toyota Production System* Industrial Management Press Institute of Industrial Engineers, (1983)

R. W. Hall with the American Production & Inventory Control Society*start undZero Inventories*, Dow Jones-Irwin, (1983)

R. J. Schonberger*Japanese Manufacturing Techniques*end und, The Free Press (1982)

American Production and Inventory Control Society, Inc. 25th Annual International Conference Proceedings, October 12-15, 1982 - Chicago, Illinois

American Production and Inventory Control Society, Inc. 26th Annual International Conference Proceedings, November 1-4, 1983, New Orleans, Louisiana

P. Schnitzler

Participative management — handling an emergency

"If we can figure out a way to do it ourselves, that's fine. If we don't, we'll probably be told what to do. I think we'd better solve it ourselves."

The use of Participative Management has been viewed as highly desirable by modern management theorists. Nevertheless, it does not seem to have received as great an acceptance in actual use as the theorists might like. One reason is that managers think that the technique will not work in high-pressure, urgent, problem-solving situations. In this article I relate a specific experience in which an urgent problem was dealt with using participative techniques.

There has been much written on the subject of participation in work groups. However, little has appeared depicting the experiences of managers using these tools. The following is based on an actual situation (although I have simulated the dialogue). I include some personal observations to provide perspective for the reader.*

The group involved had been working as a participative unit for about a year. We worked hard at developing our relationships and it had been paying off. We had agreed that our trust of each other was crucial to our success. Thus, if I were to make an arbitrary decision affecting the group, as I was asked, I felt that I would be violating this trust.

With this background, let's get on with the story.

Abstract: *This article is a narrative based on an actual situation in a research environment, where one group needs help from another group. The manner in which the managers and the engineers involved arrive at a solution shows the advantages of participative decision-making in quickly and effectively committing human resources to high-priority projects. The example shows debate and a seeming lack of managerial control characterizing the preliminary phase. However, when the group asked to help comes to appreciate the other group's problem, a spirit of cooperation evolves: ultimately, members of the group formulate an excellent action plan—broader than what the two managers had sought to achieve.*

* See, for example: Gibson, John E., *Managing Research and Development*, Chap. 5, "Management Style and Structure". John Wiley & Sons, New York, 1981.

Sashkin, Marshall, "A Guide to Participative Management" in Pfeiffer, J. W., Goodstein, L. D., Eds. *The 1984 Annuals; Developing Human Resources*, p227ff, University Associates, San Diego, 1984.

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The Cast

Bill	*The boss*
Fred, *Paul*	*Two of Bill's managers*
Carl	*One of Fred's engineers*
Jack, *Tony*, *Burt*, *Will*, *George*	*Engineers in Paul's group*

It was Monday morning. Bill, my boss, had just called. He wanted me to come down to his office. When I got there, Fred was there, too. After the usual greetings, Fred said, "Look Paul, we have a problem. The new Design Processing System development is in difficulty. We have a lot of demand for it and we are still many months from getting it running. I need some help. Can you let Jack help out on

Illustrations by Gil Tucker

this thing? He's really a good man and he has just the skills we need."

"Wait a minute", I objected "I don't think that's such a good idea. I don't know enough about the problem to be able to respond. Besides, I won't make an arbitrary assignment like this. I worked over a year to get my group working as a team and to do that I had to get them to learn to trust me. They expect to have a say in what goes on.

"Look, I'm meeting with my group this afternoon; I understand the Design Processor is important. The problem is that you need help. Let me describe the situation to the group and see what we come up with."

Fred said, "Well, I don't know..."

I looked at Bill. "Bill?"

"Okay, Paul, give it a try. Let's see what happens."

"Thanks. I know this is important and I'll make sure they know it, too."

That afternoon at the meeting, I realized that I didn't understand the technical details very well. I called Fred.

"Would you be able to come to the meeting and help explain the problem?"

"Sure, I can be there in about a half hour. Mind if I bring Carl? He's been working on the Design Processor for a year and a half now and is the best person to explain it to you."

"Good."

While we were waiting for Fred and Carl, discussion on the topic continued:

"Look, we've got our own work to do. If somebody goes off and does this, it'll hurt what we're trying to accomplish."

"Isn't what *we're* doing important?"

"Have they planned this thing?"

"Do they know what they're trying to accomplish?"

"How come they don't have enough people on it already?"

Much the same questions were directed to Fred and Carl when they arrived. Carl reacted:

"Hey, we're just trying to get our job done and we need some help. I don't think you're being reasonable. We know we have difficulties, that's why we're here."

"How about if one of us joins you for a couple of days," said Tony. "We can talk about it and see what's going on. Between us we can figure out a good approach. We could scope it and decide what kind of effort is needed."

Fred was agitated. "Look, what we really need is Jack's help. He's got the right skills. He's a good analog design engineer who knows the material and can help solve some of the specific problems."

Burt: "I don't think we know enough to decide whether Jack's the right guy."

Again: "Why don't we just have somebody spend time with Carl and see how things stand." No response from anyone.

Paul: "Look, this is important. The system has to be brought up and running and we're probably going to have to help. If we can figure out a way to do it ourselves, that's fine. If we don't, we'll probably be told what to do. I think we'd better try to solve it ourselves."

"Why don't you just give us what we asked for. We know what we're doing," Fred challenged.

From here the dialogue became more heated. There was a lot of "we" and "they"; Fred and Carl on one side and the rest on the other. The division was along group lines. And still again someone said, "You know, one of us could spend some time with Carl...."

Fred: "I don't think we're getting anywhere. Paul, maybe you and I have to talk about this separately."

"Well, okay."

Wow! Was I feeling frustrated!

Fred and Carl left.

When I got home for dinner, I realized I was feeling tight. I called Fred. "That meeting was pretty rough this afternoon. I felt agitated after it and I still do. I'll bet you were also."

"I think the group was pretty unreasonable, actually. We're trying to get a job done and we need some help and all they did was to challenge everything we said."

"Fred, why don't you come over here this evening. We'll talk about it. Maybe we can come up with a solution to the problem."

"Sounds good. I'll be over about eight."

I liked Fred. I wanted to find a solution to help him out. I thought I now understood the problem better than I did earlier in the day. Still, I didn't know what would happen when we met that evening. Though Fred was pretty upset, I had realized that I was excited rather than upset about the way the meeting went. I didn't know why, but I had a feeling that although the meeting was confrontative, it was very valuable. Somewhere in there was a solution, and I was hoping things would come together before we got into difficulties that we just couldn't fix. Maybe this would happen when I met with Fred.

Fred and I had some wine when he arrived. It was accompanied by the typical small talk.

Then: "Look Fred, I really want to help and this afternoon's meeting was pretty rough. I suspect you're pretty angry about what happened."

"Well, I don't know if I'm angry, but it just didn't seem right, I'll say."

We rehashed the meeting several times, Fred at one point saying, "You know, the project *is* bigger than I realized, but I don't know how to get more help. While I've asked for Jack, that's probably not enough, and I don't know what to do about it."

"Perhaps you need more than just one person, two or even more."

"What are you talking about? You wouldn't even give me Jack. How can you talk about giving me more than that?"

"I wasn't against giving you Jack. I was against making an arbitrary decision about what support we would provide. I'm now proposing a possibility. I don't know whether the group will accept it or not, but let's talk about it."

"Well, I certainly would like more help. I wouldn't turn *that* down," said Fred.

"How about Will?"

"I think he'd be great. They'd make an awfully good team, those two."

"Wait a minute. I'm talking about a limited period of time, though. I'm not proposing giving you these men forever."

"Well, I don't know. What am I going to do after that?"

"After that you'll have to work out an overall program and see what additional resources you can get. That's a separate issue. What we're going to help you with is getting the first phase up and running."

"Well,...all right. Do you think the group will buy it? After all, you insist that they agree to everything."

"I hope so. I think if they understand that there's a time limit they'll accept this solution. After all, it does address their concerns about how they can do their own work. While it doesn't let them have continuity right now, they will know when they'll be getting back to their own programs."

Tuesday morning I spoke with Will and Jack, as well as the several people that work closely with them. Burt said, "I like the idea, but I think you're making a mistake with Will. He's at a key point on this project and I think he's got a couple of months before he could reasonably leave it. Have you considered Tony? He knows analog circuits as well as Will and, on top of that, he's the best organized person among us and for this task, I think that's going to be important."

"I like that idea. I'll catch Tony as soon as I can. I think Tony and Jack will make a good team."

It was early afternoon before I could get in touch with Tony. He listened carefully throughout my explanation. Then he said, "George and I have been talking about this since yesterday afternoon. We think the two of us could go in and do a pretty good job on this with Carl. We hadn't thought of Jack, but he's good, too.

"Fred has been pretty helpful to us and I'd like to repay it by helping him on this Processor.

"We do have one problem, however. We're just about completing our current project, but we need some more time for a couple of quick experiments and a chance to write the report. We haven't figured out how to help on the Design Processor and still complete this other work."

I was elated. The team was collectively responding to the problem.

"How about if Jack joins the two of you and the three of you, plus Carl, do the job. That may be overkill, but if it is, it'll give you two the space to complete your present tasks as well as getting the Design Processor up and running.

"It seems to me that you need about three weeks to learn what's been going on and figure out what needs to be done and perhaps another three weeks to actually implement the work. Does that make sense to you?"

"Well, you're talking about four of us — a total of six weeks each. That really ought to do the job. When we're done we'll also have the next phase well-defined."

"All right. That's what I'll propose to Fred."

It was two-thirty when I reached Fred.

"...So that's the proposal. What do you think, Fred?"

"Well, it certainly sounds like it ought to do the trick. If that group can't do it in the six weeks, then the job is an awful lot bigger than we imagined."

"That's what I think."

"What's going to happen when this task is done and the rest of the system still has to be brought up?"

"Well, Fred, that wasn't the problem you presented, but I'm willing to help you scope it and fight for additional resources when that time comes."

"Well, that's fair.

"Paul, I don't know how you did it. Yesterday afternoon's meeting was a disaster and yet today we have a solution. How did you make it happen?"

"I didn't make it happen, but I did trust that the men would act responsibly and try to solve the problem. And they did. Besides, I don't think the meeting was a disaster. Yes, it was confrontative, but I think the confrontation got everybody involved. That led to them thinking about and ultimately finding a workable solution to the problem."

Fred: "Well, it really is a good solution. I hope it works."

Six weeks later the system was running, George and Tony were on vacation and Jack was working on another project. A solution was found, implemented and completed, just as planned, to the satisfaction of all.

We had been asked to provide help to bring the first phase of a needed Design Processing System into operation. Other people urgently needed the system and we anticipated that, without help, it would be many months before the System would be operational. How could this help be provided?

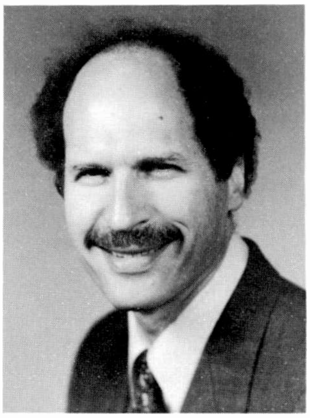
I presented the problem to the group and asked for their help. Initially, they reacted with antagonism. Why should they solve someone else's problem? Nevertheless, in a span of 28 hours, the group decided how many people, and specifically which ones, should provide the required support. The participative process led to a solution, and a method of implementing it, that satisfied everybody. In fact, the manager requesting the help judged the solution to be better than the one originally proposed.

There was energy from excitement in all of this. This energy led to involvement by many in the problem solving. It led to commitment. And it resulted in productive action. A team got in, acted, and got out.

I believe that much of the time participative techniques are not used because the manager involved is concerned about his or her lack of control under such circumstances. This lack of control is highlighted in the reported incident. We all left the first meeting uncertain of the outcome — indeed, uncertain if a useful outcome would be forthcoming. I worried about the feeling that I lacked control. The reader can see that this lack of control did not inhibit, and perhaps even contributed to, our success in finding a solution.

The details of the project and the names of the people have been changed to provide some anonymity. However, I have attempted to be accurate in reporting the feelings, concerns, and behavior observed.

I invite the reader to discuss with me both this experience and the general ideas presented. I would enjoy beginning a dialogue on this subject.



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on the job/off the job

Illustration by Joe McGarrity

R. Nigam

Operations Research/Management Science and Chess

What do chess and business problems have in common? Decision-tree and other analytical tools can aid in our quest for "foresight" in these two arenas.

The field of Operations Research/Management Science (OR/MS) came into its own during World War II. It is the application of the methods of science to solving complex problems. Its distinctive approach in problem solving is to examine the underlying issues, develop a quantitative model of the system, incorporate factors such as chance and risk, and then compare the outcomes of alternative decisions and strategies to help make a decision. Its basic purpose is to clarify issues, improve understanding, and otherwise help the decision makers in dealing with complex real-world problems.

The game of chess, on the other hand, is a war game for two players, played on a board containing 64 squares in an 8 × 8 arrangement. The game probably originated in India in the sixth or seventh century A.D. From there, it spread to Persia and then to Europe. By the thirteenth century, it was played all over Western Europe and has undergone only minor changes since. Starting with sixteen pieces, the object in chess is to checkmate the opponent's king. Generals, kings and emperors have favored it over centuries and helped make it prominent. Chess is indeed the royal game.

Abstract: *Operations Research/Management Science is a scientifically based discipline to help decision makers deal with complex business problems. Chess just happens to be a special and simple case of such problems and OR/MS techniques can help.*

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So what do OR/MS and chess have in common? In this article, I will compare and contrast the two. I will attempt to show that the fundamental nature of problems encountered, be it in business or chess, is essentially the same, and will demonstrate how OR/MS approaches to solving complex business problems can also be used to seek solutions to chess problems. But then there are differences, and I intend to bring out the contrasts, too. All in all, you should end up with the comfortable feeling that if you are an OR/MS practitioner you have a head start in chess, and that if you are good at chess, you have a leg up in OR/MS!

The game of chess

Let us look at the underlying structure of chess — its composition from a game point of view. Chess is played between two competitors (a two-person game in game-theory parlance). It is a zero-sum game, where the sum of the payoffs to the players is zero or a fixed constant — that is, if one wins, the other loses. It is also a game involving no cooperation or communication between the players. Chess is a deterministic game in that what you intend is actually what happens on the chessboard—there are no elements of chance or luck involved (if you forget and leave your queen hanging, that is a different story). Contrast this with pool where if you intend a shot it may not come off right, because you hit it a shade too hard or whatever.

Chess is also a game of complete information. At any point in time, both competitors have complete knowledge of all the factors involved in the game. Backgammon is in the same category, but bridge is not. In bridge, you can speculate where some of the cards or honors are, but you do not know them for sure. Chess also goes one step further in that it is a Markovian game. This means that all the information one needs is contained in the present state of the game and is independent of past events. The position on the board, along with the knowledge of whether castling is still permissible, is all one needs to know to make the next move. How that position was arrived at is

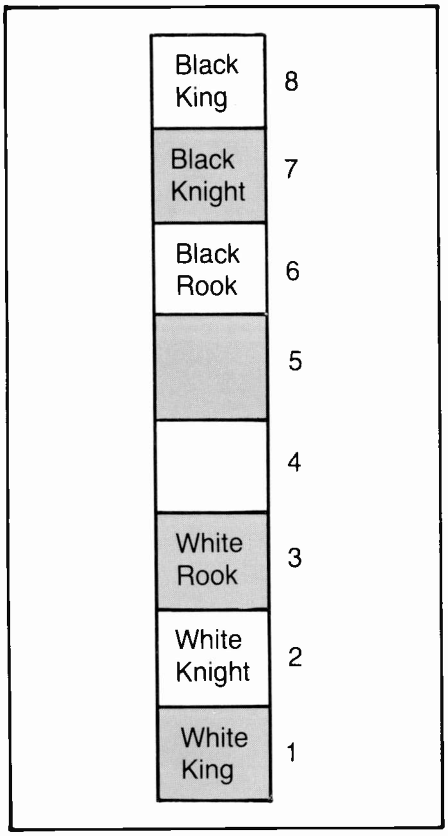

Fig. 1. *Starting positions and board for one-dimensional chess.*

immaterial. The bidding process in bridge is not Markovian because the final bid, by itself, does not contain the information of the intermediate bids.

Chess and business, contrasted

All this makes chess sound like a complicated game, but from an OR/MS point of view (game theory happens to be only one part of OR/MS repertoire), it is a simple one — simple in the sense of structuring the analysis, not in terms of finding a winning strategy. In the business world, we are more often than not faced with *n*-person games, where several competitors are involved and degrees of cooperation exist. Discussions, coalitions, and formal agreements are all part of the norm. Even though quite a few business situations involve zero-sum games, there are many non-zero-sum situations that one encounters in business. Often, when a company introduces a new product, this product contributes to additional demand and expansion of the base market so that the other brands may still gain in volume while losing out on market share. And finally, the aspects of complete information and deterministic nature are just too much to ask for in any business situation.

The complexity of the real-world business problems gives an indication of why they have not been fully amenable to game theoretic approaches. Recently, however, a particular type of business problem that is described in the literature as the "Prisoner's Dilemma" has yielded ground. The Prisoner's Dilemma deals with two players, each having two choices: cooperate or defect. The name of this game comes from a story about two criminal accomplices who are arrested and interrogated separately. Each must choose without knowing what the other will do. The highest score goes to the player who defects when the other cooperates. The second highest score occurs when both cooperate, which is better than when both defect. The lowest score goes to the player who cooperates when the other defects. The dilemma comes from the fact that if both defect, both do worse than if both had cooperated. Game theory approach has been used to show that certain tit-for-tat strategies are robust over a wide range of those situations.[1]

Decision-tree analysis and chess

While game theory has been slow in making inroads into chess, or in solving business problems for that matter, another OR/MS technique — decision-tree analysis — has proved quite successful. Decision-tree analysis is a graphical method of expressing the alternative actions available to the decision maker and of evaluating the possible outcomes. Its application to the analysis of chess or of business situations can best be illustrated by an example. Actually chess, as we know it, gives rise to just too many alternative moves, so let us look at a modified form of chess.

Consider the one-dimensional analog — played on an 1 × 8 board.[2] In this version, the pawns end up just blocking the path, bishops are meaningless, and the queen is the same as a rook. Hence we are left with the king, the knight, and the rook. Taking an analogy from regular chess, we end up with the line-up shown in Fig. 1. The only rule modification needed is that a knight moves two cells in either direction and can jump an intervening piece of either color. Let us use decision-tree analysis to see if there is a win for White or Black in this game. As a matter of fact, I recommend you try it out yourself first to see if either White or Black has a winning strategy. It is not difficult.

White has four opening moves represented by White rook capturing Black rook (represented by R × R), rook moving to cell 4 (R-4), rook moving to cell 5 (R-5), and knight moving to cell 4 (N-4). These moves are shown as the first branches of the decision tree (see Fig. 2). For each of these, we can examine Black's alternatives and/or specific outcomes that result from it. R × R is an instant stalemate, and R-5 leads to a quick loss for White. To the R-5 move by White, Black has only two moves—capturing the rook by the rook, or by the knight. As we explore further down the tree, we see that R × R leads to a fast and sure win for Black. Hence, given this situation, Black would play R × R. The R-4 opening by White also allows Black to render a quick mate by playing N-5. The opening move of N-4 by White leads to a quick win for White if Black responds with either R × N or R-5; Black's reply of N-5 delays the defeat the longest.

If we were to work out the whole tree, we would see that White does have a win and that the only opening move leading to a win is N-4. Thus, decision-tree analysis leads us to conclude that White's winning strategy is to play N-4. Note that even for such a simple version of chess, the number of possible branches becomes large. However, because of the deterministic nature of the game, threading one's way through the tree is easy. In regular chess, it is estimated that 10^{120} branches may exist — which is why it is practically impossible to find winning strategies, even though the game can be structured easily as a decision tree.

Decision-tree analysis in business

To show how decision-tree analysis can be used in business situations, we draw on an article from *Harvard Business Review*.[3] The application deals with the management of legal risks and costs and whether one should pursue a patent infringement suit or settle out of court. The key questions that needed to be answered were when to settle and how to ascertain the size of the settlement offer the plaintiff would accept. This business problem is more complex than those encountered in a game of chess because risks and uncertainties are involved. However, risks associated with each outcome can be quantified, and alternatives examined, to help the decision maker reach a decision.

This case involved company *P*, which had sued company *D* for allegedly in-

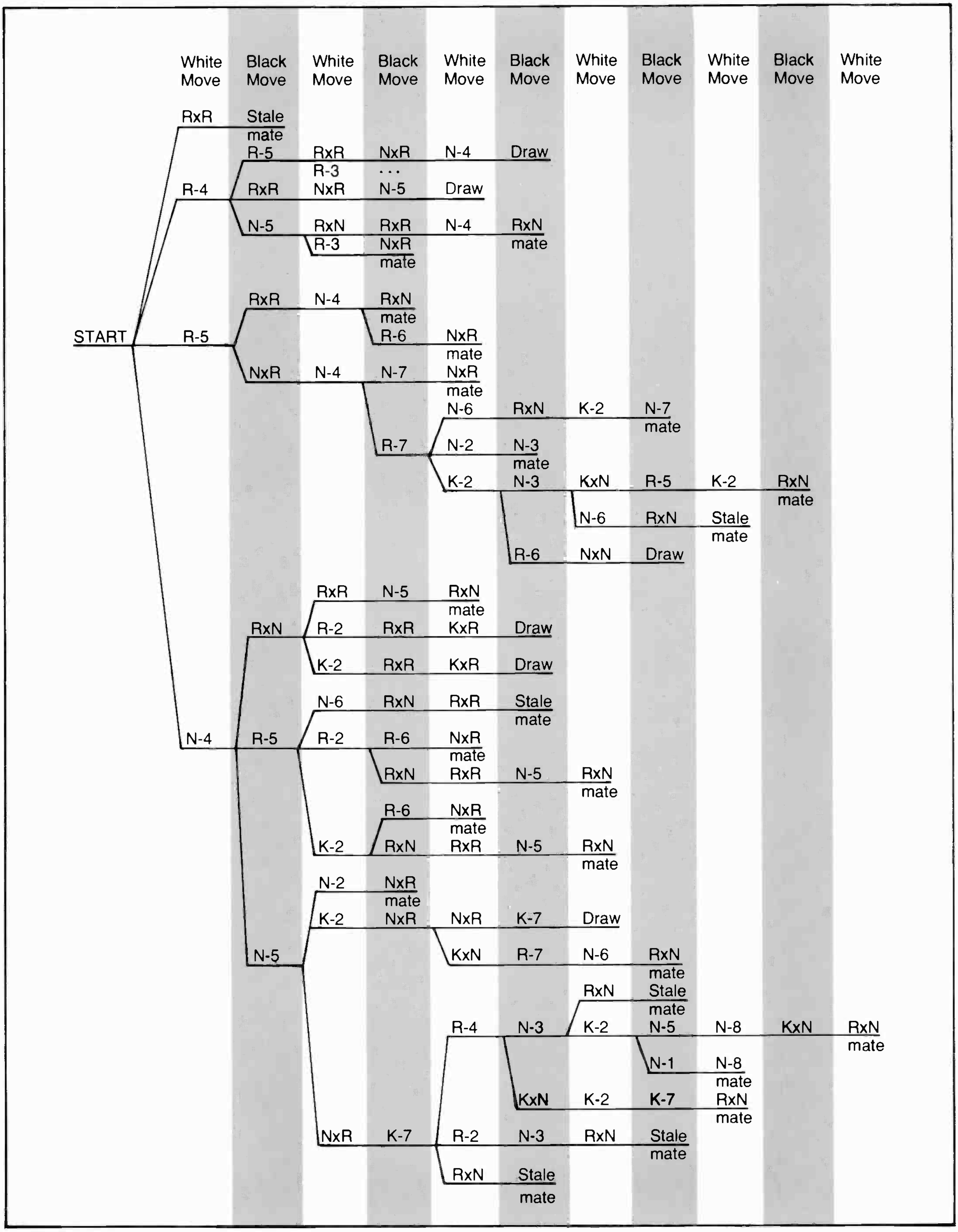

Fig. 2. *Decision-tree analysis of one-dimensional chess.*

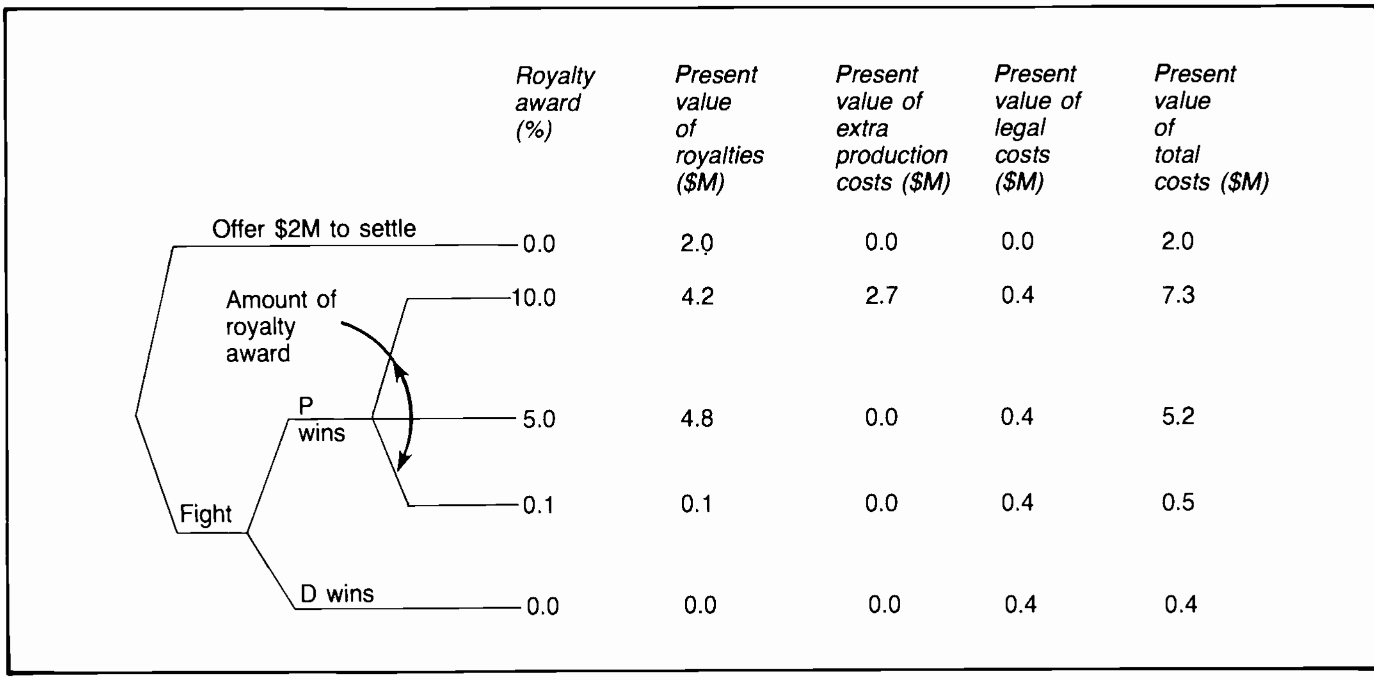

Fig. 3. *D's decision-tree diagram at the time the lawsuit was filed.*

fringing on a manufacturing patent. Figure 3 shows how the decision tree for settlement looked, to *D*, at the time the suit was filed. A lot of research and judgment went into determining the probabilities and net present value of associated gains and losses. Estimates of the probability distribution for the amount of royalty award if *P* wins and the probability of *P* winning in the first place are critical parameters in assessing alternatives.

The decision tree also shows a typical procedure used on continuous probability distributions. The amount of royalty award is made discrete by choosing three representative points, and a branch is associated with each of the outcomes. The problem-solving procedure used is to lay out all the alternatives in a decision-tree format, assess the probabilities associated with each branch, and determine the value (amount of gains and losses and their timing) of the outcome of each branch. Then we can work our way back, combining the probabilities and net present values along the way, to determine the best course of action to be taken now.

Another advantage of applying such OR/MS techniques is that one can exploit the structure, underlying the issue, to examine the sensitivity of decisions and judgments on the dollar impact to the company and to determine how robust our actions can be, and so on. A more complex business situation and how it yielded to decision-tree analysis is described in a more recent *Harvard Business Review* article.[4] This article also describes several other successful uses of decision analysis.

The practice

The analogy between chess and business problems is clear in the application of decision-tree analysis. The difference is that in chess one usually has, theoretically, a very large number of alternatives to examine (but following a branch is easy), whereas in a business situation the formulations are a lot more complex (because of the continuous nature of the decision variables involved) and the assessment of the outcome is harder because of the risks and uncertainties associated with the gains/losses and their timing.

These examples show how, in chess or a business situation, the number of branches in a decision tree can quickly become very large. Since it is not possible to enumerate all the alternatives and since following a branch out to its end is usually not possible, the practical task one is faced with is to decide which branches to explore and how deeply to fathom them. The OR/MS technique of branching-and-bounding can be applied to help in these kinds of decisions. Often, the resultant savings can be of several orders of magnitude.

Based on these techniques, and other modifications, Belle — a computer program/hardware system developed at Bell Laboratories — became the first certified master-level chess program. That puts it in the 97th percentile of the U.S. Chess Federation-rated players. And Belle just lost out to another computer program — Cray Blitz — at the recently held fourth World Computer Chess Championship!

Conflicting objectives

The resolution of conflicting objectives is another theme common to chess and OR/MS. Chess gambits are the best examples of giving up material early in the game to gain control of space and/or mobility. In a business situation, tradeoffs of similar kinds abound. If one wants to increase market share, some short-term profits may have to be given up. Time and money tradeoffs have to be made all the time.

It is only recently (and remember that OR/MS came into its own only 40 years ago) that formal mathematical attention has been devoted to the question of multi-objective decision making. Different approaches like utility theory and multiple-criteria decision making are beginning slowly to lay a firm foundation under the simplest of cases. As evidenced by the strength of the computer chess programs, weighing of conflicting issues such as material balance, pawn structure and position, control of squares, mobility of pieces, attack on king, and so on, have been tackled at a significantly successful level. We hope that conflicting issues of market share, price erosion, capital investments, market-size risks and uncertainties, internal rate of return, and others will be the next to follow.

Vive la difference

There is, however, one particular area of departure. Business issues and problems are serious and usually of a critical nature; chess, on the other hand, can be made into a fun activity easily. If you are bored with regular chess (or afraid to start, in the first place) try playing fun variations. One of the easiest to implement is to designate one of the four center squares as off-limits — either for occupation by any piece or for passage through it (knights may jump over it but bishops, for example, have to go around it). Another variation is to play in tandem. There are two players on each side who alternate playing the moves. No consultation is allowed, and it is often amazing how one's partner just doesn't see the strategy one is trying so hard to implement. Cylindrical chess, where the two rook files are assumed to adjoin, takes on a fascinating turn because there are no safe corners for the king to seek shelter in. The game of fairy chess opens up a whole new vista with grasshoppers, nightriders and imitators, and other new pieces. These are well detailed by Dickins,[5] who also lists an extensive fairy chess bibliography.

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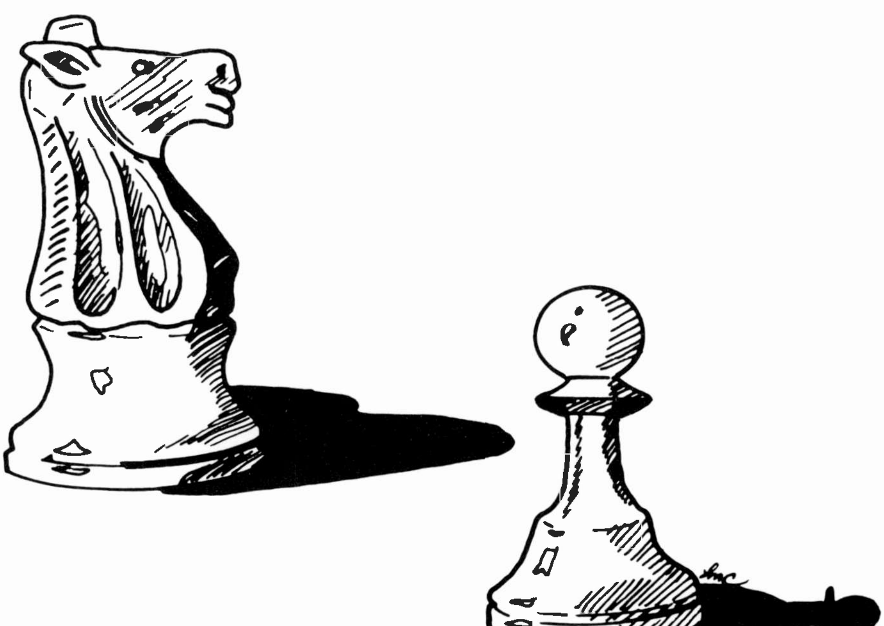
Well, get your quantitative feelers and thinking cap on and 1. P-K4....anyone? Or would you rather tackle a production-scheduling problem?

References

1. R. Axelrod, *The Evolution of Cooperation*, Basic (1984).
2. M. Gardner, "Mathematical Games", *Scientific American* (July 1980).
3. S. E. Bodily, "When Should You Go to Court," *Harvard Business Review*, Vol. 59, No. 3, pp. 103-113 (May-June 1981).
4. J. W. Ulvila and R. V. Brown, "Decision Analysis Comes of Age," *Harvard Business Review*, Vol. 60, No. 9, pp. 130-141 (September-October 1982).
5. A. Dickins, *A Guide to Fairy Chess*, Dover Publications Inc., New York (1971).



Patents

Advanced Technology Laboratories

Ammon, G. J.
Track jump servo system for disc player—4443869

Reno, C.W. | Allee, G.L.
Dual input telescope for multi-beam optical record and playback apparatus—4432085

Siryj, B.W. | Lazzery, A.G.
Protective cartridge for optical discs—4433410

Smith, A.M.
Fall soft tri-state logic circuit—442551

Astro-Electronics

Fuldner, M. V.
Linearity adjustment of spacecraft tubular spar-type members—4451828

Hedlund, L. V.
Tunnel for tape accumulation during wind-off—4442465

Kujas, E. F.
Separator material for alkaline storage cells—4430398

Maehl, R. C.
Extendible tubular booms for remote sensors—4446466

Muhlfelder, L.|Phillips, K.J. | Blasnik, S.L.
Magnetically torqued nutation damping—4424948

Automated Systems

Rickman, J.D. Jr.
Motion sensor utilizing eddy currents—4439728

Broadcast Systems Division

Bendell, S.L. | Levine, P.A.
Low noise CCD output—4435730

Bendell, S.L.
Electron beam alignment in tube cell assemblies—4429258

Easter, F.C.
Switching voltage regulators with output voltages indirectly regulated respective to directly regulated boosted input voltages—4425611

Hedlund, L.V. | Shields, J.D.
Tunnel for tape accumulation during wind-off—4442465

Consumer Electronics

Cochran, L.A.
Dynamic coring circuit—4437124

Cochran, L.A.
Automatic video signal peaking and color control—14430665

Harlan, W.E.
Dynamically controlled horizontal peaking system—4437123

Harwood, L.A. | Shanley, R.L., 2nd
Television receiver with selectively disabled on-screen character display system—4435729

Harwood, L.A. | Shanley, R.L., 2nd
Adjustable coring circuit—4441121

Kliebphipat, R.
Television receiver disabling circuit—4435731

Lambert, E.F. | Christopher, T.J.
Video apparatus having improved antenna transfer switching system—4432015

Lehmann, W.L.
Television receiver tuning circuit tunable over a wide frequency range—4442548

Luz, D.W.
Deflection circuit with linearity correction—4441058

Luz, D.W.
Horizontal deflection circuit with a start-up power supply—4429259

McGlashan, K.W.
Pincushion raster distortion corrector with improved performance—4429293

Shanley, R.L., 2nd | Parker, R.P.
Translating circuit for television receiver on-screen graphics display signals—4432016

Shisler, R.W.
Desoldering tool and method of desoldering leadless components—4436242

Tamer, G.G.
Television channel indicator with automatic on-screen display—4430671

Shanley, R.L., 2nd
Adjustable coring circuit permitting coring extinction—4438454

Tults, J.
Counter arrangement useful in a frequency locked loop tuning system for measuring the frequency of a local oscillator signal—4442547

Willis, D.H.
Degaussing circuit for television receiver having switched mode power supply—4441052

Government Communications Systems

Bradshaw, J.L.
Frequency-controlled variable-gain amplifiers—4429285

Katz, G.
Method for improving the inspection of printed circuit boards—4427496

Mattei, A.
Automatically adaptive transversal filter—4438521

Mattei, A.
Phase locked loop, as for MPSK signal detector—4439737

Orr, J.R. | Hoover, J.H., Jr.
Fixed pulse width, fast recovery one-shot pulse generator—4425514

Riddle, M.H. | Orr, J.R.
Protection circuit for memory programming system—4439804

Sherwood, D.L.
High-speed data sorter—4425617

Laboratories

Acampora A.
Arithmetic circuits for digital filters—4430721

Aceti, J.G.
Apparatus for measuring the dimensions of delicate parts—4424630

Aschwanden, F.|Groeneweg, W.H.
Frequency search system for a phase locked loop—4443769

Bell, A.E.|Arie, Y.
Reversible recording medium and information record—4425570

Berkman, S.
Chemical vapor deposition of epitaxial silicon—4430149

Botez, D.
Constricted double heterostructure semiconductor laser—4426701

Brown, R.|Jozwiak, P.C.
Composition and thickness variation in dielectric layers—4426249

Carlson, D.E.|Williams, B.F.
Photodetector having enhanced back reflection—4442310

Chang, K.K.
Deflection yoke integrated within a cathode ray tube—4429254

Chin, D.|Henderson, J.G.|Maturo, R.J.
Signal-seeking tuning system with signal loss protection for a television receiver—4429415

Datta, P.|Poliniak, E.S.
High Density Information Disc Lubricants—4444820

Dholakia, A.R.
Flip-flop grinding method—4428165

Faith, T.J., Jr.
Monitor for impurity levels in aluminum deposition—4440799

Gange, R.A.
Line cathode support structure for a flat panel display device—4429251

Gange, R.A.
Telephone station incorporating exchange message system—4443664

Goodman, A.M.
Method of forming a self aligned aluminum polycrystalline silicon line—4433469

Haferl, P.E.
Variable horizontal deflection circuit capable of providing east-west pincushion correction—4429257

Harwood, L.A.|Shanley, R.L., 2nd
Television receiver with selectively disabled on-screen character display system—4435729

Harwood, L.A.|Shanley, R.L., 2nd
Adjustable coring circuit—4441121

Harwood, L.A.
High voltage protection for an output circuit—4441137

Hernqvist, K.G.
Structure and method for eliminating blocked apertures caused by charged particles—4431939

Hinn, W.|Knight, M.B.
Dual-standard secam pal color tv receiver with automatic control of operating mode—4438451

Ipri, A.C.|Stewart, R.G.
Electrically alterable nonvolatile floating gate memory device—4442447

Jastrzebski, L.L.|Lagowski, J.
Method for determining oxygen content in semiconductor material—4429047

Kern, W.
Chemical deposition termination—4442134

Kern, W.
Structural defect detection—4436999

Kim, J.K.
Method of making an array of series connected solar cells on a single substrate—4428110

Kipp, R.W.
Tracking filter system for use with a FM|CW radar—4429309

Kipp, R.W.
Radar ranging system for use with sloping target—4435709

Kipp, R.W.
FM-CW radar ranging system with signal drift compensation—4435712

Knop, S.A.
Semi-thick transmissive and reflective sinusoidal phase grating structures—4426130

Kumar, M.|Upadhyayula, L.C.
Variable power amplifier—4439744

Levin, L.J.
Information record with a thick overcoat—4435801

Levine, P.A.|Limberg, A.L.
Electrical compensation for misregistration of striped color filter in a color imager with discrete sampling elements—4437764

Lipp, S.A.|Adams, M.P.
Method for making a dipolar-deflecting and quadrupolar-focusing color-selection structure for a CRT—4427395

Lipp, S.A.
Focusing color-selection structure for a CRT—4427918

Lipp, S.A.
Method of making a focusing color-selection structure for a CRT—4443499

Lock, B.E.
Concentricity measuring instrument—4439925

Meyers, W.H.|Curtis, B.J.
Dry developable positive photoresists—4433044

Moore, A.R.
Method and apparatus for determining minority carrier diffusion length in semiconductors—4433288

Morris, C.H., Jr.
Method for the manufacture of lapping disc for forming keels on videodisc styli—4440604

Nowogrodzki, M.
Wheel wear measurement system—4432229

Oakley, C.B.|Dischert, R.A.
Compatible television system with increased vertical resolution—4429327

Oholakia, A.R.
Stylus lowering, lifting and cleaning apparatus—4443871

Oholakia, A.R.
Capacitive playback stylus—4439853

Oholakia, A.R.
Capacitive playback stylus—4439855

Olsen, G..H.|Zamerowski, T.J.
Semiconductor laser—4429395

Osaka, S.|Toda, M.
Shutter construction—4427043

Osaka, S.|Toda, M.
Shutter Construction—4435920

Powers, K.H.
Transcoder for sampled television signals—4438452

Reitmeier, G.A.|Strolle, C.H.
Video pre-filtering in phantom raster generating apparatus—4432009

Reitmeier, G.A.|Strolle, C.H.
Compaction of television display graphics in phantom-raster-scanned image memory—4442545

Riddle, G.H.
Method and apparatus for recording video signals into a metal substrate—4433407

Robinson, J.W.|Kaganowicz, G.
Apparatus and method for preparing an abrasive coated substrate—4430361

Saeki, T.
Video disc stylus deflector system—4429376

Schiff, L.N.
FM TV transmission system—4434440

Schnable, G.L. | James, E.A.
Doped-oxide diffusion of phosphorus using borophosphosilicate glass—4433008

Schroeder, J.O.
Cross-coupled complementary power amplifier—4424493

Shahbender, R.A. | Gordon, I. | Wendt, F.S. | Gries, R.J.
Television receiver ferroresonant high voltage power supply using temperature stable core material—4424469

Stavitsky, D. | Beres, E.A.
Mold for recorded disc—4437641

Strolle, C.H. | Smith, T.R.
Generating angular coordinate of raster scan of polar-coordinate-addressed memory—4434437

Swartz, G.A.
Series connected solar cells on a single substrate—4443651

Toda, M. | Shima, E.
Traveling wave surface acoustic wave tranducer—4434481

Truskalo, W.
Television receiver power supply terroresonant load circuit provided with a redundant operating capability—4429260

Tults, J. | Wine, C.M.
Arrangement useful in a phase locked loop tuning control system for selectively applying an aft voltage in a manner to improve loop stability—4426734

Vieland, L.J. | Alig, R.C.
Color picture tube having an expanded focus lens type inline electron gun with improved static convergence—4429252

Warren, H.R.
Crosstalk filtering arrangement with variable frequency filtering to remove effects of FM carrier—4441090

White, L.K. | Popov, M.
Planarization technique—4427713

Wu, C.P.
Electromagnetic radiation annealing of semiconductor material—4439245

Missile & Surface Radar

Dixon, E.
Digital gyromagnetic phase shifter—4445099

Fish, J.W.
System for controlling indicators for switches—4437094

Schwarzmann, A.
Switching microwave integrated bridge T group delay equalizer—4443772

Smith, E.B. | Craft, R.A.
Phase locked-loop generator with closed-loop forcing function shaper—4442412

Selectavision

Brauer, E.A.
Stylus protecting mechanism for video disc player—4442517

Hughes, L.M.
Disc player having record handling apparatus—4439852

Kirschner, T.F.
Disc record player having shutoff switch actuating apparatus—4435799

Kirschner, T.F.
Video disc player having caddy lockout mechanism—4443872

Louik, L. | Ballaro, R.E.
Apparatus for molding a recorded disc having a molded-in center hole—4439128

Miller, M.E.
Video disc stylus—4439854

Newell, S.T.
Damping mechanism for a video disc stylus holder—4441176

Prusak, J.J.
Apparatus for grinding the back surfaces of record molding stampers—4435922

Prusak, J.J. | Patel, B.P.
Apparatus for separating a replica from a matrix—4436603

Service Company

Crosby, E.L., Jr.
Strain measurement—4426875

Solid State Division

Butterwick, G.N.
Anode structure for photomultiplier tube—4439712

Butterwick, G.N.
Photomultiplier tube having a heat shield with alkali vapor source attached thereto—4426596

Caprari, F. | Geshner, R.A.
Visual defect inspection of masks—4432641

Faulkner, R.D. | McHose, R.E.
Electron discharge device having a high speed cage—4431943

Harwood, L.A. | Shanley, R.L., 2nd
Circuit for linearly gain controlling a differential amplifier—4426625

Kocmanek, K.H.
Controlled environment for diffusion furnace—4436509

Mendelson, R.M.
Self-extinguishing load driving system—4441069

Preslar, D.R.
Push-pull non-complementary transistor amplifier—4442409

Steckler, S.A. | Balaban, A.R.
Digital television AGC arrangement-4434439

Stewart, R.G.
Sense amplifiers—4434381

Wacyk, I.T.
Actively controlled input buffer—4437024

Wheatley, C.F., Jr.
Operational amplifier—4429284

Wittlinger, H.A.
Differential current amplifier—4429283

Special Contract Inventors

Yarnitsky, Y. | Kaldor, S.
Jig for machining stylus blanks—4433794

Video Component & Display Division

Barbin, R.L.
Electron beam and deflection yoke alignment for producing convergence of plural in-line beams—31552

Chen, H.
Electron gun for dynamic beam shape modulation—4443736

Deal, S.B. | Bartch, D.W.
Method of making a cathode-ray tube having a conductive internal coating exhibiting reduced arcing current—4425377

Farmer, F.C., Jr. | Knight, D.P.
Drive level control system for testing kinescopes—4437120

Kelly, W.R. | Alvero, E.J.
System and method for controlling the exposure of color picture tube phosphor screens—4436394

Poff, W.R. | Bartch, D.W.
Method for selectively etching integral cathode substrate and support—4441957

Ragland, F.R., Jr.
Cathode-ray tube having a temperature compensated mask-frame assembly—4437036

Sohn, F.M.
Color picture tube having improved temperature compensating support for a mask-frame assembly—4439709

Video Disc Division

Hughes, L.M.
Turntable apparatus for video disc player—4432086

John, G. | Rainey, J.H. | Valembois, P.V.
Cutting stylus for mechanically cutting masters for keel-lapping—4429678

Kirschner, T.F.
Process for improving dimensional stability of video disc caddy—4426349

Martin, C.J.
Process for preparing conductive PVC molding compositions—4430460

Thorn, J.H. | Jennings, R.E.
Nozzle for coating a disc with a lubricant—4424761

Weaver, C.A. | Wierschke, D.J. | John, F.
Matrixing apparatus and method for use in the manufacture of molded records—4431487

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G. J. Ammon | B. W. Siryj
Performance of an Optical Disk Jukebox—Published in the *Optical Data Storage Technical Digest* WC-B3-1-WC-B3-4 (4/18-20/84)

M. Beacken
Evaluation of Signal Processing Architectures Via an Integrated Simulation Environment—Presented at the IEEE 1984 International Conf. on Acoustics, Speech & Signal Processing, San Diego, CA and published in the *Proceedings* (3/18-22/84)

V. Benokraitis
One-On-One Hit Avoidance Model—Presented at the 15th Annual Modeling & Simulation Conference, Pittsburgh, Pennsylvania, and published in the *Proceedings* (4/19-20/84)

D. Britton
Formal Verification of a Secure Network with End-to-End Encryption—Presented at the 1984 Symposium on Security & Privacy, Oakland, California, and published in the *Proceedings* (4/30-5/3/84)

D. E. Britton
Formal Verification of a Secure Network with End-to-End Encryption—Presented at Proceedings of 1984 Symposium on Security & Privacy, 154-166 (4/30-5/3/84)

G. Drastal
Rulewriter: A Knowledge Acquisition Tool for Expert Systems—Presented at Conference on Intelligent Systems & Machines, Oakland University, Rochester, Michigan (4/24-25/84)

A. Feller
Custom VLSI Design Using Automated VLSI Design Techniques—Presented at IGAS Workshop, Johns Hopkins University, Columbia, Maryland (3/8/84)

J. Hoover | J. Waring
Measured Optical Disk Media Error Model and Compatible Error Management Implementation—Presented at the Topical Meeting on Optical Data Storage, Monterey, California, and published in the *Proceedings* (4/18-20/84)

J. Hoover | J. L. Waring
Measured Optical Disk Media Error Model and Compatible Error Management Implementation—Published in the *Optical Data Storage Technical Digest*, WC-C5-1-WC-C5-4

J. McAdams
An Expert System for Automatic Test Equipment—Presented at the Conference on Intelligent Systems & Machines, Oakland University, Rochester, Michigan, and published in the *Proceedings* (4/24-25/84)

B. S. Mudge
Hierarchical Discrete Correlation: A Method for Pyramid Image Processing—Presented at the Valley Forge Research Center, Pennsylvania (5/11/84)

J. Tower | B. McCarthy | L. Pellon
R. Strong | F. Warren
Visible and Shortwave Infrared Pushbroom Sensors for Remote Sensing Instructions—Presented at the SPIE Technical Symposium East, Arlington, Virginia and published in the *Proceedings* (4/30/84)

Astro-Electronics

D. A. Aievoli
Talk-TIROS-The Polar Orbiting Meterological Satellite Program—Presented at Fort Monmouth IEEE, Ft. Monmouth, NJ (4/30/84)

D.A. Aievoli | R.A. Lauer | D. Podlesney
The TIROS Isogrid Instrument Mounting Platform—Presented at the SPIE Symposium, Huntsville, AL (6/11-14/84)

D. L. Balzer
Liquid Propulsion Highlights—Published in *Aerospace America*

D.L. Balzer
A Transfer Orbit Subsystem for Shuttle Use—Published in *RCA TREND*

S. J. Becker
Contour Integrals Used for General Section Properties—Published in *Machine Design*

D. Benton
Thermal Control of Large S/C Antenna Reflectors—Presented at the 19th AIAA Thermophysics Conference, Snowmass, CO (6/24/84)

R. F. Buntschuh | L. P. Yermack
RCA's Direct Broadcast Satellites—Presented at the 14th International Symposium on Space Technology, Tokyo, Japan (6/1/84)

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A Compilation of Design and Performance Characteristics for Thermal Louver Systems—Presented at the AIAA 19th Thermophysics Conference, Snowmass, Colorado (6/24-28/84)

F. H. Chu
Harmonic Responses Reanalysis of Modified Structures—Presented at the AIAA 25th Structures, Structural Dynamics and Material Conference, Palm Springs, California (5/14-16/84)

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P. Goldgeier | R. Sudarsanam
17/12 GHz Communication Receiver for DBS—Presented at the International Microwave Symposium IEEE MTT-S, San Francisco, California (5/30/84)

R. Feconda | J. Weizman
Sat Reaction Control Subsys Augmented Catalytic Thrusters—Presented at the AIAA ASME SAF Propulsion Conference, Cincinnati, Ohio (6/11/84)

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Advanced Analysis Methods for Spacecraft Composite Structures—Presented at the SAMPE Conference, Reno, Nevada (4/3/84)

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Beryllium Application in an Advanced Composite Solar Array Substrate—Presented at the 25th Structures, Structural Dynamics & Materials Conference, Palm Springs, California (5/14-16/84)

D. Hogan | A. Rosenberg
Analysis 0.5 Micron Spaceborne Wind Sensor—Presented at Conference on Satellite Meteorology/Remote Sensing and Applications, Clearwater, Florida (6/25/84)

K. Johnson | N. Samhammer
Implementation of a Computer Aided System for Spacecraft Structures—Presented at the SAMPE Conference, Reno, Nevada (4/3/84)

V. J. Mancino | W. J. Slusark, Jr.
Reliability Growth in Communications Satellites—Published in *RCA Review*—(6/84)

L. O'Hara | A. Rosenberg | J. Sroga
Groundbased Demonstration 0.5 Micron Wind Sensor—Presented at the Conference on Satellite Meteorology/Remote Sensing and Applications, Clearwater, Florida (6/25/84)

P. R. Pierce
Space Power for Communication Satellites Beyond 1995—Presented at the NASA Space Power Workshop, Cleveland, Ohio (5/84)

C. E. Profera
Communication Satellite Antenna Technology—Presented at the Benjamin Franklin Symposium, Philadelphia, Pennsylvania (5/5/84)

L. C. Scholz
The Astro Satellite Operations Center—Published in *RCA TREND* (4/84)

A. Sheffler | D. Gross
Design and Development of a Hybrid Composite Solar Array Substrate—Presented at the 1984 SAMPE Conference, Reno, Nevada (4/3/84)

J.T. Sroga
Variations of Aerosol Backscattering and Extinction Cross Sections with Relative Humidity—Published in *Applied Optics Magazine*

D. J. Zion
Variation in the Design of Symmetrical Branch Guide Couplers—Thesis for BS at MIT (5/85)

Automated Systems

J. W. Betz
Comparison of the Deskewed Short-Time Correlator and the Maximum Likelihood Correlator—Published in IEEE *Transactions on Acoustics, Speech and Signal Processing*—(4/84)

J. S. Heffernan
Using DEC VAX Software from PASCAL—1984 Spring DECUS U.S. Symposium, Cincinnati, Ohio (6/84)

K. H. Kim
Real Time Data Acquisition through DMF-32—Presented at 1984 Spring DECUS U.S. Symposium, Cincinnati, Ohio (6/84)

E. M. Melendez
"Chapter Motivation" Workshop Talk—Workshop, Tau Beta Pi, Northeast Regional Convention, Northeastern University, Boston, Massachusetts (4/7/84)

J. C. Tranfaglia
Hybrids and Computer Aided Design—Presented at the International Society of Hybrid Microelectronics (ISHM), Waltham, Massachusetts (5/84)

Laboratories

D. Botez
The Effect of Carrier-Induced Index Depressions on Fundamental-Transverse-Mode Characteristics in DH Laser Structures—Published in *RCA Review*, Vol. 45, No. 1 (3/84)

P. J. Burt | E. H. Adelson
A Multiresolution Spline With Application to Image Mosaics—Published in *ACM Transactions on Graphics*, Vol. 2, No. 4 (10/83)

R. L. Camisa | G. Taylor | W. Reichert
F. Cuomo | R. Brown
A Flip-Chip GaAs Power FET with Gate and Drain Via Connections—Published in IEEE *Electron Device Letters*, Vol. EDL-5, No. 4 (4/84)

G. W. Cullen | M. T. Duffy
L. Jastrzebski | J. Lagowski
The Characterization of CVD Single-Crystal Silicon on Insulators: Heteroepitaxy and Epitaxial Overgrowth—Published in *Journal of Crystal Growth 65* (1983)

P. Datta | H. Kawamoto
Properties of Carbon-filled Polyvinylchloride for Capacitance Electronic Video-Discs—Published in Plastics in a World Economy Proceedings of the SPE 42nd Annual Technical Conference and Exhibition Laboratories

T. J. Faith | R. S. Irven | L. H. Reed
J. J. O'Neill, Jr. | M. C. Jones
Contact Resistance Monitor for Silicon Integrated Circuits—Published in *Journal of Vacuum Science and Technology* B2(1) (1-3/84)

B. Faughnan | Arnold Moore | R. Crandall
Relationship Between Collection Length and Diffusion Length in Amorphous Silicon—Published in *Applied Physics Letters* 44(6) (3/15/84)

G. Harbeke | L. Krausbauer
E. F. Steigmeier | A. E. Widmer
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Growth and Physical Properties of LPCVD Polycrystalline Silicon Films—Published in *Journal of the Electrochemical Society: Solid-State Science and Technology* (3/84)

K. W. Hang | A. N. Prabhu | J. Andrus
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Low Expansion Porcelain-Coated Copper-Clad Invar Substrates—Published in *RCA Review*, Vol. 45, No. 1 (3/84)

S. T. Hsu
A Novel Memory Device for VLSI E^2 Prom—Published in *RCA Review*, Vol. 45, No. 1 (3/84)

F. L. Hsueh | L. Faraone | J. G. Simmons
Two-Carrier Conduction in MOS Tunnel Oxides—1 Experimental Result—Published in *Solid-State Electronics*, Vol. 27, No. 6, (1984)

J. McGinn | V. A. Greenhut | T. Tsakalakos
A Mechanism for Particle Coalescence, Grain Growth and Twin Formation During Annealing of Gold Particles in an Amorphous Silica Matrix—Published in *Mat. Res. Soc. Symp. Proc.*, Vol. 21 (1984)

D. Raychaudhuri
Increasing the Capacity of Broadcast Random Access Channels Using an Announced Retransmission Protocol—Published in *Science, Systems and Services for Communications* (1984)

R. C. Ross | J. Jaklik, Jr.
Plasma Polymerizationa and Deposition of Amorphous Hydrogenated Silicon from rf and dc Silane Plasmas—Published in *J. Appl. Phys.* 55 (10) (5/15/84)

S. A. Siegel | D. J. Channin
PIN-FET Receiver for Fiber Optics—Published in *RCA Review* Vol., 45, No. 1 (3/84)

Ch. Steinbruchel
Reactive Ion Beam Etching: Dissociation of Molecular Ions Upon Impact—Published in *J. Vac. Sci. Technol.* B 2(1) (1-3/84)

J. Lagowski | L. Jastrzabski | M. T. Duffy
C. Magee | G. W. Cullen
The Characterization of Heteroepitaxial Silicon by Surface Photovoltage Technique—Published in *Journal of the Electrochemical Society*, Vol. 131, No. 3 (3/84)

J. T. McGinn | L. Jastrzabski | J. F. Corboy
Defect Characterization in Monocrystalline Silicon Grown Over SiO^2—Published in *Journal of the Electrochemical Society* Vol. 131, No. 2 (2/84)

D. Raychaudhuri
ALOHA with Multipacket Messages and ARQ-Type Retransmission Protocols —Throughput Analysis—Published in IEEE *Transactions on Communications*, Vol. COM-32, No. 2 (2/84)

A. K. Sharma
Spectral Domain Analysis of an Elliptic Microstrip Ring Resonator—Published in IEEE *Transactions on microwave theory and techniques*, Vol. MTT-32, No. 2 (2/84)

G. A. Swartz
Reverse Bias and Heat Treatment to Improve Performance of a-Si Solar Cells—Published in *Appl. Phys. Lett.* 44(7) (4/1/84)

S. Tosima | S. Harada | E. O. Johnson
Interaction with Metal Films on Glass: A New Method for Evaluating Solder Parameters—Published in *RCA Review*, Vol. 45, No. 1 (3/84)

J. L. Vossen | J. H. Thomas, III
J.S. M | J. J. O'Neill
Preparation of Surfaces for High Quality Interface Formation—Published in *J. Vac. Sci. Technol.* A 2(2) (4-6/84)

B. S. Yarman | A. Rosen
W. R. Curtice | P. Stabile
Low-Loss Millimeter-Wave Digital Phase Shifters Suitable for Monolithic Implementation—Published in IEEE 1984 International Symposium on Circuits and Systems *Proceedings* (5/84)

B. S. Yarman | A. K. Sharma
Extension of the Simplified Real Frequency Technique and a Dynamic Design Procedure for Designing Microwave Amplifiers—Published in IEEE 1984 International Symposium on Circuits and Systems *Proceedings* (5/84)

L. Chainlu Upadhyayula
Status of GaAs MESFET Comparators for Gigabit Sampling Rate ADCs—Published in IEEE 1984 International Symposium on Circuits and Systems *Proceedings* (5/84)

L. K. White
Approximating Spun-On, Thin-Film Planarization Properties on Complex Topography—Presented at the 165th Meeting of Electrochemical Society, Cincinatti, Ohio and published as Abstract No. 94, Vol. 84-1, pp. 138-139 (5/6-11/84)

Missile and Surface Radar

J. Anderson, Jr.
Lesson Authoring & The MEGATEK 1645—Published in MEGATEK Users Group Bulletin (5/84)

T.A. Dorsay
Command Activated Remote Computer Loading (CARL) for the DDG Ship—Presented at the Tactical Embedded Computer Resources (TECR) Conference (5/15/84)

H.O. Ladd, Jr.
Models Related to Surface-to-Air Missile Scheduling in Nuclear Environments—Presented at 52nd MORS, Ft. Leavenworth, Kansas (6/6/84)

W.R. Leahy
Chairman, Technical Session 1 - Trends in Technical Documentation—Presented at Computer Aided Design Engineering Conference, CADCON East 84, Boston, Massachusetts (6/12/84)

W.R. Leahy | R.J. Felbinger
Data Base Management/Automated Graphics Generation—Presented at Computer Aided Design Engineering Conference, CADCON East 84, Boston, Massachusetts, and published in the *Proceedings* (6/12/84)

R.F. Kolc
Experiences With LCC Packaging On A Military System—Presented at the International Electronics Packaging Society (IEPS), Workshop B, Boston, Massachusetts (6/4/84)

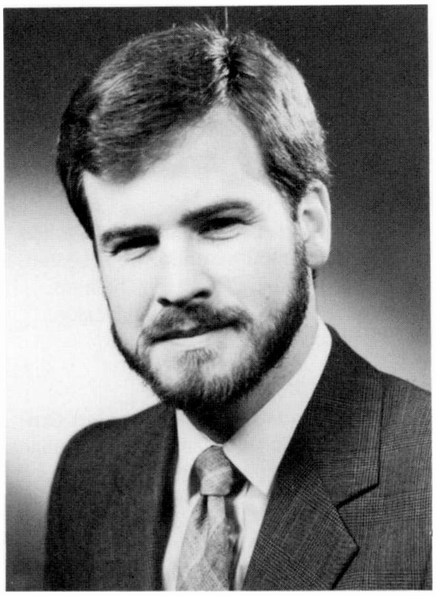
E.J. Podell
Mathematics Must Be Effective in Technical Communication—Presented at the IEEE Transactions on Professional Communication, and published in Volume PC 27, No. 2 (6/84)

A.W. Wainwright, Jr.
A Brief Commentary on "Third Party" Software—Presented at the Applicon Users' Group Ninth Annual Meeting, Clearwater, Florida (5/23/84)

R.S. Wang
Systems Design Approach—Presented at the 1st International Conference on Computers and Applications, Peking, China (6/20-22/84)

Engineering News and Highlights

Sweeny is new Editor, *RCA TREND*

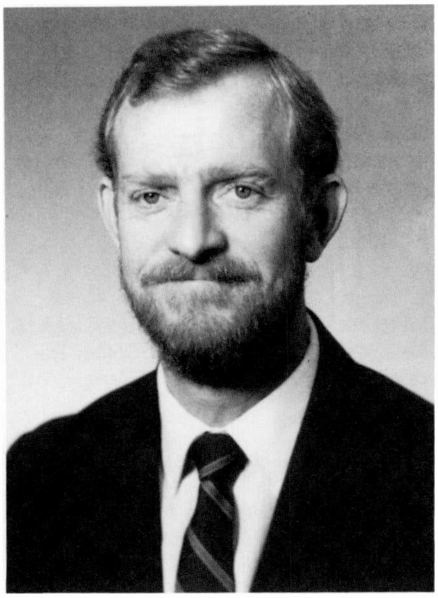


Michael R. Sweeny was appointed Administrator, Engineering Communication, Technical Excellence Center, reporting to Anthony J. Bianculli, Manager, Engineering Information. Mr. Sweeny will serve as Editor of *RCA TREND*, the research and engineering news digest circulated to approximately 15,000 engineers, managers and marketing people within the company. Mr. Sweeny succeeds Frank J. Strobl, Editor of *TREND* for fifteen years, who has accepted a position with RCA in Cherry Hill. Since 1980, he has been Associate Editor, *RCA Engineer* and before that he was the managing editor of a monthly medical news-feature trade magazine. He received a 1979 Jesse H. Neal Editorial Achievement Award (the "Pulitzer Prize" of the American Business Press) for his work on a medical microbiology news-feature article. In 1983, he received a Distinguished Communication award from the New York Chapter of the Society for Technical Communication for "Guide for RCA Engineer Authors."

Mr. Sweeny graduated cum laude from Villanova University with a B.A. in the Honors curriculum, and took a B.S. in Science from the Pennsylvania State University in 1978.

Contact him at:
RCA Technical Excellence Center
13 Roszel Road,
Princeton
TACNET: 226-2108

Lynch is new Associate Editor of *RCA Engineer*



Michael D. Lynch joined the staff of the *RCA Engineer* in July 1984. He succeeds Michael Sweeny, who is now the Editor of *TREND*. Mr. Lynch has broad experience in publications, both as a writer and as an editor, and much of it was gained at RCA. He has written user and training manuals for such diverse subjects as computer-aided design systems and accounting software. He has edited college-level technical textbooks, and for three years he served as editor of *MAC Review*, a quarterly microprocessor applications journal. In 1980 a publication he designed and wrote was awarded first prize in the Society for Technical Communication national competition. In 1982 he was involved in the design of an on-line documentation system for technical manuals.

Mr. Lynch originally joined RCA in 1972 as a technical writer for the Solid State Division in Somerville, N.J. In 1980 he went to AT&T Bell Laboratories, where his primary responsibilities were as editor of an in-house microprocessor journal. In that capacity he had overall responsibility for the publication, including editorial policy, article acquisition, and issue design, and he often wrote many of the articles himself. From Bell Laboratories he went to a major New York financial consulting firm where, as senior technical writer, he wrote user manuals for accounting software.

Mr. Lynch has a B.A. in English from Rutgers University, and an M.S. in Technical

Communication from Rensselaer Polytechnic Institute, Troy, N.Y.

Contact him at:
RCA Technical Excellence Center
13 Rozsel Road
Princeton, New Jersey
TACNET: 226-3091

Suchy is named SSD TPA

Susan Suchy joined RCA's Solid State Technology Center (SSTC), Somerville, in December 1983 as Technical Program Administrator. In that capacity she is the IR&D coordinator and editorial representative for RCA Engineer.

Suchy graduated from Rutgers University with a B.S. in 1980, then returned to school to study electrical engineering and is now nearing completion of an associate degree in Electrical Engineering from Middlesex County College.

Before coming to RCA, Ms. Suchy was the Marketing Director for IPA, a computer software company located in Princeton, New Jersey, that specializes in custom software. Prior to that, she worked as assistant to the editor of *Ferroelectrics*, a scientific journal.

Contact her at:
Solid State Technology Center
Somerville, NJ
TACNET: 325-7492

Staff announcements

Consumer Electronics

James E. Carnes, Division Vice President, Engineering, announces the appointment of **Willard M. Workman** as Director, Digital Product Design Engineering.

Willard M. Workman, Director, Digital Product Design Engineering, announces the organization of Digital Product Design Engineering as follows: **Todd J. Christopher**, Principal Member Engineering Staff; **Ned J. Kiser**, Manager, Digital Control Systems; and **James C. Marsh, Jr.**, Manager, Project Engineering.

Eugene Lemke, Staff Technical Coordinator, Engineering Operations, announces the appointment of **Theodore L. Allen** as Manager, Direct Broadcast Satellite Systems.

Robert P. Parker, Director, Signal Systems, announces his organization as follows: **David J. Carlson**, Manager, Advanced Tuner Development; **James Hettiger**, Manager, RF Systems; **William A. Lagoni**, Manager, Signal Processing; and **John F. Teskey**, Manager, Digital Tuning Systems.

Larry A. Olson, Manager, Manufacturing Technology Center, announces the appointment of **John J. Kowalchik** as Manager, Computer Integrated Manufacturing Systems.

Robert C. Arnett, Plant Manager, Bloomington Plant, announces the appointment of **Edward W. Curtis** as Manager, Monitor Operations.

Edward W. Curtis, Manager, Monitor Operations, announces his organization as follows: **Ronald D. Orman**, Manager, Manufacturing Engineering; **Roger D. Peterman**, Manager, Quality Control; **Edward W. Curtis**, Acting Manager, Resident Engineering; and **Edward W. Curtis**, Acting Manager, Manufacturing. Messrs. Orman and Peterman will report to the Manager, Monitor Operations.

Gary A. Gerhold, Plant Manager, Indianapolis Components Plant, announces his organization as follows: **James R. Arvin**, Manager, Operations—Components; **Elliott N. Fuldauer**, Manager, Materials; **James P. Gallagher**, Manager, Plant Financial Operations; **Randall R. Mitchell**, Manager, Plant Quality Control; **E. Rene Parks**, Manager, Employee Relations, CED—Indianapolis; **J. B. Thomas**, Manager, Operations—Plastics; and **Walter E. Todd**, Manager, Facilities Services, CED—Indianapolis.

Ronald R. Norley, Manager, Monitor Engineering, announces his organization as follows: **Robert L. Lineberry**, Manager, Monitor Development; and **Gene K. Sendelweck**, Manager, Monitor Circuit Design. Messrs. Lineberry and Sendelweck will report to the Manager, Monitor Engineering.

Robert C. Arnett, Plant Manager, Bloomington Plant, announces the appointment of **Robert D. Veit** as Manager, Television Manufacturing—Plant

Government Services Division

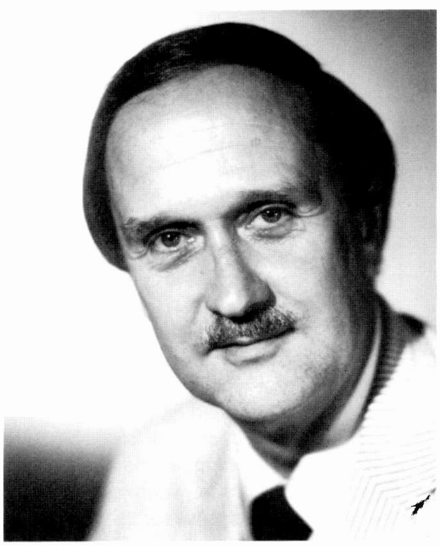
John M. Herman III, Acting Director, VLSI Manufacturing Technology, announces the appointment of **Peter P. Idell** as Manager, Process Engineering.

RCA Laboratories

Robert D. Lohman, Staff Vice President, Solid State Research, announces the appointment of **Norman C. Turner** as Manager, Solid State Program Integration.

Obituary

Donald R. Musson, with RCA for 22 years



Donald R. Musson, Director of Technical Development, Operations and Technical Services for the National Broadcasting Company, died on June 9, 1984, at the age of 49. Don was well known in the broadcasting industry, both from his long engineering career with RCA and NBC, and from his active participation in many professional society activities.

Don was with RCA for 22 years, starting with the Broadcast Transmitter Engineering group, where he began as a staff engineer in 1958, working on the design of medium, shortwave and UHF television transmitters. He rose through the positions of Engineering Staff Leader, Transmitter Engineering Manager, Television Transmitter and Advanced Development Engineering Manager, and in 1978, became the sales representative for RCA Broadcast Equipment Sales in the New England region. He transferred to NBC in 1979, becoming a Senior Staff Engineer in the Allocations Engineering Group, and in 1982 was appointed Director of Technical Development within the Network Television Division, Operations and Technical Services. Don played a leading role in establishing NBC's leadership and present effort in developing Television Multichannel Sound.

Don was an active member of both the Society of Motion Picture and Television Engineers (SMPTE) and Institute of Electrical and Electronics Engineers (IEEE) as well as other organizations dedicated to progress in the broadcasting industry. As a member of SMPTE he served on two committees (SG15.3, SG15.3.3), Time Code Standards (V16.25), and with the Component Analog Video Standards committees (V16.38WG, V16.38 Subgroup). With IEEE he was President, Administrative Committee, of the Broadcast Technology Society. His activities with other United States organizations included Electronic Industries Association (EIA), National Association of Broadcasters (NAB), Advanced Television Systems Committee (ATSC), Direct Broadcast Satellite Association (DBSA) and Center for Advanced Television Systems (CATS). International organizations included International Telecommunications Union-Space Conference Preparation, and the Comite' Consultatif International des Radiocommunications (CCIR) Study Groups 10 and 11, on Sound Broadcasting and Television. Don graduated from Michigan State University with a B.S. in Electrical Engineering/Communications, and he did some Graduate work at the University of Pittsburgh.

Istvan Gorog, Director, Manufacturing Technology, Research Laboratory, announces his organization as follows: **David P. Bortfeld**, Head, Systems Research; **Philip M. Heyman**, Head, Advanced Technology Research; and **Michael C. Sharp**, Head, Process Analysis Reasearch.

Solid State Division

Carl R. Turner, Division Vice President and General Manager, Solid State Division, announces that the Power Product Marketing organization currently reporting to **Herbert V. Crisclto**, Division Vice President, Marketing, is transferred to the staff of **Robert P. Jones**, Director, Power Operations

Jon A. Shroyer, Division Vice President, LSI Products and Technology Development, announces the appointment of **H. Gene Patterson** as Director, Memory and Microprocessor Operations.

H. Gene Patterson, Director, Memory and Microprocessor Operations, announces his organization as follows: **R. Adrian Bishop**, Manager, Product Marketing and Applications Engineering—Memory and Microprocessors; **Al A. Key**, Manager, Product Engineering & Test—Memory and Microprocessors; **H. Gene Patterson**, Acting Manager, Design Engineering—Microprocessors and Peripherals; and **Arthur L. Lancaster**, Manager, Design Engineering—Memory.

Jon A. Shroyer, Division Vice President, LSI and Technology Development, announces the appointment of **Eugene M. Reiss** as Director, Offshore Support and Assembly Development.

Larry J. Gallace, Director, Product Assurance, announces the appointment of **Samuel C. Cilla** as Manager, Engineering Standards.

Robert P. Jones, Director, Power Operations, announces his organization as follows: **Donald E. Burke**, Manager, Power Engineering; **Joseph V. Colarusso**, Manager, Materials, Planning & Operations Support; **William B. Hall**, Manager, Wafer Fabrication—Power; **George W. Ianson**, Manager, Power Planning and Analysis; **Allen L. Sands**, Manager, Quality and Reliability Assurance and High Reliability Products—Power; **Joseph R. Spoon**, Manager, Employee Relations—Mountaintop; and **Parker T. Valentine**, Manager, Product Marketing—Power.

Video Component & Display Division

Mahlon B. Fisher, Division Vice President, Engineering, announces the appointment of **David F. Hakala** as Manager, Manufacturing Processes and Pilot Development.

Richard W. Osborne, Manager, Product Engineering, announces the promotion of **Dr. Henry J. Peresie** to Leader, Technical Staff, Product Engineering.

Arnold T. Valencia, Division Vice President and General Manager, VideoDisc Division, announces the appointment of **Harry Anderson** as Division Vice President, Disc Operations.

Professional activities

Astro-Electronics

Dr. Carl Hubert will be the Session Organizer and Session Chairman, American Institute of Aeronautics and Astronautics (AIAA) Guidance and Control Conference in Seattle, Washington, August 1984.

The application of **Constance E. Holmes** for the Graduate Study Program has been approved. She is pursuing her Masters Degree in Computer Science at the University of Pennsylvania.

Joseph J. Gombar received his Masters of Engineering/Engineering Science degree from Pennsylvania State University on May 19, 1984.

Daniel L. Balzer received the American Institute of Aeronautics and Astronautics (AIAA) U.S. Space Shuttle Flag Award for outstanding contributions to the AIAA and the aerospace community. The award consists of a plaque with a U.S. and AIAA Flag that flew 2,836,864 miles in the STS Challenger Mission 41-B, February 3-11, 1984

Siu H. Chun has been selected for membership on the American Institute of Aeronautics and Astronautics (AIAA) Technical Committee on Electric Propulsion.

R. D. Scott has been appointed a member of the (American Institute of Aeronautics and Astronautics Interactive Computer Graphics Technical Committee, and has also elected to sit on the subcommittee for use of graphics in concept design.

The committee is in the process of defining short-term and long-term goals. Activities will include sponsorship of AIAA technical sessions, and exchange of state-of-the-art technical information.

Gaston receives Aerospace Power Systems Award

Stephen J. Gaston, Astro-Electronics, has been selected to receive the 1984 Aerospace Power Systems Award. The selection was confirmed at the May 9 meeting of the Aerospace Power Technical Committee of the American Institute of Aeronautics and Astronautics (AIAA). Mr. Gaston was cited for "providing technical leadership in the diverse disciplines associated with electro-chemical storage design and development."

Honorarium checks and copies of recently filed U.S. Patent Applications were presented to:

Peter T. S. Lin, Astro-Electronics
Method and apparatus for trimming and finishing the outer edge of a molded record—RCA 78,379

E. Kujas, Astro-Electronics
Soldering process—RCA 80,110

J. L. Martinelli/A. Katz, Astro-Electronics
Fixed-length dielectrically tunable coaxial cavity resonator—RCA 79,027

Hoffman elected Fellow Member of SWE

Dorothy M. Hoffman, RCA Laboratories, has been elected Fellow Member of the Society of Women Engineers (SWE). Fellowships in SWE are awarded to those individuals who have made outstanding contributions to the advancement of women in engineering and who have been recognized for their contributions to engineering and management.

Mrs. Hoffman has been with RCA since 1962, when she joined RCA Laboratories as a Member of the Technical Staff. Since 1967 she has been in charge of the Thin Film Technology Service group, where she is responsible for developing evaporative coatings for various types of devices, including kinescope parts, optical wave guides, semiconductors, and optical elements. She also helped create a central Corporate resource of computer know-how on the design of optical interference coatings.

GCS holds reception for authors, inventors, and graduates

Jim Clanton, Left, and **Jeff Viola** were among the 104 authors, inventors, and degree recipients honored at a May 3 reception given by Camden's Government Communications Systems Division. All of those honored had published a paper, been granted a patent, or received an advanced degree between July 1, 1983 and June 30, 1984.

Mrs. Hoffman holds three U.S. patents and has published 17 technical papers. She was President of the American Vacuum Society (AVS) in 1974 and was elected an Honorary member in 1982. That same year she was elected Engineer of the Year by the Central New Jersey Engineering Council. She is a founding member and Past Chairman of the Delaware Valley Chapter of the AVS. She is also a Past President (1974) and President (1984) of the Engineering and Technical Council of Delaware Valley, and a member the Engineer's Club of Philadelphia.

Mrs. Hoffman attended the City University of New York and received a B.S. in Chemical Engineering from Rensselaer Polytechnic Institute, and she received an M.S. in Chemical Engineering from Bucknell University.

Robbi wins IEEE Centennial Medal

Anthony D. Robbi, David Sarnoff Research Center, was recently awarded the Centennial Medal and Certificate by the Social Implications of Technology Society of the Institute of Electrical and Electronics Engineers (IEEE). Mr. Robbi's award is one of 1,984 medals being presented throughout 1984 as part of IEEE's centennial celebration. These medals are in recognition of outstanding service to the engineering profession.

Mr. Robbi was recently elected to a three-year term on the Administrative Committee of the IEEE Social Implications of Technology Society.

Richard J. Klensch, Communications Research Laboratory, and **James P. Wittke**, Manufacturing Technology Research Laboratory, are President and Vice President, respectively, of the Princeton Chapter of Sigma Xi for 1984-85.

Liston Abbott, Communications Research Laboratory, was recently cited by the Princeton Area Council of Community Services as a nominee for the Robert E. Clancy Award for outstanding service as a volunteer.

New book available for IC hobbyists

178 IC Designs and Applications, the latest book for electronics hobbyists and experimenters by Bob Mendelson, Applications Engineer in the Solid State Division, capitalizes on the "black box" theory of the integrated circuit – you don't have to know what's inside to use it effectively – to produce a book offering an abundance of power supply, operational amplifier, waveform generator, amplifier, communications and instrumentation, controller, and timer circuits, all built and tested by the author. There is very little discussion of the internal circuitry of the IC. Instead, emphasis is directed toward wiring and adjustment, an approach that allows each circuit type to be treated on one page with a short paragraph and a schematic diagram. A table of substitutes for active components is included.

The 193-page book is a 1983 publication of Hayden Book Company, Hasbrouck Heights, N.J. and is available for $14.95.

Productivity panel meets in Princeton

On May 9th, the Chamber of Commerce of the Princeton Area assembled a prestigious panel of business leaders to explore the problem of how to increase productivity in America. The panel met at the Woodrow Wilson School of Public and International Affairs, Princeton University.

Jim Cavanaugh of RCA Capital Planning assembled this free public service program valued at $20,000 of contributed effort and materials. Jim, who also directed the program, opened the discussions with a quote from J. Peter Grace, Chairman and Chief Executive, W. R. Grace & Company: "Productivity is everybody's job."

Technical excellence

GCS announces team Technical Excellence Award

The Technical Excellence Award has been made to the SELDON Engineering Team from the Digital Communications Engineering Section for their outstanding work in the development of a complex COMSEC device that automatically provides secure wirelines to radio calls for a wide variety of telephone and radio instruments. The team members are **F. O. Bartholomew**; **J. P. Brizek**; **J. Capitanio**; **E. C. Cassai**; **R. A. Chicalo**; and **R. O. Roderique.**

The hardware functions of this device, which would normally be accomplished in large-scale integration (LSI), were designed with microprocessors due to schedule constraint of LSI development. This required real time processing using multiple low-power devices (1802).

Production follow-on will be sole source to RCA, and our position as a contractor that delivers on time and within budget has been considerably enhanced.

GCS announces team Technical Excellence Award

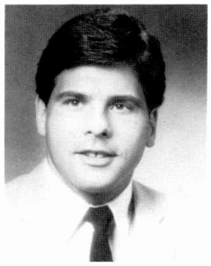
The Technical Excellence Award has been made to the Computer Controlled Equipment Engineering team responsible for the design and development of a 1-MHz Digital Acquisition System under the Unit's Independent Research and Development program. The team members are: **Thomas J. Fritsch; Joseph F. Hoey; Edward A. Timar;** and **Stanley A. Tomkiel**.

This equipment can digitally channelize a 1-MHz bandwidth signal into 160, 8-kHz wide channels (on 6-kHz centers), recognize signals at a 4-dB S/N ratio in an 8-kHz bandwidth, and provide cross-correlation of a multi-pattern signal at a 10-Megabit rate. The project included the development of a special mass storage, interactive controller capable of sustaining a 2.4-Mbit read/write rate in association with a Winchester disc drive.

The team's performance in conceiving a two-stage coarse and fine-grain processing architecture to handle a wide range of signal characteristics, and developing an overlap seek and read/write of data in order to record 16 channels and read 2 channels of 125 Kbps real-time data simultaneously was an outstanding example of engineering creativity.

This effort has led to an in-house resource for sophisticated signal-processing equipment, digital filtering and correlation. RCA Government Communications Systems has submitted a sole-source proposal for classified applications of the system that is now included in the customer's 1984 budget and is expected to lead to substantial Navy business in the future.

First-quarter 1984 Missile and Surface Radar Technical Excellence Awards announced.



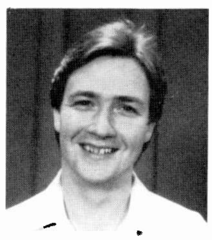
Rabbitz

Wawrzyniak

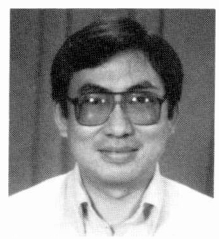
Richard J. Rabbitz – for innovative development of graphics techniques for shipboard equipment arrangements and large-scale simulations. He developed new algorithms and combined them with adaptations of existing software to provide three-dimensional viewing of objects, without hidden lines, from positions within the object space. His work with the interactive capabilities of graphics hardware facilitates the design of scenarios for complex naval battle group simulations.

Daniel J. Wawrzyniak – for outstanding technical achievement in addressing two Command and Decision operational problems during USS Ticonderoga's first deployment: diagnosis and correction of a severe display slowdown problem occurring under high air traffic surveillance conditions, and establishment of a workable secondary search radar interface to C&D using existing messages and architecture. His prompt resolution of these problems contributed significantly to the successful initial deployment of the Ticonderoga.

Two SSD awards at Findlay



Stuhler



Wang

Two Technical Excellence Awards were presented at the 1984 Business Review meeting held on May 21.

Rob Stuhler—for technical excellence while working in the Bipolar Photo Group. He has been involved in the justification, installation, and implementation of the KLA mask inspection system, establishing mask cleaning and inspection procedures, performing bipolar and DMOS mask conversions, helping to design a new bipolar auto-align key, and categorizing bipolar mask defect printing capabilities at several critical levels.

Eric Wang—for technical excellence while working in the Bipolar Diffusion Group. He established beta controls and in-line beta checks, established many 100mm diffusion processes, helped improve P+ and VEBO zener control, developed base implant diffusion schedules, developed diffusion schedules for the 100mm power base process, and developed salvage processes for high- or low-beta product.

TEC Workshop held in Princeton

The sixth annual Technical Excellence Committee (TEC) Workshop was held at the David Sarnoff Research Center at Princeton on June 12, 1984. This meeting, which is sponsored by the Corporate Technical Excellence Center, brought together the Chairpersons and the Employee Relations Liaisons from the 21 TEC locations.

The workshop afforded the 35 attendees the opportunity to exchange information concerning their programs. This was especially useful to the newly appointed leaders, giving them an insight into the successful operation of a TEC.

In addition to the roundtable discussions other events included a brief welcoming message by W. C. Hittinger, Executive Vice President, Corporate Technology, and a talk by M. Leedom, Director of the Manufacturing Systems Research Laboratory, about his recent visit to several Japanese TV manufacturing plants. The program closed with a videotape presentation produced by the Society of Manufacturing Engineers that described manufacturing engineering operations, including one segment about RCA's record plant in Indianapolis.

Editorial Representatives

Contact your Editorial Representative at the TACNET numbers listed here to schedule technical papers and announce your professional activities.

Broadcast Systems Division (BSD) — TACNET

*Jack Dearing	Camden, New Jersey	222-4688

Consumer Electronics (CE)

*Eugene Janson	Indianapolis, Indiana	422-5208
John Hopkins	Indianapolis, Indiana	422-5201
Larry Olson	Indianapolis, Indiana	422-5117
Byron Taylor	Indianapolis, Indiana	426-3367
Don Willis	Indianapolis, Indiana	422-5883

Corporate Information Systems & Services

Sue Handman	Cherry Hill, New Jersey	222-6242

Corporate Technology

*Tony Bianculli	Princeton, New Jersey	226-2111

Government Systems Division (GSD)

Advanced Technology Laboratories		
*Merle Pietz	Camden, New Jersey	222-2161
Ed Master	Camden, New Jersey	222-2731
Astro-Electronics		
*Frank Yannotti	Princeton, New Jersey	229-2544
Carol Coleman	Princeton, New Jersey	229-2919
Automated Systems		
*Paul Seeley	Burlington, Massachusetts	326-3095
Dale Sherman	Burlington, Massachusetts	326-3403
Government Communications Systems		
*Dan Tannenbaum	Camden, New Jersey	222-3081
Thomas Altgilbers	Camden, New Jersey	222-3351
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*Peter Hahn	Cherry Hill, New Jersey	222-5319
*Susan Suchy	Solid State Technology Center, Somerville, New Jersey	325-7492
Missile and Surface Radar		
*Don Higgs	Moorestown, New Jersey	224-2836
Graham Boose	Moorestown, New Jersey	253-6062
Jack Friedman	Moorestown, New Jersey	224-2112

National Broadcasting Company (NBC)

*Bob Mausler	New York, New York	324-4869

New Products Division

*Art Sweet	Lancaster, Pennsylvania	227-6878
Bob Reed	Lancaster, Pennsylvania	227-6845
Bob McIntyre	Ste Anne de Bellevue	514-457-9000

Patent Operations — TACNET

George Haas	Princeton, New Jersey	226-2888

RCA Communications

American Communications		
*Murray Rosenthal	Princeton, New Jersey	258-4192
Carolyn Powell	Princeton, New Jersey	258-4194
Global Communications		
*Dorothy Unger	Piscataway, New Jersey	335-4358

RCA Laboratories

Eva Dukes	Princeton, New Jersey	226-2882

RCA Records

*Greg Bogantz	Indianapolis, Indiana	424-6141

RCA Service Company

*Murray Kaminsky	Cherry Hill, New Jersey	222-6247
Dick Dombrosky	Cherry Hill, New Jersey	222-4414
Ray MacWilliams	Cherry Hill, New Jersey	222-5986

"SelectaVision" VideoDisc Operations

*Harry Anderson	Indianapolis, Indiana	426-3178

Solid State Division (SSD)

*John Schoen	Somerville, New Jersey	325-6467
Power Devices		
Harold Ronan	Mountaintop, Pennsylvania	327-1473 or 327-1264
Integrated Circuits		
Dick Morey	Palm Beach Gardens, Florida	722-1262
Sy Silverstein	Somerville, New Jersey	325-6168
John Young	Findlay, Ohio	425-1307

Video Component and Display Division

*Ed Madenford	Lancaster, Pennsylvania	227-6444
Lou DiMattio	Scranton, Pennsylvania	329-1435
Nick Meena	Circleville, Ohio	432-1228
J.R. Reece	Marion, Indiana	427-5566

***Technical Publications Administrators, responsible for review and approval of papers and presentations, are indicated here with asterisks before their names.**

16 Aug 1984

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