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RCA Engineer

Vol. 25 No. 5 Feb./Mar. 1980

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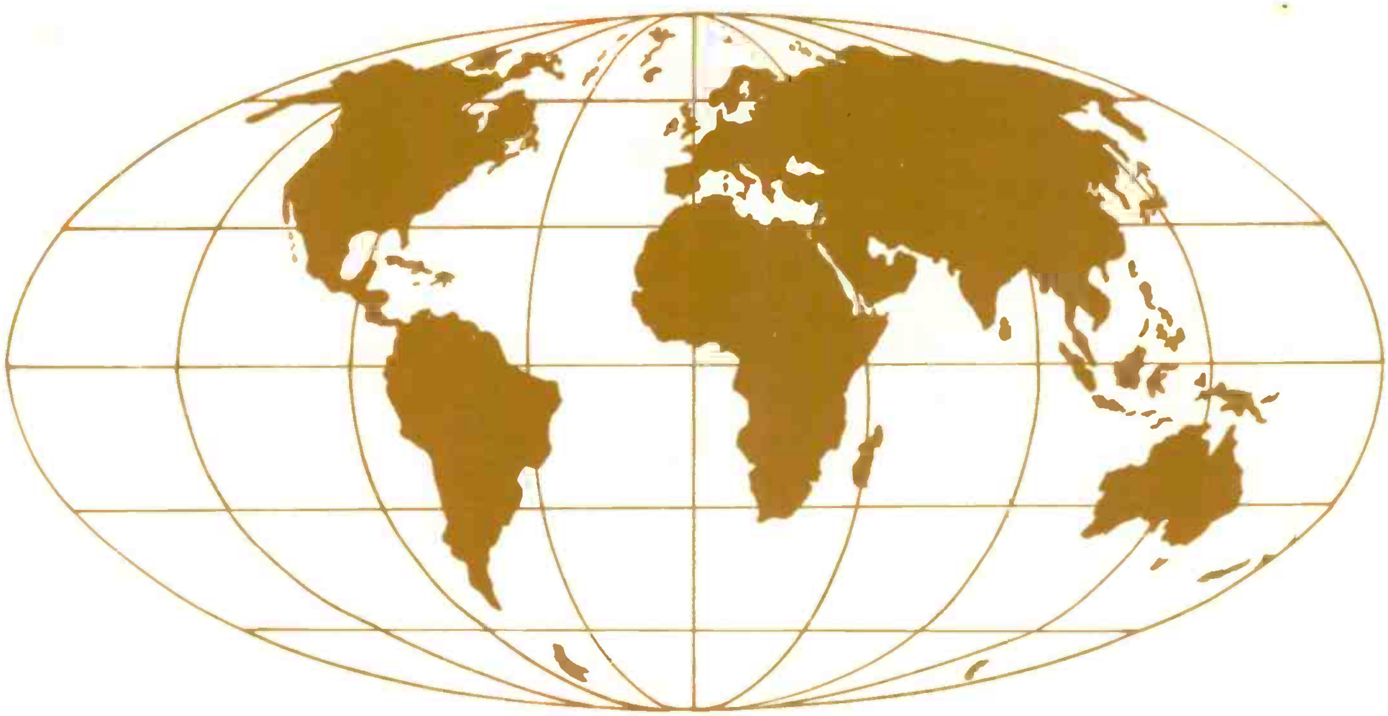

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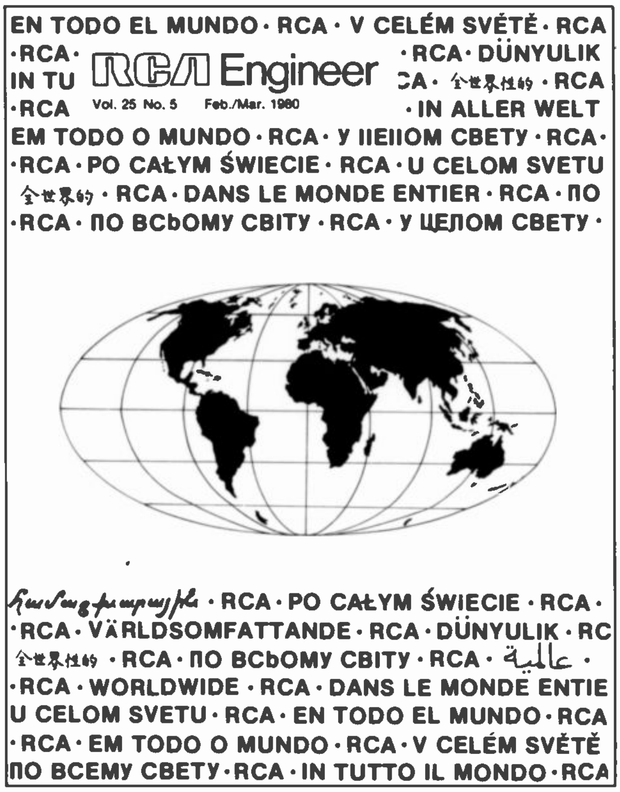

RCA business activity includes every continent on the globe except Antarctica. To stress this international involvement, Art Editor Louise Carr has repeated the word "worldwide" in many of the languages native to the countries in which we do business. On the facing page, Gene Sekulow discusses the complexities of foreign commerce.

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•To disseminate to RCA engineers technical information of professional value •To publish in an appropriate manner important technical developments at RCA, and the role of the engineer •To serve as a medium of interchange of technical information between various groups at RCA •To create a community of engineering interest within the company by stressing the interrelated nature of all technical contributions •To help publicize engineering achievements in a manner that will promote the interests and reputation of RCA in the engineering field •To provide a convenient means by which the RCA engineer may review his professional work before associates and engineering management •To announce outstanding and unusual achievements of RCA engineers in a manner most likely to enhance their prestige and professional status.

Eugene A. Sekulow

The decade of international challenge

RCA business is increasingly international. Not only is foreign direct investment growing, but so too are the dollar values of exports and overseas sales.

What is perhaps more important is the increasingly intimate interrelationship between traditional domestic business and international business. We can no longer assume that each can be conducted apart from the other.

The world can no longer be viewed as a collection of segmented markets, with each slice bearing no relationship to the others and insulated from outside events. Indeed, it is questionable that the international market should ever have been regarded in any way other than as an interrelated whole.

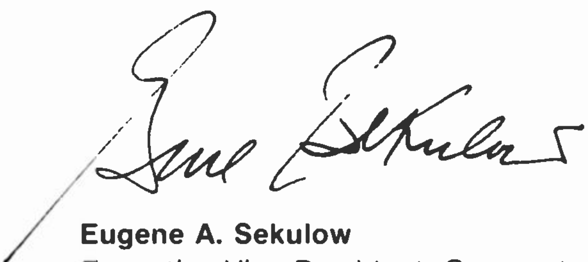
A possible worsening economic outlook abroad coupled with a volatile political outlook is going to present unprecedented challenges in the 1980s:

- The complexity of international operations has become intensified by proposed international codes of business to regulate investment, technology transfer, disclosure of proprietary information, and labor practices.

- The escalating and often seemingly arbitrary regulation of foreign companies by developing countries represents a serious impediment to business operations because of their sovereign powers of enforcement.

- Foreign restrictions on majority ownership, intra-company pricing and exports are increasingly widespread. Even developed countries have begun to place restrictions on foreign business operations. The increasing regulation by the U.S. Government of American business activities abroad is fast rivaling the well established role of the government in domestic business activities.

For RCA, with substantial stakes in overseas markets, the implications are clear. We must refine our mechanisms to monitor and respond to this complex matrix of events, regulations, emotions, challenges, and opportunities. Moreover, we must continue our commitment to technological and marketing excellence across our diversified range of operations.



Eugene A. Sekulow
Executive Vice President, Corporate Affairs

Highlights

RCA and the foreign market

active participation in the foreign market promises to be advantageous for RCA.

RCA research laboratories abroad

American and foreign engineers overcome language and cultural barriers and work together profitably.

international communications

development of a Pacific Basin digital communications network could serve as the forerunner of a regional satellite system.

worldwide support systems

a cooperative approach to engineering and logistics support provides efficient, cost-effective maintenance of instrumentation radars.

in future issues

color TV receivers, anniversary issue, custom LSI, communication trends, computer-aided design

Illustration by L.M. Carr

RCA Engineer

Vol 25|No. 5 Feb.|Mar. 80

L. Caprarola

Solid State Division and the Brazilian marketplace

The Brazilian electronic industry shows promise of real growth. RCA Records and Picture Tube Division have already established themselves in the Brazilian marketplace and SSD is following suit.

Abstract: *Brazil is viewed as one of the world's more attractive growth areas for the electronics industry. This article tells why. The major emphasis of the article is on the electronics industry in Brazil. Consumer, industrial, commercial and scientific electronic products are discussed along with how the Solid State Division fits into the Brazilian electronics picture.*

The business climate

As the largest country in South America, and the fifth largest country in the world, Brazil represents an important international market for the sale of RCA Solid State Division products. This vast country of over 100 million people, rich in natural resources, with a significant part of its area still unexplored, ranks today among the top ten world economies, and is likely to become, through its vast resources and potential for production, one of the world's major industrial powers of the future. Its current gross national product, which approaches 200 billion U.S. dollars, and its anticipated annual growth rate of 7 to 8 percent through the mid-1980s explains, in part, why Brazil is viewed as one of the world's more attractive investment areas. Tables I and II display strikingly the rapid growth in both gross national product and population since 1970.

Brazil's success is, unfortunately, not without its price. Rapid growth has brought attendant social and political problems, and has contributed to the formation of an economy that may experience a 1979 inflation rate as high as 70 percent. A key factor in Brazil's economic problems, which includes a negative balance of trade in 1979, is the world oil crisis; Brazil imports more than 80 percent of its petroleum. Its programs to utilize alcohol distilled from local sugar cane as vehicle fuel and its internal and off-shore exploration for oil can only provide minor relief over the next five years.

The newly installed Government, with a six-year tenure, took office on March 15, 1979, and, while it represents a continuation of previous regimes, gives some indication of interest in improving the distribution of wealth, particularly at the lowest wage levels, and of permitting the general population a greater voice in shaping future policies. The dynamic social, political and economic changes apparently destined to take place in Brazil over the next ten years make real market growth and expansion inevitable.

The fact that Brazil appears to have "cornered the market" in red tape in the form of a bewildering array of administrative and procedural business requirements should not act as a barrier to participation in the marketplace. Perseverance and an attitude ready to adapt to each new requirement can overcome the natural frustrations of administrative excesses and permit very successful operations in Brazil.

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RCA's competition

Over the last few years, the Japanese have gradually improved their market position in electronics in Brazil at the expense of U.S. and Western European suppliers. Table III explains this statement in more detail. In addition to their commercial aggressiveness, the Japanese appear to more readily accept a longer-term pay-off for current investments. Their rapid gains in the electronics market in Brazil since 1975, particularly in television, illustrate the point well.

The electronics industry is concentrated, with the exception of the Manaus Free Zone in the North (heavily populated by Japanese), in the Southeast region of Brazil, principally the states of Sao Paulo, Rio de Janeiro and Minas Gerais. This

Table I. Brazilian gross national product (in millions of 1979 U.S. dollars).

Year	*GNP*	*Increase over previous year (percentage)*
1970	94,704	8.8
1971	107,300	13.3
1972	119,854	11.7
1973	136,634	14.0
1974	150,024	9.8
1975	158,426	5.6
1976	173,001	9.2
1977	181,132	4.7
1978	192,001	6.0
1979	205,440	7.0 (est.)

region also represents the population concentration of Brazil and the largest consumer market for durable goods. It appears that, as the Brazilian electronics industry grows, these same areas will remain the focal point of the electronics market in spite of the Government's active policies to populate the major interior sections of the country.

Electronics in Brazil

The output of the Brazilian electronics industry has increased at an average annual rate of about 16 percent during the 1970s, and reached a level exceeding 1.1 billion U.S. dollars in 1978. A projected 10 percent growth in this industry through the mid-1980s appears to be realistic; this projection will be tempered, of course, by world economic conditions. Although the Brazilian market has been, and is, largely in consumer electronic products, the greatest future growth will likely occur in telecommunications, data processing, automotive electronics, medical and military equipment, and most particularly in the broad area of industrial controls.

Although most of the electronic products available today in Brazil are either imported or assembled locally from imported components, the Government's goal of greater self-sufficiency in this area is evident. While Government policies have been changing toward "imported electronics," some market segments, notably telecommunications and data processing, have been reserved for Brazilians, and are under direct or indirect Government control. The "knife-edge" on which Brazil must walk separates a need to slowly build its local electronics independence while simultaneously permitting foreign companies, on whom it must rely for technology, to meaningfully participate in its marketplaces. This dichotomy is particularly difficult in areas of high technology, and is even more troublesome in areas such as semiconductor development, where the world's knowledge moves forward at a bewildering pace. Brazil, whose future general economic goals as an exporting nation must include increasing exports of manufactured goods, requires modern technology to compete in world markets.

Consumer electronics

A strong domestic demand for televisions and radios has kept Brazilian factories

Table II. Brazilian population.

Item	*Unit*	1960	1973	1974	1975	1976	1977	1978	1979
Population	Millions	71	101	104	107	110	113	116	120 (est.)

Source: Inter-American Development Bank, *Economic and Social Progress in Latin America,* 1977 Report.

Table III. Brazilian imports of major capital goods categories among leading foreign suppliers (in millions of U.S. dollars).

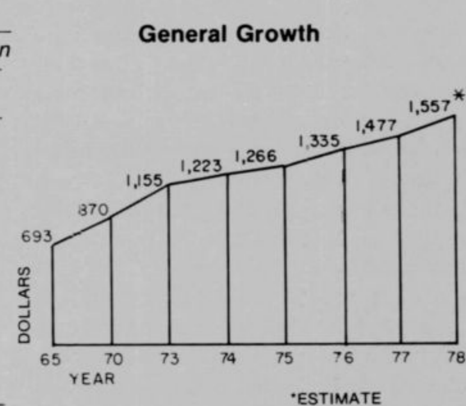
	1975		1976		1977		1982	
Country	*Value*	*Share (%)*	*Value*	*Share (%)*	*Value*	*Share (%)*	*Value*	*Share (%)*
United States	1,480	35	1,277	36	1,086	36	2,459	48
Japan	514	12	535	15	505	17	—	—
West Germany	772	18	558	16	504	16	—	—
Others	1,413	34	1,190	33	962	31	—	—
Total	4,179	100	3,560	100	3,057	100	5,160	100

Source: Foreign Trade Department (CACEX) of the Bank of Brazil and trade interviews.

Per Capita Income in U.S. Dollars

Population Income Distribution for Two Selected Years

	Percent of Population	
Income Range	*1972*	*1976*
Less than $500	21.3	12.4
$500 to $1000	23.7	25.1
$1000 to $2000	24.3	29.4
$2000 to $5000	20.2	20.9
$5000 to $10,000	6.5	7.3
$10,000 to $20,000	2.8	3.4
More than $20,000	1.2	1.5



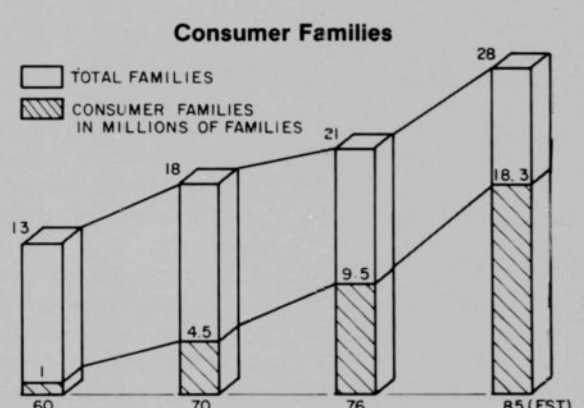


Fig. 1. The upper graph shows the general past growth of the per capita income in Brazil in U.S. dollars; the accompanying table, a population/income distribution table for two of the years covered by the graph, provides more detail. The lower graph shows the growth in the number of families with sufficient income to be consumers of electronic systems.

producing at near capacity levels over a period of years. Real increases in the purchasing power of workers in industrialized regions (Fig. 1) and progress in bringing electricity and television reception to isolated areas has boosted the sales of black-and-white and color TVs as well as all other types of home-entertainment equipment. Since 1972, when color television transmission was first introduced, the number of black-and-white sets sold in Brazil has remained fairly level, while the number of color sets sold in 1976 more than quadrupled the 1973 figure. The market for audio equipment, including radios, phonographs, tape equipment and hi-fi systems, is expected to move ahead. Trade sources estimate that, in spite of government credit restrictions to curb inflation, Brazil's production of home entertainment products will rise about 11 percent yearly to about $1.2 billion by 1980.

Home-entertainment equipment circuitry has rapidly moved from the use of electron tubes to transistors and then to ICs: linear, bipolar and metal-oxide types. There will be increasing demand for bipolar-memory digital ICs, linear voltage regulators, digital MOS ICs and special consumer circuits. There will also be a stable demand for ICs of the TTL type, as well as for most transistors and other products which are produced in Brazil and whose use is encouraged by various forms of governmental support.

Brazil's yearly production of automotive radio and tape recorders is expected to increase from $175 million in 1976 to $275 million in 1980 in spite of slow growth in the automotive industry. A large portion of automotive radio production is exported; about 38 percent of the industry output will be destined for foreign markets.

An increasing number of pocket calculators are manufactured in Brazil, but the sales value of this production probably peaked in 1976. The production of electronic watches is expected to start in the next two or three years.

Industrial, commercial and scientific electronic products

The industrial, commercial and scientific sector of Brazil's electronics industry has demonstrated a major expansion, with a yearly production of about $376 million in 1973, jumping an average 21 percent annually to reach an estimated $668 million by the end of 1976. The telephone-equipment industry is the largest part of this sector, and there is very little competition from foreign sources. Prior to 1964, there were only two telephones per 100 inhabitants, with over half of Brazil's urban centers having no telephone service at all. To remedy this situation, the Government originally planned to put in some one million terminals each year between 1975 and 1980. This goal has not yet been met, and only about 300,000 to 400,000 terminals per year have been installed. The demand for electronic components has been favorably affected by the changeover in equipment production from electromechanical devices to semielectronic switching. The telecommunications industry has begun a definite trend toward the use of semiconductors, such as diodes, digital bipolar devices, MOS ICs and LEDs, especially as a result of the introduction of stored program-controlled telephony in the replacment of mechanical systems.

A most important new development is the creation of a Government controlled company, Computadores Y Sistemas Brasiliera S.A. (COBRA), to produce minicomputers primarily for process and machine controls. Until recently, the domestic EDP industry was restricted to assembly operations of the major internationals, IBM and Burroughs, which were set up mostly for the export market.

Until 1974, the manufacture of medical diagnostic and treatment equipment was practically nonexistent. Since that time the production of cardiological equipment, electronic scalpels, and intensive-care and X-ray equipment has progressed rapidly. A yearly output of $20 million in 1976 is expected to more than double and reach $50 million by 1980.

Governmental protection

A key element of the Brazilian business environment is the existence of a federally protected market. Brazil traditionally has maintained a strong protectionist posture toward local manufacturers, and this attitude has strengthened since the oil crisis and its adverse affect upon the balance of payments.

Import duties tend to be higher; the duty on solid-state products ranges from 15 to 55 percent, and the "reference prices" that exist for some solid-state devices peg the value of the import at higher than normal levels for import-duty calculation purposes.

While this article was being written, President Joao Baptista Figueiredo, on Dec. 7, 1979, ordered a sweeping change in the country's ten-year old economic program. Prior to this announcement, imports, with rare exceptions, were subject to a 360-day deposit resistriction. Under this regulation, the importer was required to post with the Government for one-year a deposit equal to 80 percent of the FOB value of the import; the deposit gained no interest and was not subject to future monetary-value correction. Because of the high inflation rate in Brazil, this deposit had the effect of penalizing the importer approximately 50 percent of the amount of the deposit by the time it was returned.

The effects of the recently announced changes in economic policy are too uncertain to permit their full assessment now. However, a few things have been made clear. The 360-day deposit has been eliminated, the cruzeiro, the main unit of Brazilian currency, has been devalued 30 percent, and certain controversial export subsidies have been discontinued. President Figueiredo expects that these changes will stimulate export income and buy time while the country hastens to develop alternate energy sources to free itself from excessive oil imports. The new program also calls for a gradual return to a free-market economy through the removal of subsidies to and controls on the private sector. This policy could lead to profound and lasting positive changes in the Brazilian market.

RCA Solid State, Brazil

RCA's Solid State Division (SSD) had established in Brazil in 1975 an assembly operation using U.S. produced parts to fabricate products aimed primarily at supporting some large multinationals that had established equipment manufacturing operations there. In the last few years, as dynamic changes have occurred in Brazil, three major factors have dictated a reanalysis of SSD's position: first, the electronics marketplace was expanding in size and complexity; second, the Brazilian Government's existing policies, and those anticipated, placed a premium on maximum content of locally produced electronic components in electronic equipment; and third, competitors were strengthening their position and threatening RCA's existing market share.

SSD's continuing analysis suggested in 1976-1977 that its current profile in Brazil required modification. In the final analysis, it appeared evident that SSD required an expansion of its business base in both size and local concentration or it faced an eventual withdrawal from the market.

After a concentrated analysis of alternatives, it was concluded that SSD's continued participation in this excellent growth market was critical to its worldwide growth. A major element of this evaluation verified that RCA's solid-state product lines and special application skills were especially complementary to the major Brazilian solid-state markets. A joint venture with another U.S. multinational corporation was determined to be the vehicle that would provide the best opportunity for RCA. The joint-venture approach provided advantages for each of the participants; each one brought unique and important resources to the program. Additionally, RCA's proposed partner was a major solid-state device consumer. Of prime importance to Brazil, the proposed plan, by virtue of its objective — to perform all operations in Brazil, including the high-technology area of wafer processing — would, if implemented, bring important state-of-the-art technology to Brazil through the necessity to develop and train an essentially all-Brazilian staff.

After considerable analysis and negotiation, the joint venture was formed and began operations in July of 1979. Two companies were formed; one a manufacturing company, the second, a sales/marketing company. Each of the participants had controlling interest (51 percent) in one company and a minority interest in the other (49 percent). RCA Corporation provided the technology and manufacturing expertise, and each party contributed appropriate equity and management skills. Since both companies had modest existing semiconductor operations in Brazil, these were incorporated (personnel, fixed assets and other assets) in the joint venture with the result that the new companies were a "going concern" on the first day of operation.

At this writing, the new companies, having experienced some anticipated early growing pains, are progressing well, and fully expect to comply with their optimistic five-year business plans.

Conclusion

Considering many of the world areas in which the wisdom of future investments is being evaluated, Brazil may well be unique in its growth potential. Even a pragmatic analysis of the future reveals the overwhelming evidence of Brazil's eventual economic power. Relying on fundamentals that provide the sharpest and most realistic guides for action, it appears that those willing to muster the necessary perseverance and resources, coupled with the proper balance of short- and long-term business strategy, can participate with better than average return in the Brazilian market. The dynamics of the area are such that it is not an environment for the faint-hearted. It is, in fact, a significant opportunity for those who are alert, capable of dealing with a very fluid system, and who have confidence in their ability to operate in a highly complex and competitive arena.

During the next decade, doing business in Brazil will require changes in marketing practices and business strategy as the Brazilian Government shifts its priorities and attempts to conform with a rising voice of a growing population desiring a greater share of Brazil's successes. It is still too early to judge the actions of the newly installed officials; the path they select, particularly as it relates to the degree of true free enterprise in Brazil, will in large measure guide corporate strategy. RCA's ability to operate successfully in Brazil has already been proven through the efforts of the Record Division and the Picture Tube Division; it remains for the Solid State Division to match this performance.

Roy Caprarola joined RCA in 1949 in the Specialized Engineering Program and participated in the development of the color picture tube. He was the recipient of the David Sarnoff Engineering Achievement Award in 1961 for team contributions to the development of a nuclear-reactor powered thermoelectric generator. Mr. Caprarola was Manager, Thermoelectric Product Operations from 1965 through 1977; he is currently Manager, Planning and Support, Brazil.

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J.J. McHugh

Technology transfer — color-picture-tube plant for Poland

Assignment: design and build a color-tube plant from scratch, get it running, and teach Polish engineers how to keep it running smoothly.

Abstract: *Technology transfer on such a large scale as building an entire picture-tube plant is new to RCA. Such an undertaking requires a new form of management — a modified form of the matrix method. American engineers have found working with their Polish counter-parts to be a rewarding but challenging experience, since engineering is language as well as equations.*

The plant itself will consist of both a glass works (technology provided by Corning Glass Works) and the tube manufacturing plant. The contract runs from initial design to prove-in and check-out, and will require the coordinated effort of RCA plant, equipment, process, industrial, and laboratory engineers.

Imagine yourself flying on a jumbo jet. As the aircraft, with hundreds of people aboard, lands safely, one can not help but think, "Thank God for engineering." It's amazing to think that engineering can provide the structural wheelbase to land such a massive object at greater than 160 miles per hour without collapsing. This engineering ability was not developed overnight. It was developed from an amazing "inventory" of development know-how

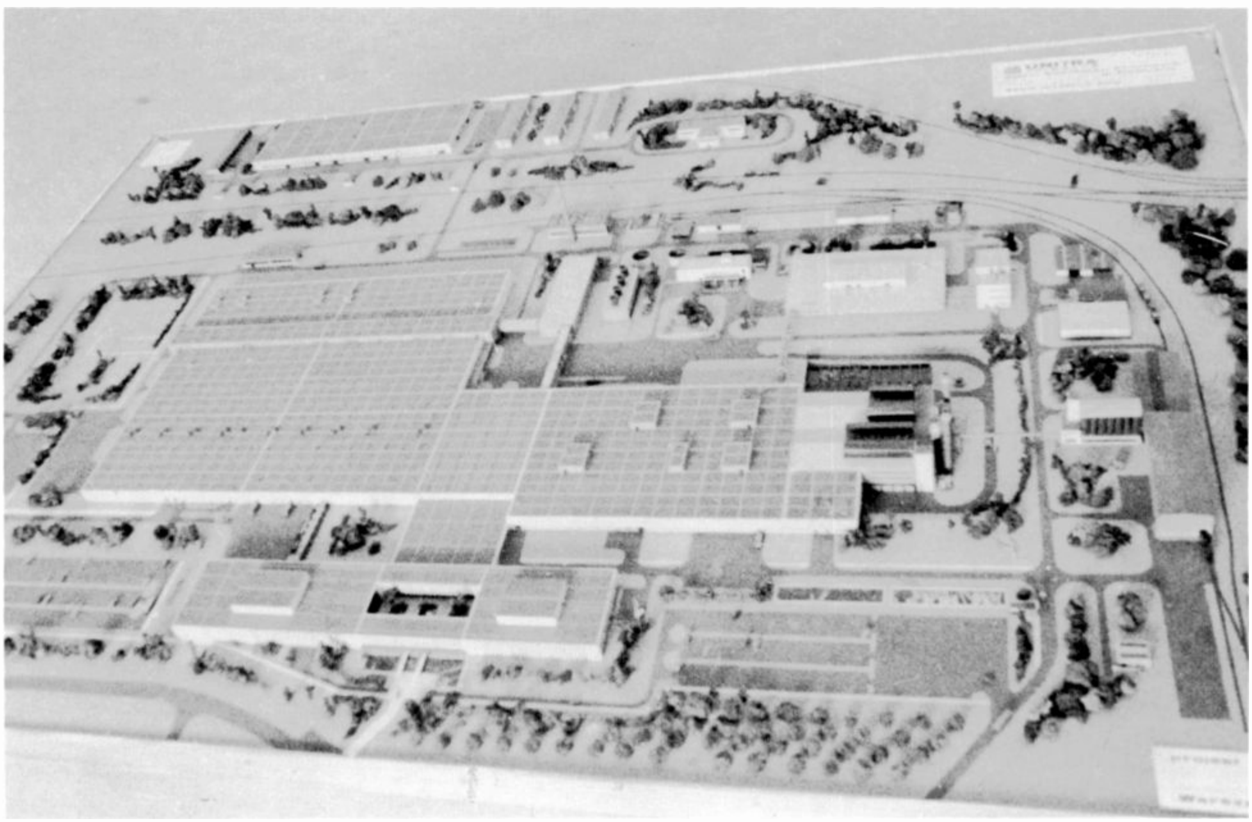

Fig. 1. This architectural model shows the 1- x 1½-mile site.

amassed over years of enormous investment. Likewise, RCA has developed a massive skills inventory in many areas of electronics.

RCA has successfully engineered and produced many electronic component parts. After our success in inventing and producing an electronic component part like the color-television picture-tube, and after a period of market maturity, it becomes logical to sell this technological know-how and so to capitalize on its engineering development investment. With this thought in mind, RCA elected, some years ago, to sell color-television picture-tube technology.

In 1975, RCA signed a contract to transfer color-television picture-tube technology to Poland, in the form of designing, building, and starting up a full-scale manufacturing plant, from glass works to finished product. A great challenge had begun. (For details on how the contract came about and what work is involved, see the material in the box at the right.)

The RCA/UNITRA technology transfer contract

In June of 1972, President Richard Nixon and the First Secretary of the Central Committee, Polish United Workers Party, Edward Gierek, signed an agreement called the American-Polish Trade Accords. This agreement provided for the exchange of goods, services, and technology. After the two countries authorized banks for such transactions, the doors of commerce between Poland and the United States opened. Consequently, many American companies ventured forth to exchange goods, services, and/or technology transfer with Poland. In November of 1975, the RCA Corporation signed a technical contract with the UNITRA Foreign Trade Enterprise of Warsaw.

This contract provides for the transfer of RCA color-television picture-tube and receiver technology, know-how and technical assistance. Under its provisions, RCA will transfer to UNITRA technical services and equipment, building designs, plant services equipment, materials, and other items necessary to produce color-television picture-tubes in Poland. RCA's obligations under this contract are threefold:

1. To provide equipment, materials, training, on-site support, and engineering technology to enable UNITRA to produce 300,000 21-inch 110° deflection angle, precision inline toroidal net good tubes annually. Under this part of the contract, "proof of performance" levels must be achieved on pre-determined manufacturing processes.
2. To provide additional equipment in the event that UNITRA, at some future date, would unilaterally elect to increase production capability to 600,000 net good tubes annually.
3. To provide plant design and plant services engineering capable of permitting UNITRA to increase the capacities of their facilities to an annual production of 900,000 net good tubes.

It is important to note that RCA must also provide power-house and waste-treatment facilities for a glass plant, which is being built under separate contract by Corning Glass Works.

Management methods

After signing the Foreign Trade Enterprise (UNITRA)/RCA Contract, RCA selected experienced managers of various disciplines to man this exciting new business. Those disciplines included construction, plant design and services, plant, equipment and industrial engineering, tube and components manufacturing and engineering, laboratory engineering, and industrial relations. This small cadre of seasoned managers was chartered to define the factors of production, manpower, material, and machinery necessary to comply with RCA's contractual requirements.

As involvement with the contract grew, RCA employed a modified version of the "matrix method of management," which makes the services of the entire Picture Tube Division available. The first group of managers became "project" managers, interfacing with the client in their respective areas of discipline. Thereafter, employees throughout all departments responded to the needs of this small cadre as a means of executing this contract. More specifically, if a departmental manager was responsible for a particular phase of color-tube engineering, it would likely follow that he and his respective employees would be far more qualified to take their everyday experience to Poland to successfully start up that part of the facility, rather than the project manager. Today, RCA recognizes the success of using this method of management.

A broadening experience

Within the scope of this contract, when we speak of engineering, we mean all engineering: plant, process, equipment, industrial, product and laboratory, which in itself covers a wide field, including chemical, physical, metallurgical, analytical, developmental and design. Many of today's RCA engineers, working in these fields and interfacing with the client, have broadened their experiences by working with their counterpart engineers who operate under entirely different managerial directives, methods of measurement, languages, etc.

The excitement here lies in understanding the foreign engineer's theories, thoughts, and methods of implementation. Although the mathematical equations may be the same, people reared and educated in different parts of the world may have an approach to business that is markedly different from ours. The excitement that arises from this contact cannot be totally realized, or even imagined, unless personally experienced. It provides opportunities — opportunities of testing one's education, experience, and know-how with those of another individual with similar education but with different orientation.

One must take the knowledge and years of experience and act as a teacher, transferring that knowledge to a foreign counterpart. In the end, the foreign engineer must perform as efficiently as his source of new knowledge and know-how.

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One must also learn diplomacy and the art of communicating with a foreigner who was reared and educated under a different culture, different standard of living, and in the case of Poland, under a socialistic and tightly controlled society.

Are there problems? Certainly, but not insurmountable ones. One can learn to adjust to the different cultural standards. One can learn to speak some part of his counterpart's native language. One can learn to recognize his counterpart's needs, demands and pressures. The Polish engineer can be assured that his counterpart will know every piece of the contract that pertains to his area of responsibility. Consequently, the RCA engineer must do exactly the same. By so doing, the two engineers will establish and have greater respect for each other.

The engineering involvement

Now let's take a look at some of RCA's engineering requirements under the UNITRA contract.

Plant engineering

To successfully produce a top-quality color-television picture tube, factory design, construction and services must be engineered and administered by the plant engineering activity. As of this writing, the design of the various buildings (tube, electron gun, parts works, phosphor, and mask manufacturing, plus powerhouse and waste treatment) is complete. All building construction and plant services will be completed by June of 1980.

Plant-engineering activities do not end at this point — the plant engineers now help install, check out, and test the processing equipment, working with the client and subcontractors. Building design includes many things — the boiler room, powerhouse, cooling towers, demineralized water systems, electricity, gas, water, hydrogen — everything it takes to meet the needs of an entire vertically integrated color-tube manufacturing facility.

Equipment engineering

This activity must define the processing-equipment services and wastes of each piece of equipment for the plant-engineering activity. These engineers must also work closely with the process engineers to design the equipment to meet predetermined processing parameters. Thereafter, they must interface with numerous equipment manufacturers prior to, during, and after the manufacture of RCA's proprietary equipment. The design engineers and technicians must then go to Poland to help check out and test the equipment with the process engineers.

Process engineering

After the plant and equipment engineering is complete, the process engineer must test, start up, and begin to process the indirect and direct materials necessary to produce a top-quality color-television picture tube. All processing parameters — equipment speeds, temperatures, pH factors, specific gravities, weights, parts cleaning, and so on — must comply with the tube design and good industrial-engineering practices.

Industrial engineering

To complete the production equipment complement, the industrial-engineering activity must establish worker and machine rates, and create efficient operational process charts for all direct materials. Equipment layout drawings must be prepared to show maximum use of floor space and efficient use of manpower, machines, and materials. Material waste (scrap) must also be addressed, or equipment complements may not be adequate. The industrial engineer coordinates plant, equipment, and processing engineering, with manufacturing management.

Laboratory support

Technology is not stagnant, especially picture-tube technology. Therefore, Picture Tube Division laboratory support follows a tube type from inception, through market maturity, to its ultimate obsolescence. Our chemical, physical, metallurgical, analytical, development and design engineers have, over the past 25 years, continually improved color-

Fig. 2. The Polish engineer can be assured that his counterpart will know every piece of the contract that pertains to his area of responsibility.

Fig. 3. The RCA engineer must also be able to depend upon the expertise of the Polish engineer.

Fig. 4. The equipment engineering activity must define the processing equipment services and scrap of each piece of equipment for the plant-engineering activity. Alan Greer, left, and Joe McHugh inspect a piece of newly arrived equipment.

television picture-tube technology. For example, we have changed the geometry of the tube from 70° to 90° to 110° beam deflection angles, from 21-inch round to 25-inch diagonal picture screens, from delta to precision inline concepts, and so on.

Since all of these changes have to be professionally documented, the Picture Tube Division has for years maintained an Engineering Standards Department. This means of maintaining and controlling changes has enabled RCA to transfer color-television picture-tube technology to Poland under the existing UNITRA/RCA contract.

Conclusion

And now as our jumbo jet streaks down the runway, headed for Poland, we hope we have provided you with some insight as to our commitments in Poland and the engineering achievement we are building there. We believe it will be a tribute both to our technical capability and our new-found ability to cope with a foreign environment. We believe that the tube plant will be one of the finest integrated color picture-tube production facilities in the world. We also believe our working together will have helped further mutual world understanding.

Joseph McHugh, for the past three years, worked for the Tube Division on assignment in Europe with Directorial responsibility for establishment of a picture tube manufacturing facility. From 1973-1976, he was Manager of Manufacturing with total responsibility for color TV tube manufacturing at the Scranton facilities. For a brief period in 1973, he was assigned to Video Color Tube factory in Anagni, Italy. From 1956 to 1973, he held a variety of manufacturing positions in Scranton and is presently assigned to RCA Records as Division Vice President of Manufacturing.

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Errata

Software techniques for a microprocessor-based data acquisition device

By H.A. Goldstand
Vol. 25, No. 3, Oct./Nov. 1979, p. 34.

Although Figs. 5, 6, and 7 were referenced properly in the text and contained the appropriate captions, the artwork which appeared with Fig. 7 should be associated with Fig. 5; the artwork which appeared with Fig. 5 should be associated with Fig. 6; and the artwork with Fig. 6 should be associated with Fig. 7. The artwork which appeared with Fig. 7 should include the flowchart entry point (α) above the box "D-QUEUE EXTENDED INTERRUPT." On page 37, in the paragraph starting "The task scheduler...the sentence beginning on the eighth line should read. "All active tasks have a bit, corresponding to their priority mask."

A microcomputer glossary

By P.P. Fasang
Vol. 25, No. 3, Oct./Nov. 1979, p. 14.

The titles for the block diagrams on page 15 are reversed. The left diagram is of a basic microprocessor and the right diagram is of a microcomputer.

Low arc picture tube development using statistically designed experiments

By C.W. Thierfelder and
F.J. Hinnenkamp
Vol. 25, No. 4, Dec.1979/Jan.1980, p. 27.

The last sentence of the paragraph beginning "Picture tube arcing..." in column three of page 27 and the caption for Fig. 1 should read, "The sample on the right shows the multiform glass bead plane view of the HiPi electron gun, and the left-hand sample shows the electrode plane view." In Figs. 2 and 3, the right- and left-hand photographs are reversed.

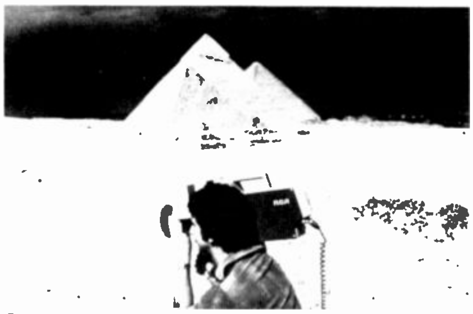
D.G. Mager

Broadcast products and services world wide

London

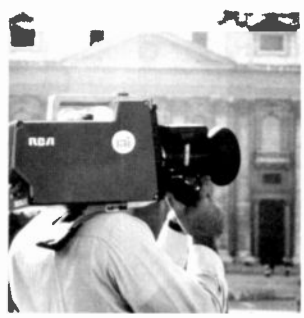
Sydney

Comprehensive RCA broadcast systems have been put in service on every continent — except Antarctica — during the last five years.



Cairo

Paris



Rome

Moscow

Abstract: *RCA Broadcast Systems is actively participating in the international market. This article describes selected BCS activities throughout the world. It includes a range of projects from single-piece hardware sales to more comprehensive turnkey programs. The project descriptions include installation, checkout, training and on-going technical support after the sales.*

BCS and the international market

Over the last ten years, Broadcast Systems (BCS) has experienced an expanding international market for its products. In 1970, approximately twenty percent of its total divisional sales came from the international market. In 1979, almost one out of every three sales dollars were realized from sales outside of the United States. This dynamic improvement in international activity can be primarily attributable to engineering objectives that were formulated during the late sixties to make this equipment adaptable to accommodate all international broadcasting standards including SECAM, PAL-M, and PAL-B.

In addition, Broadcast Systems has established facilities in the international market to meet changing international sales requirements. Along these lines, this division built a plant on the Isle of Jersey where it does a substantial amount of its manufacturing for the European Common Market, Africa and the Middle East. BCS international resources also include fourteen field sales offices, one training center, two replacement parts depots, plus technical field service representatives living in four countries. RCA laboratories in Zurich, Switzerland have played an instrumental role in helping to adapt RCA broadcast equipment to satisfy various international standards.

The scope of Broadcast Systems' worldwide involvement can best be visualized by examining some of the international projects involving the sale of Broadcast Systems merchandise and services.

Africa

In Africa, BCS was responsible for the installation and checkout of two VHF transmitter sites and a studio complex for the Nigerian Television Authority (NTV) during 1977 and 1978 (Fig. 1). This project was unique in that RCA had comprehensive responsibilities extending from the supplying of hardware to the training of NTV employees on-site during the first year of operation. To accomplish th s task, BCS participated in the initial planning with the consultant and provided technical personnel to implement the installation of RCA-supplied equipment.

To accommodate the customer's tight scheduling requirements, RCA arranged to have eight plane loads of broadcast equipment flown to Kano, in the Northwestern State of Nigeria. From there, it was trucked to either Sokoto, to equip the studio facilities and one transmitter plant, or to Gusau to provide for a 25-kw VHF transmitter relay facility with Telecine originating capability. When the installation was completed, RCA provided a four-man engineering crew in all aspects of maintenance and operation. Nine training seminars were conducted which lasted from three days to two weeks, during which time NTV personnel were provided with both academic classroom instruction and practical hands-on training on all major equipment. During the installation phase, housing for the RCA personnel was provided by using a special house trailer which had been shipped to Nigeria by boat several months earlier. Before shipment, the trailer was loaded with canned foods and other non-perishable foods.

The transmitter relay site in Gusau was ultimately fed by a microwave link. Initially, this site used an off-air signal picked up from Sokoto, seventy-five miles away. This broadcasting complex was the first color-originating and transmitting facility in Nigeria and the first TV station in the Northwestern State.

Fig. 1. BCS was responsible for installation and checkout of two VHF transmitter sites and a studio complex for the Nigerian Television Authority during 1977 and 1978.

Persian Gulf

In the Persian Gulf, there is a five-mile wide, ten-mile long island, which under the direction of the Kish Island Development Organization, was transformed into a new major resort complex in 1978 (Fig. 2). Broadcast Systems was one of the eight major RCA operating units that was instrumental in providing equipment, engineering support and customer training to develop this island into a vacation showcase of the Eastern world. Comprehensive telecommunications facilities were an integral part of the construction of modern hotels, villas, and a casino. These facilities include a radio and TV program production center; cable TV system designed to serve 3,400 color receivers; three. FM stereo broadcsting stations; a mobile radio system, plus a security, safety, and management system.

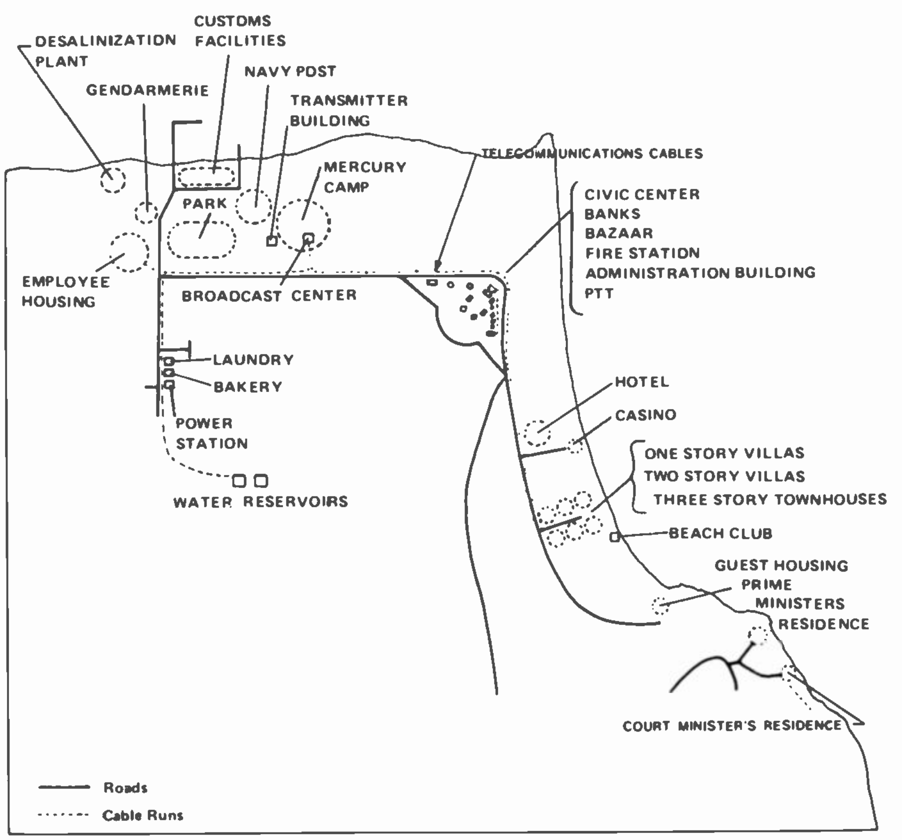


Fig. 2. The five-mile wide, ten-mile long island of Kish was transformed into a new major resort complex in 1978. Broadcast Systems was one of the eight major RCA operating units that was instrumental in providing equipment, engineering support and customer training to implement this transformation.

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Fig. 3. The distribution system at Kish Island provides off-the-air and local studio-generated TV programs. This self-contained comprehensive radio and TV facility provides the island with indigenous broadcasting capability.

The distribution system provides off-the-air and local studio-generated TV programs and FM signals (Fig. 3). It includes reverse signal transmission, as an expansion capability, from any receiver termination point to the Broadcast Center which receives and processes up to two off-the-air TV channels plus FM signals. Three RCA BTF-10E FM transmitters, equipped for stereo operation, are programmed and operated as separate entities, but include facilities for interconnection for special program material. Each transmitter feeds a separate RCA BFC-6B FM antenna to provide an effective radiated power of 30 kilowatts for each of the three channels.

The radio facilities include an RCA automated DAP-100 Digital Automatic Program Control Center capable of controlling ten or more audio sources selected at random and so sequenced that events can be stored in its computer-type memory banks. Eight RCA RT-21 reel-to-reel stereo playback machines provide the primary inputs for automatic programming.

Three FM originating studios — each with a separate control room — are used to supplement the automated programming system. Each system is capable of originating programs from voice, stereo records, prerecorded stereo tape cartridges and stereo reel-to-reel playback machines. One studio is equipped with record/playback machines; consequently, it functions as a production studio.

The television facilities include an audio/video distribution center plus a production center. This TV complex includes three RCA TK-45A color cameras, two RCA TR-70C quadruplex video tape recorders, two RCA TK-28 Telecine chains plus complete control equipment permitting high quality video recording and playback.

This self-contained comprehensive radio and television facility provides the island with indigenous broadcasting capability to meet the most demanding entertainment and communication requirements for such a resort complex.

Fig. 4. Broadcast systems provided 17 TR-600 quadruplex video tape recorders, 5 TK-28 Telecine chains, 38 live color TV cameras, and 18 Video IV character generators to support the Montreal Olympic coverage.

Montreal Olympic Games

Olympic games have always been a special challenge to broadcasters, and RCA has played a significant role in supplying equipment and technical personnel for these events over the years. The Montreal Games were an excellent example of such involvement (Fig. 4). To support the coverage efforts of the Olympics Radio and Television Organization (ORTO), a division of the Canadian Broadcasting Corporation (CBC), BCS provided a significant amount of equipment including 17 TR-600 quadruplex video tape recorders, 5 TK-28 Telecine chains, 38 live color TV cameras, and 18 Video IV character generators.

To install, checkout, maintain, and help train broadcasters from around the world on the use of these items, BCS had up to twenty-one technical personnel on site during the games.

The programming concept adapted in Montreal differed from previous Olympic coverage. ORTO provided as many as fifteen simultaneous feeds from which its TV and radio clients, broadcasting groups and entities from 110 countries, assembled their own programs. These programs were relayed to a world wide audience estimated at one billion. Twelve of the VTRs were divided into pairs interfaced with a rack of electronics for a tape editing programmer with two time-code readers. Each configuration was assigned to recording and editing a particular event.

To stay on schedule, the use of this

pickup, recording and editing equipment was carefully controlled and maximized. With competitive events compressed into 15 days, it was necessary to condense them within allowable programming times. This was done to meet critical satellite, or other transmission schedules, to reach the maximum size audience in home countries at suitable viewing times. For example, personnel from the Russian and Polish broadcast organizations used the RCA equipment early each morning to edit and assemble ORTO library tapes into programs tailored to the interests of their audiences.

By combining skill and adaptability with the TR-600's state-of-the-art features, the operators were able to meet a variety of production requirements with great efficiency. Some of the features were:

- Automatic edit (Tonewheel) phasing permitted lining up the off-tape signal about to be recorded as soon as the tape reel was rolled prior to making the edit. An edit display or window insert on the video picture monitor indicated proper timing with the coincidence of a moving vertical white line (TR-600 timing) with a fixed white line (signal timing).
- Disturbance-free video monitoring meant no picture disturbance at the edit point, thereby, eliminating the need to rewind the tape for checking.
- Variable capstan speed control was still another major advantage. Lip synchronization of two TR-600s was achieved simply by slowing down or speeding up tape motion on either machine until the desired time relationship was reached.
- Unity/variable controls for audio/video input and output levels provided a unity position which, once set, required no further adjustment.
- Pre-settable light emitting diode (LED) tape timer display allowed an arbitrary time reference to be set in either the record or edit mode. This saved a step each time a tape was cued up.
- Audio matrix pushbutton, located on the control panel, allowed operators to monitor both audio and cue tracks simultaneously. It was especially advantageous in locating cue tones for editing.

As further indication of the excellent performance of the TR-600s, the sixteen machines in use were "on" for 24 hours daily for almost three weeks. And for the two weeks while the games were on, recording and editing was virtually an around-the-clock operation, beginning each day at 6:30 a.m. and continuing until 2:30 a.m. the following morning.

Five TK-28 multiplexed Telecine chains met unilateral requirements for playing out film coverage of the events not covered electronically, in addition to ORTO's daily 20-minute film summary of all events.

Each chain was equipped with a TP-7 35 mm slide projector, two TP-66 16 mm film projectors, and a sep-mag unit for foreign-language audio playback.

South America

In South America, BCS has been a major supplier in an expanding broadcast market as Latin American Nations convert from monochrome to color television (Fig. 5). The 1978 World Cup Soccer matches held in Argentina provided BCS with the opportunity of participating in the successful broadcast coverage. It was successful not only from a technical standpoint, but the host country was victorious in the final playoffs.

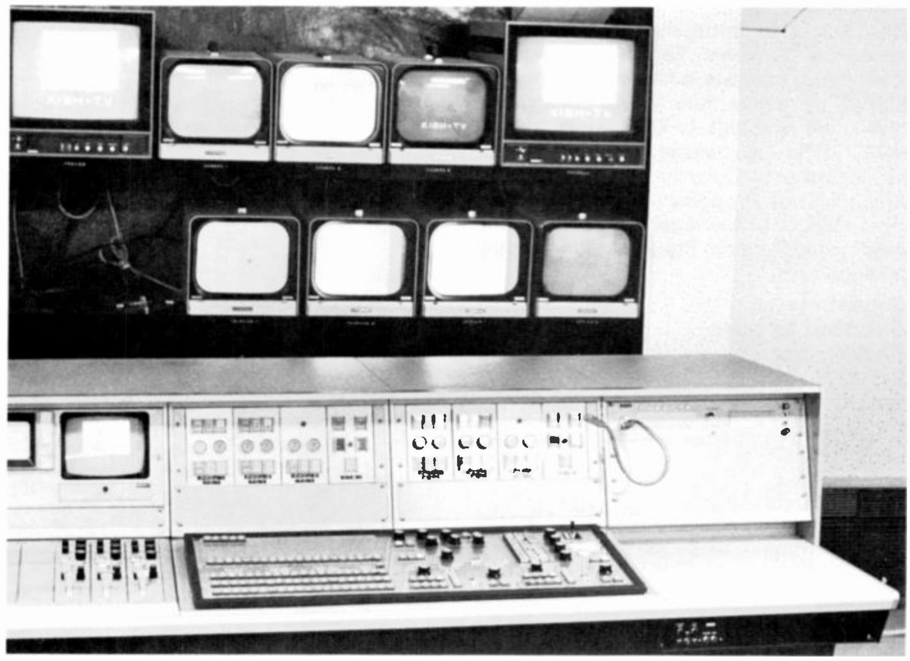

Fig. 5. In South America, Broadcast Systems has been a major supplier in an expanding broadcast market. During the World Cup Soccer matches, most of the equipment was located at this broadcast center studio in Argentina.

Fig. 6. The VTR editing system, located at the main broadcast center in Buenos Aires, was designed to provide synchronous operation among all of the tape machines.

Dan Mager is currently the Manager of Broadcast Systems Tech Alert and the technical specialists in his department have played an active role in supporting the diversified activities of BCS. Since joining RCA in 1960, Dan has held various positions as Contract Coordinator, Inventory Administrator, Proposal Administrator, Project Manager, Manager of Engineering Administration and Projects plus product management.

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BCS sold sixteen TR-600 quadruplex video tape recorders with AE-600 editing facilities; six complete TK-28 Telecine systems with magnetic sound accessories, and two TK-76 ENG cameras.

During the soccer matches, the majority of this equipment was located at the Argentina Broadcast Center studios in Buenos Aires with the balance of equipment located at the outlying stadiums at Mendoza, Cordoba, Rosario, and Mar Del Plata. Two TR-600s and a TK-28 Telecine system were installed at each of these locations. The VTR editing system (Fig. 6) at the main broadcast center was designed to provide synchronous operation between all of the tape machines which could be located in any of the six studios and could be controlled from either of two special editing control suites. A custom-built system was used to interface the sprocketed and non-sprocketed machines for precise operation. This proved to be particularly valuable at the World Cup Games because of the number of languages involved in dubbing sound. This equipment was installed and checked out prior to the games by BCS Tech Alert representatives who remained on site during the games to provide technical support.

Conclusion

Comprehensive RCA BCS systems have been put in service on every continent — except Antartica — during the last five years. We have also succeeded internationally in selling smaller systems or individual pieces of equipment. Most notable has been the worldwide acceptance of our electronic news gathering ENG camera, the TK-76. Over two thousand of these units have been supplied to the communication industry since April 1976.

The TK-76 has repeatedly proven its ability to take punishment and continues to deliver superb pictures. The reliable "out of the box" operational capability from initial customer delivery to each location shot was an initial design objective for this self-contained color camera. Its users want it to go "anywhere" and shoot "anything." And it has. From the depths of the Pacific Ocean to exacting studio application.

The expanding international sales potential for BCS products and services has resulted in a merchandising program which embraces the world as its market.

N.A. Di Orio

International procurement

The search for the best materials at the best price often leads overseas. In some cases, it even leads to unusual "counter-trade" or barter agreements.

Abstract: *Foreign procurement adds one more dimension to RCA's international businesses. This activity can be conducted in connection with, or independently of, RCA's other international businesses which mainly focus on overseas plant investments, exporting U.S.-manufactured products, and foreign licensing. For example, Major Operating Units, such as Consumer Electronics, Distributor and Special Products Division, and the Solid State Division, import components, capital equipment, and finished goods from foreign suppliers. However, even feeder plants like RCA Taiwan are importers of foreign materials—e.g., from Japan, Hong Kong, and Europe. The basic motive to buy overseas must be economic, although an added benefit is often the utilization of advanced foreign technology. In addition to providing Major Operating Units the opportunity to remain competitive in world markets, foreign procurement requires no capital investment and its use can be short or long term, depending on the needs of individual MOU's. Overseas suppliers may also be able to provide materials that are in critical supply domestically.*

On October 11, 1979, RCA Purchasing Co., N.V., a Branch of an RCA subsidiary in Curacao, celebrated its 20th anniversary in Japan. This event is significant because it illustrates that RCA pioneered in establishing a buying office in Tokyo long before Japan became a successful supplier to world markets. From a one-man operation, RCA Purchasing has grown to a thriving function of approximately 30 Japanese specialists who provide purchasing services to RCA domestic divisions and subsidiaries (Fig. 1).

The mission

A multi-national corporation must buy overseas as well as sell abroad. Components, raw materials, and finished products produced overseas must be explored continuously and considered as a resource to assure that RCA purchases the best value on a worldwide basis.

Pursuant to this business concept, RCA's International Procurement activity, over the past twenty years, has provided international purchasing services on a worldwide basis. This activity differs from domestic buying due to differences in language and customs that are compounded by the physical distance from the manufacturer to the using location. Also, post-order services are more complicated because of letters of credit, export documentation and utilization of import brokers and ocean carriers. The main thrust of this activity is, of course, to locate foreign suppliers that produce goods of superior quality at lower cost.

Since 1967, Corporate Staff Materials has been assigned the basic charter for international procurement within RCA. In our term of reference, international or foreign procurement means the buying of goods and services overseas, outside the limits of the United States, Canada and Puerto Rico, generally for import into the United States.

Foreign procurement, as applied to a subsidiary company or feeder plant in another country, extends only beyond the geographical confines of that country. For example, when RCA Taiwan buys in Taiwan, it does its own buying. If it imports from Japan or Europe, RCA Taiwan uses the buying facilities of Corporate Staff Materials.

This Staff function is line-oriented in the sense that it provides procurement resources to Major Operating Units and foreign subsidiaries and feeder plants on an "as needed" basis.

The group's primary responsibility is to provide the buying resources, both personnel and physical sites, for exploring sources of supply and negotiating contracts in behalf of RCA locations. All U.S. divisions and foreign subsidiaries have direct access to foreign buying offices. In effect, the foreign buying offices are extensions of the local purchasing departments in sourcing whatever materials they wish (see Tables I and II). The final decision as to what to purchase offshore rests with the MOU or Subsidiary.

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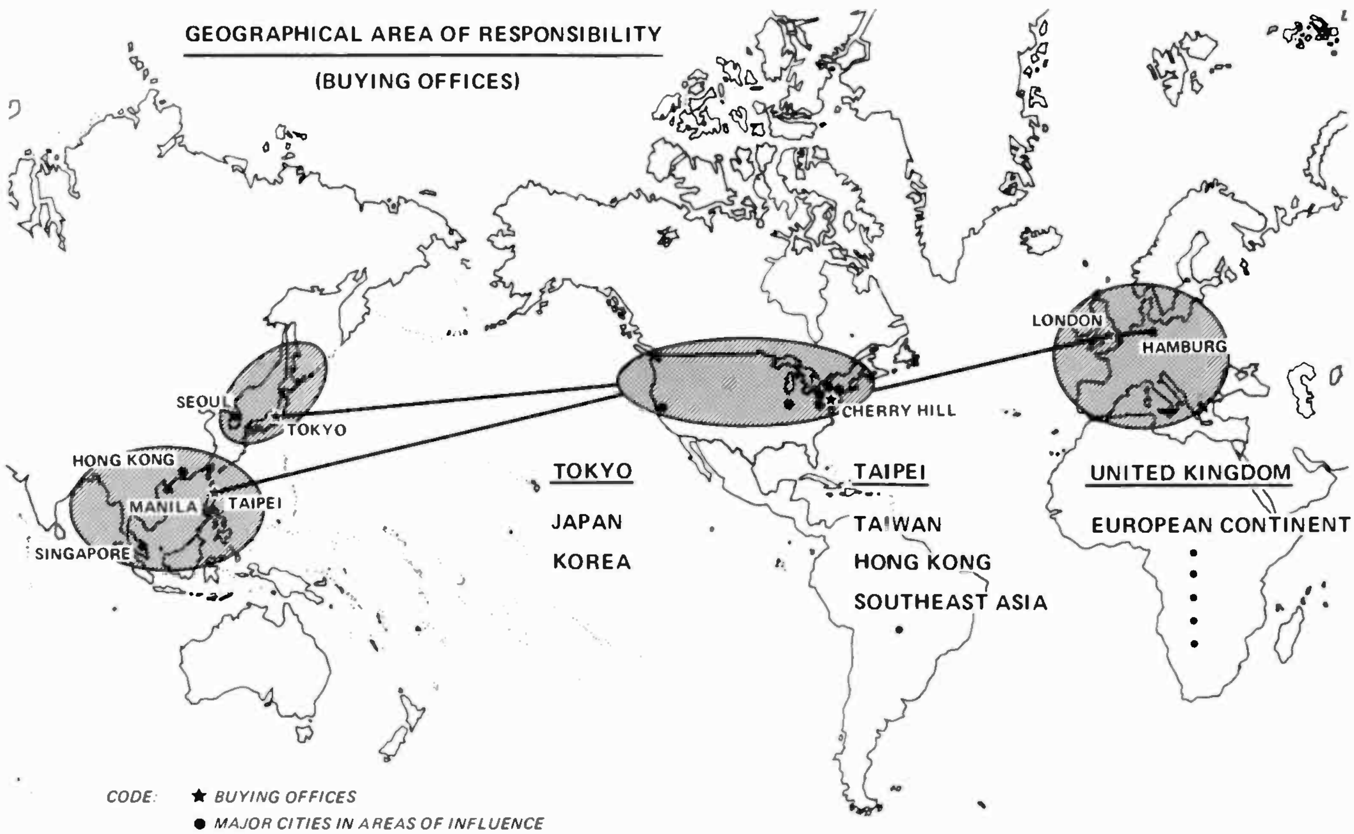

Fig. 1. RCA's International Procurement activity is centered in three overseas offices with a headquarters in Cherry Hill, N.J.

Table I. Where and what we buy.

Japan	*Taiwan Hong Kong Southeast Asia*	*Western Europe*
VCR (consumer)	TV reception aids	Special steel for PTD
VTR (broadcast)	FM converters	Broadcast support equipment
Saticon tubes	IC assembly	Optical sighting devices
Vidicon tubes	IC testing	Broadcast antennas
Optics	C—O cassettes	Traveling wave tubes
Auto radios	PC board assembly & test	Tooling
Car tape players	CCTV cameras assembly & test	Record presses
CCTV/monitors	Car tape players	Video disc presses
	AM/FM chassis	TV yoke cores
Wire bonders		Solder
Conveyor system		
Telephone switch		
Cathode ray tubes		
Electronic journalism VTR and editor		
Tooling		
Mobile radios		
Multitaps for CATV		
Cameras for VCR		
Castings		

Guidelines for operation

In directing RCA's overseas buying effort, the International Procurement activity is guided by objectives designed to exploit global procurement opportunities. These can be summarized as follows:

1. Be responsive to the needs of RCA by locating and developing offshore resources that reduce costs.
2. Monitor fluctuations in foreign exchange rates. Since most foreign commitments must be made in the currency of the suppliers' country, RCA must accept the risk of exchange fluctuations. In conjunction with Corporate Staff International Treasury Operations, recommendations are made for hedging the exposures in the future's market.
3. Coordinate RCA procurement efforts with other Staff functions involved in RCA's international business in the formulation of common business strategies.
4. Motivate and influence the Divisions to evaluate and take advantage of the best that is available on a worldwide basis.
5. Provide feedback on new product development or competitive products.
6. Identify future geographical areas with

potential for RCA by keeping abreast of the world marketplace.

7. Explore countertrade opportunities in Eastern Europe and other Socialist countries in behalf of those Operating Units seeking to expand sales in those countries.

Worldwide purchasing

Purchasing from Japan

Not surprisingly, most of RCA's offshore buying activity is concentrated in the Far East. Presently, RCA Purchasing offices are maintained in Japan, in Taiwan and in the U.K. The Tokyo function is also responsible for sourcing in Korea. The Taiwan buying office has responsibility over Hong Kong and Southeast Asia, including the Philippines, Singapore and Malaysia. The U.K. office services Europe.

In Tokyo, RCA Purchasing Company (or RCA Purco, as it is more commonly called) has served since 1959, as the agent of domestic divisions and subsidiary companies with vendors in Japan and Korea.

As Japanese wage rates escalated to the present level (70 percent of that of the U.S. and West Germany, plus 35 percent over that of Great Britain), it was assumed that Japan could be competitive on only the more sophisticated products. While it is true that the manufacture of some of the more common electronic components, such as fixed carbon resistors, has been shifted to other countries in the Far East, Japan has remained remarkably competitive on the bulk of the items used by RCA. The Japanese have made excellent use of the kind of automation which not only reduces cost but also improves quality.

RCA procurements from Japan have been extremely brisk and are well diversified across Major Operating Units. Consumer Electronics' purchase of video casette recorder equipment plus television components leads the way. However, major purchases have been made from Japan by a multitude of other RCA operations highlighted by helical-scan video tape recorders for Broadcast Systems, low-cost mobile radio for Mobile Communications Systems, and car-radio and tape-recorder products for Distributor & Special Products, multitaps for Cablevision Systems, hotel/motel radios for RCA Service Company, a wide range of components and capital equipment for the Solid State Division and color weather radar components for Avionics Systems.

Table II. Where and what we buy—electronic components.

Japan	*Taiwan — Hong Kong Southeast Asia*	*Europe*
Semiconductors	Fuses	Semiconductors
Fuses		
Integrated circuits		
Resistors	*Resistors*	*Resistors*
Carbon film	Carbon film	Carbon film
Variable	Variable	Variable
	Carbon comp.	
Wirewound		
Capacitors	*Capicitors*	*Capicitors*
Ceramic	Ceramic	Ceramic
Mylar	Mylar	Mylar
Mini 'Lytics	Mini 'Lytics	Feed thru
Mica	Large 'Lytics	Trapezoidal
Feed thru		Trimmer
Head lead		
Large 'Lytics		
Tantalum		
General	*General*	*General*
Antennas	Antennas	Transducers
Speaker magnets	Delay lines/balun	Knobs
Hookup wire	Coils	Coax connectors
Magnet wire	Speakers	
Laminates	Cans	Parts for semiconductors
Crystals	PC boards	• Stems
Lamps	Extrusions	• Shells
Transducers	Knobs	• Clip strips
Glass stems (photomultiplier)		

Purchasing from Taiwan and Southeast Asia

The Taiwan office of RCA Purchasing Co. was formed in November, 1972, with responsibility for the farflung geographical area of Taiwan, Hong Kong, and the rest of Southeast Asia. Development of component suppliers capable of meeting the stringent requirements of Consumer Electronics television components has been progressing at a steady pace.

Distributor and Special Products purchases both components and finished products while Electro-Optics has been very successful in assembling closed-circuit TV cameras in Taiwan. Hong Kong and Southeast Asia remain heavily committed to labor-intensive assembly, which in the electronics industry is currently centered in semiconductors. Other component suppliers capable of meeting RCA requirements have matured at a much slower pace than was originally estimated. The bulk of commitments for components other than the semiconductors remains centered in Taiwan.

Purchasing from Europe

On the other side of the world is the European Procurement office, physically located at RCA Ltd., Sunbury, England. The Sunbury operation, originally based in Geneva, has the responsibility for buying on the European Continent — a monumental task at best. Recent purchases have included the buying of components such as resistors and solid-state devices for Consumer Electronics, yokes for the Picture Tube Division, transistor components for the Solid State Division and capital equipment for several Major Operating Units, including automatic presses for RCA Records and "SelectaVision" VideoDisc Operations.

A new concept — "countertrade" or barter

A recent innovation in the responsibilities of International Procurement has been its role in providing assistance to Major Operating Units in exploring a concept,

new to the United States, called countertrade. Some countries of the world, chiefly those referred to as planned economy countries, (e.g., the Eastern European countries and the People's Republic of China,) are requiring or at least offering countertrade transactions as an alternative to payment in a hard currency (U.S. dollars) for the products and services purchased.

Countertrade transactions are those in which a seller provides finished products, machinery, equipment, technology and/or services to a buyer and contractually agrees to purchase goods from the buyer in an amount equal to an agreed-upon percentage of the original contract sales price. Countertrade transactions may occur in different forms and may appear under various names such as barter, buyback, swap, counterpurchase, compensation and switch. Under whatever name, a countertrade transaction is an acceptable business practice for meeting RCA's policy stated above, but only after all other means of conducting normal arms-length commercial transactions have been exhausted.

In concert with Staff International Marketing, International Procurement has provided guidance and assistance in exploring the various alternatives available to comply with the countertrade aspects of sales inquiries from such planned-economy countries as the German Democratic Republic (GDR) and Romania. This assistance includes exploration of buying opportunities in those countries as well as selecting trading house vendors (third parties) when foreign trade organizations impose requirements for the purchase of commodities RCA does not use.

Most of the planned-economy countries are not "most-favored nations" and accordingly must operate within high tariff walls. Consequently, they carry a duty rate which penalizes their imports into the United States — a resistor imported from West Germany, for example, has a six percent duty, but the same resistor carries a 35 percent rate if imported from the German Democratic Republic. This situation could change if most-favored nation status is ultimately granted to the Soviet Union, and other Socialist countries.

Conclusion

In general terms, the electronics industry in foreign countries continues to grow rapidly, facilitating opportunities for RCA to expand its base of offshore suppliers. In our judgment, Singapore and the Philippines are the next areas to watch in the Far East. Korea may offer limited opportunities in selected products, but its high inflation rate and its own domestic demands limit opportunities.

The People's Republic of China, which as we go to press, has been granted most-favored nation status, and the Eastern European Bloc of countries must be considered for the future because of the importance of two-way trade. But Japan, Taiwan, and Europe will continue to provide the majority of the opportunities in the challenging world of international procurement for years to come.

Not everything, obviously, can be bought overseas. However, the foreign marketplace must be routinely tested to be assured that RCA obtains the best value for the materials it purchases on a worldwide basis.

Nick Di Orio, Director, Corporate Contracts and International Procurement has been with RCA for 27 years, having started with the RCA Service Company in 1952 as a methods analyst, and later as Manager of Systems and Procedures. He was transferred to the International Division of RCA in 1956 where he served in various capacities, including Manager of Purchasing. Since 1963, Nick has been a member of Corporate Staff Materials. In 1967, when RCA's International Division was restructured, the International Procurement's function was transferred to Corporate Staff under Nick.

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On October 11, 1979, RCA Purchasing Co., N.V., a Branch of an RCA subsidiary in Curacao, celebrated its 20th anniversary in Japan. The celebration was held at the Hilton Hotel in Tokyo and attended by eighty RCA employees, mostly Japanese. The visitors included representatives and spouses from the RCA domestic divisions, Purchasing Company, Research Labs, Inc., and Engineering Labs, Ltd. This event is significant because it illustrates that RCA was a pioneer in establishing a buying office in Tokyo.

E.O. Johnson

RCA's Tokyo Research Laboratories—unusual situation, unusual results

"Small is beautiful."

E.F. Shumacher

An unusual situation...

The phrase "Small is beautiful" was not initially coined to describe research laboratories, but it applies well to RCA's Tokyo Research Laboratories. With a staff of only 36, it is rather unusual. With a Japanese staff, an American director, and a home office half the globe distant, it is quite unusual.

...has its advantages

The laboratories have a number of assets. First, their relatively small size is rather ideal with respect to personal interaction, particularly for the director, who is forced to practice "hands-on management" on virtually all matters. Another unique feature is the enthusiastic "can do" environment of Japan. This feature is evident in the cooperative spirit of the laboratories personnel to work long hours with diligence and perserverance, and with the vendors who supply product and services. Another advantage is the close proximity of the RCA Engineering Laboratories in Tokyo. This group is skilled in circuit and applications technology of the commercial world, and provides almost daily assistance in evaluating the practical performance of many of our materials and devices. Their enthusiastically cooperative assistance is indispensable in maintaining our coupling with the commercial world.

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...and disadvantages

As with all situations, there are also disadvantages. Perhaps the most severe of these is the long communications link with the home office in Princeton. But this is overcome to some degree by frequent letters, reports, telegraph and telephone discussions, as well as by staff visits to Princeton. And, sometimes, a problem can be an opportunity, or even an advantage. We tend to document our activities and thoughts more than perhaps is usual, and with a heightened awareness of the need to keep descriptions and developments simple; with so many kilometers of intervening ocean and continent there is less chance to straighten out matters verbally back at the home office.

Language is indeed a formidable problem in communicating with the all-Japanese staff. For an American, by actual measurement, the Japanese language is roughly ten times more difficult to learn than major European languages. Former directors, as well as myself, could lecture for hours on this subject, one we have all grappled with every day. Were it not for the long language training of the Japanese staff, and their patience and understanding in bridging two cultures, we would surely be severely handicapped.

Hopefully, someday a good book will appear describing the relatively few people of the world who have served to bridge the world's more difficult interfaces. In today's shrinking world, their importance is immense. But so few people exist who have this intellectual and cultural bandwidth! The RCA staff in Japan is outstanding in this regard.

A somewhat unexpected advantage of our communications problems is the frequent contact with visitors from RCA operations in other parts of the world. Tokyo is a focal point for this and helps us keep abreast of various projects within RCA. One, for example, is an effort between RCA and Fujitsu to develop reliable field effect transistors (FETs) to replace travelling wave tubes in future communications satellites.[1] Our role in this effort is to provide a local cross-check on the reliability inspections.

Research projects

In addition to the research and development (R&D) projects described below, the laboratories provide administrative support for resident patent services that tie into the Princeton Patent Operations.

Piezoelectrics

Our background in this field enabled us in 1975 to recognize the significance of new developments in Japan with the polymer PVF_2 used in some fishnets. This material is mechanically extremely tough and, when properly polarized, displays piezoelectric properties almost equal to those of the piezoelectric materials, such PZT and quartz, widely used in the electronics industry for audio record pickups, microphones, and signal filters. Whereas PZT and quartz are stiff and brittle, piezoelectric PVF_2 is mechanically flexible and can be made into a variety of interesting new devices based on bimorph action.[2]

One such device has been under study as a replacement for the electromagnetic device used as the motion transducer in the RCA VideoDisc "Armstretcher." The advantages with the PVF_2 device are its postage-stamp size and weight, and its potentially low cost.

Another such device is a wing-type fan reminiscent of the ancient Oriental hand fan (*uchiwa*). When driven by a low-frequency ac voltage, a fan with wing dimensions of the order of several centimeters can pump about 5 liters of air per second. Construction is very simple, and reliability should be good. Two such fans can circulate enough air to adequately cool electronic components in a cabinet volume of a few cubic feet, even with sealed louvers. Power consumption is only about 30 milliwatts because the electrical-mechanical conversion efficiency is unusually high (~50%) compared to that of electrical motors of comparable size. We understand the operation and optimization of such fans in considerable detail. This optimization includes economy of material for a given performance.

The Japanese inventive spirit may seem a bit unusual to the American engineer. Given the assignment of finding uses for a new product, the design team came up with an excellent solution to a problem, but without using the new product!

Various other motion, or motion detection, devices have been demonstrated including numeric displays with both large (~10 cm) and small (1 cm) characters. And recently, a new type of piezoelectric rotary-motion motor was demonstrated. This is of interest, possibly for space applications, because of its simple construction, light weight, electronic control flexibility, and possibly high efficiency.

Piezoelectric applications: skylight shutter

We have personal knowledge of how practically difficult it is to control the outside light coming into a room when the window or skylight is located in the ceiling or some other physically inaccessible place. In thinking about this, we thought of using large strips of the piezoelectric polymer PVF_2 in a multi-element venetian-blind-like array (Fig. 1). When each laminated bimorph strip is mounted along one long edge and supplied with a voltage, the strips could be made to lie flat and block out light, or to bend up and let in outside light. This was an attractive, all-electronic, arrangement that eliminated the usual troublesome ropes, pulleys, and other mechanical contraptions.

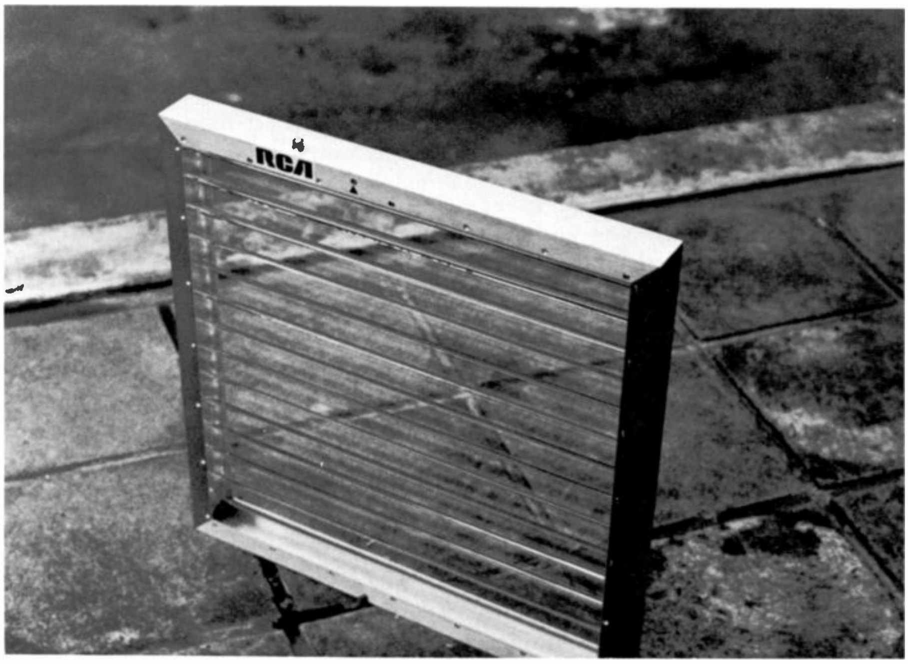


Fig. 1. Large strips of the piezoelectric polymer PVF_3 were used in this multi-element venetian-blind-like array.

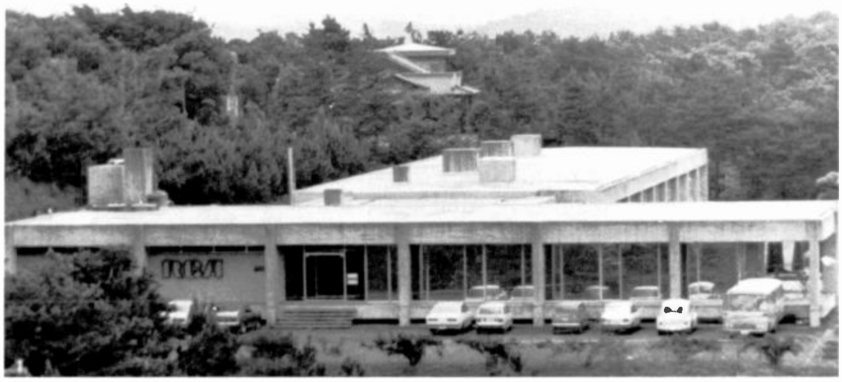
A small 10 x 20 cm^2 demonstration array was made for the APC Corporation, an RCA subsidiary which markets dome skylights for home and industrial markets. The power required to open and close this crude first model was exceedingly small (milliwatts) and could be supplied with a small solar array provided by Princeton. We were then asked by an interested APC to investigate the material problems posed by more practical arrays of the several square meters in size. We quickly discovered cost, quality, and vendor-supply problems that appeared insurmountable in any short time period. But, as so often happens, seemingly insurmountable problems lead to new and much improved approaches. In this case, the Japanese environment was a distinct advantage: first of all, there was a traditional background in paper-like technology and all that this implies in terms of light weight, low-cost materials, and a simple technology. And, second, there was no concern about NIH (not invented here), a well-known affliction of many Westerners.

But, I was more than a little dubious when I saw half-mm-thin aluminum material being formed into long shutter blades. These appeared so fragile that perhaps even an evening breeze might blow them away. However, when a large array of wire-pivoted blades was assembled into an aluminum frame, and protected with a thin plastic dust shield, the combination was surprisingly rugged. The light mass of each blade, about 2 grams, makes them largely immune to shock effects, and dramatically reduces bearing friction, wear, and structural problems. Furthermore, a motive force of only about ten grams is necessary to open or close an array a square meter in area. This opens new options for the motional control system; it can operate from small batteries, or even solar cells, without any need for relatively costly and troublesome connections into the ac power line. Four penlight cells are estimated to drive a square-meter array under manual or automatic control for about one year.

The batteries and control circuitry are contained in a wall-mounted control box connected to the skylight or window by wires that carry only milliwatts of power.

The required motor drive power is so small that even the smallest commercially available electric motors can supply it with ease. Alternatively, the mechanical motion can be supplied with a piezoelectric bimorph arm using either PVF_2 or commercially available PZT. However, the standard small electric motor seems like the best choice at this time because of ready availability and the simplicity of the accompanying circuitry. This is an interesting result; the much-beloved materials and devices that initiated the project have all been designed out, apparently without the slightest trace of NIH feelings. The end objective of a practical system is what mattered.

The piezoelectric effort is considerably broader than briefly noted in these two sections. It covers material studies aimed at understanding material optimization, particularly with regard to electrical polarization and non-uniformity effects. The work with the fans has led to a simple and more revealing means to measure the material's stiffness parameter (Young's modulus). Results show unreported anomalies in the PVF_2 material that can have a significant effect on the behavior of a wide range of different devices. In another realm of the piezoelectric field, we have demonstrated in considerable detail very high energy density surface acoustic waves, and are now exploring their application in programs of company interest.



This laboratory is located southwest of Tokyo, almost halfway to famous Mt. Fuji, whose beautifully symmetrical snow-covered slopes have long been a symbol of Japan. The laboratories were moved here in 1968 from the center of Tokyo to reduce staff commuting and living inconvenience, as well as to provide materials-handling facilities unavailable in city office space. The laboratories are located in Japan because of long-term RCA business relations in this part of the world, and the recognition of the technical and commercial potential of the country.

Luminescent materials

The largest of our other programs concerns development of luminescent materials for kinescopes. Present emphasis with color-TV phosphors is on surface-layer behavior, a hitherto relatively neglected area of study. Studies involve surface chemical composition as probed by Auger measurements, and the effect of particle surface-to-volume ratio as affected by particle size. We have developed an experimental technique to separate phosphor particles according to their size. And by a new phosphor-preparation technique, first disclosed in Asia, we have succeeded in substantially diminishing a surface-related problem that has held back commercial use of a promising new phosphor. Although considerable work remains for us to understand this result, as well as others of this type, we are increasingly confident of eventual success.

All of the Tokyo Laboratories' 36 personnel are Japanese, with the exception of the director. The technical staff has shown great adaptability, as the purpose of the laboratories has shifted in the twenty years since their founding. At their inception in 1960, the Tokyo Research Laboratories focused on fundamental research in solid-state materials, particularly regarding magnetic, optical, and microwave properties. This is perhaps best exemplified by their pioneering work into plasma oscillatory effects that promised a new class of high-frequency devices. But these promises, along with many others in the device world of the 1960s, were pre-empted by the now-ubiquitous transistor. Furthermore, the laboratories were too small to compete in transistor or IC development. Accordingly, effort was redirected toward technical domains in keeping with available skills and, also, increasing industry emphasis on commercial applications. The primary skills available are in materials preparation, measurement, and analysis, with an additional strong background in piezoelectric and acousto-electric phenomena.

In the course of our luminescence work, we discovered a new family of luminescent glasses that have a surprisingly high luminescence efficiency when illuminated with ultraviolet (UV) or X-rays. These have promise for X-ray intensifier screens, and possibly also for tomography because of their relatively high efficiency, and shape and size flexibility, compared with crystalline phosphor materials. Close relations with Japanese university personnel have enabled us to carry out supporting measurements without investing in special equipment.

Soldering

In another field of importance to RCA, soldering, we are developing measuring techniques and using them to help unravel phenomena that, so far, have mostly had only empirical treatment. Increasing component density and reliability requirements demand an improved basic understanding of the solder parameters of surface tension, viscosity, composition, temperature, and impurity effects. The long-term goal is this improved understanding, as well as the development of simple measuring techniques that can be used in production, and yet will reveal key static and dynamic parameters. Some progress on this has been made. Although, at first glance, the field of soldering might appear technically uninteresting, it is in reality very interesting and challenging from both an engineering and scientific viewpoint.

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Ed Johnson has been director of the RCA Research Laboratories in Tokyo since 1975. Previously, he was Manager of Technical Liaison for International Licensing. He has worked extensively in the fields of semiconductor devices, optoelectronics, and gas-discharge displays, and has received two RCA Outstanding Achievement awards for his research.

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"Software for Real-Time/Engineering Systems" reprint now available in RCA libraries

The Missile and Surface Radar (MSR) reprint, "Software for Real-Time/Engineering Systems," is now available for your review at all RCA libraries. Additional copies may be secured by contacting Frances Bucalo, MSR, Moorestown, N.J., ext. 3644. Authors and titles included in the reprint are:

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S.A. Steele	"Characteristics of managing real-time software development for military systems"

W.J. Merz|R.A. Mills

RCA's Zurich laboratories— fundamental studies and applied research

Work at this European laboratory ranges from basic studies on light scattering to inspection machinery for IC production to television circuit design.

Abstract: *RCA's Zurich laboratories work on projects ranging from the fundamental to the practical. Light-scattering research, for example, is fundamental, but has produced automated optical testing machinery for integrated-circuit production. High-resolution pattern transfer by dry etching is another research project that has direct application in IC manufacturing. In the area of engineering, the laboratories have recently done work on picture-tube arcing and automatic background-color balance for TV receivers.*

In 1955, RCA established in Zurich, Switzerland, Laboratories RCA Ltd. for the dual purpose of conducting fundamental and applied research within the European scientific community and of furnishing technical service to RCA's European licensees. During their 25 years of existence, the laboratories have grown into a stable, well respected technical center of RCA. It is a truly European operation, staffed by Europeans, located in the center of Europe, and in close contact with European industrial, government, and university laboratories.

The research activity, which reports to the RCA Laboratories in Princeton, consists of 21 members of technical staff and 22 research technicians and is directed by Dr. Walter J. Merz. The licensee and engineering activity, which reports to Corporate Licensing in New York, consists of 13 members of technical staff and 5 research technicians and is directed by Ronald A. Mills. The general administration is headed by Konrad Troesch.

Research

W.J. Merz

The projects in research are closely coupled to the research work at the laboratories in Princeton and to certain technical problems in some divisions, in particular Solid State Division (SSD), Consumer Electronics (CE), and Picture Tube Division (PTD). The broad technical activity is centered around solid-state physics and optics. In the beginning the work was almost completely devoted to fundamental studies which brought us to the forefront of physics research in a number of fields. The laboratory became a well-respected group in the European scientific community. During the last few years, the situation has changed somewhat, as we now have a more balanced activity between fundamental and applied work. On the one hand, we study materials and processing techniques by fundamental methods. On the other hand, we are working on device developments and applications useful to the divisions. This has led to a closer interaction with the divisions; a number of projects are progressing by almost daily direct discussions with people in the Princeton Labs and some divisions. Since it is impossible to describe all the current activities here, we will discuss three projects showing the wide range of work done at the laboratories. The three projects are:

- "Optical methods for testing," a project with very practical applications;
- "High-resolution pattern transfer by dry etching," a technological subject; and
- "Light scattering as a tool in research and applications," a project of a more fundamental nature.

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Optical methods for testing

The purpose of this project is to develop instruments to routinely measure critical parameters in silicon devices and kinescope masks by optical means during processing. Such on-line measurements should give considerable yield improvement. The project was started about 3 years ago when it was realized that our experience in sophisticated optics, acquired over many years, could be applied to routine optical wafer and mask inspection and control. As

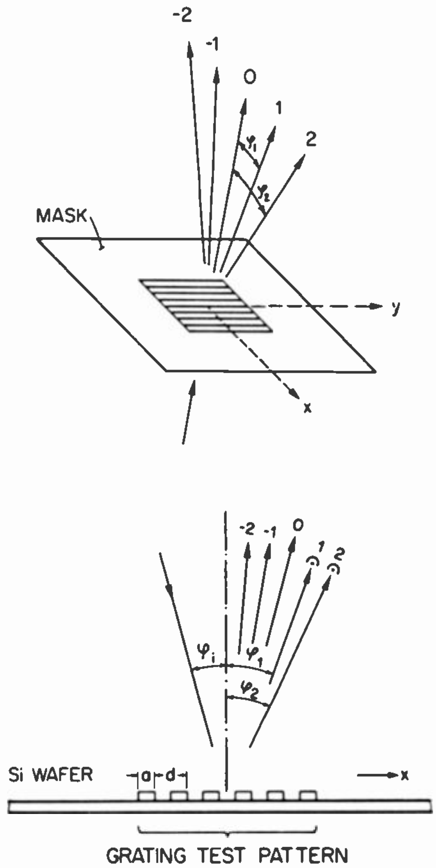


Fig. 1. Linewidth (a) measurement is done optically by measuring the relative intensities of first- and second-order diffracted light. In measurements for masks (above), light is transmitted through; in wafers, light is reflected.

a result of this work, the following instruments have been designed, built, tested, and introduced into various places in RCA.

Linewidth measurements

Since line dimensions in ICs are approaching 1 micron, sophisticated methods are required for producing and controlling critical parameters such as width and profile of the lines. For this reason we have built a setup which monitors linewidth quickly and automatically by diffracting a laser beam on a grating located at a special place in the mask or on the wafer. By measuring the ratio of intensity of the first- and second-order diffracted light, one obtains a direct measurement of the linewidth *a* of the grating test pattern as schematically shown in Fig. 1. Thus, after each etching step, one can control this critical parameter. A completely automated machine was built for SSD in Somerville in order to test linewidths in chrome masks in conjunction with the MEBES electron-beam machine. Figure 2 gives a general view of the setup. A similar machine for linewidth control on wafers is being tested at SSD. In contrast to the machine for mask tests, which operates in the transmission mode, this machine works in the reflection mode. It is likely that a number of these machines will be built in the near future, for IC wafer control.

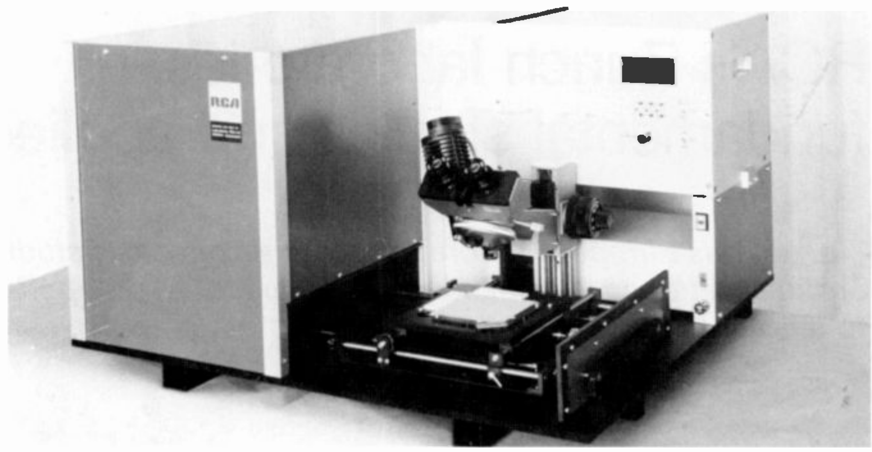


Fig. 2. Automated optical linewidth-measuring setup now in use at the Solid State Division.

Automatic mask aligner

By using the same technique of diffracting a laser beam on a grating located on the wafer, we built and set up an automatic proximity aligner for SSD in Somerville. In Zurich, we have also built a projection aligner using the same principle. By measuring the intensity of the diffracted light from a set of four gratings of different orientation, one can monitor the alignment of a mask with the wafer quickly, precisely, and automatically. The purpose of our test model was to show the feasibility of a new concept. Since these machines are relatively involved, we will not carry the design any further. However, a number of test-equipment manufacturers have shown great interest in our design and may build machines under license.

Light scanner

Our fundamental research on light scattering (see below) has led us to develop a tester which can determine the type of imperfection present on silicon wafers—dust particles, scratches, and pinholes. The method is based on light scattering of a laser beam. By scanning the wafer, one can display the variation of scattered light on a storage oscilloscope, thus, measuring the quality of the wafer surface directly. One light scanner has been in operation at SSD's Mountaintop plant since June, 1978 and works very well, and four more

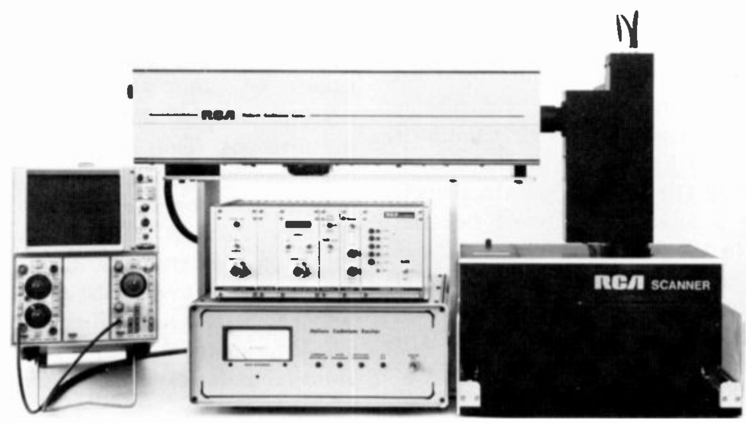
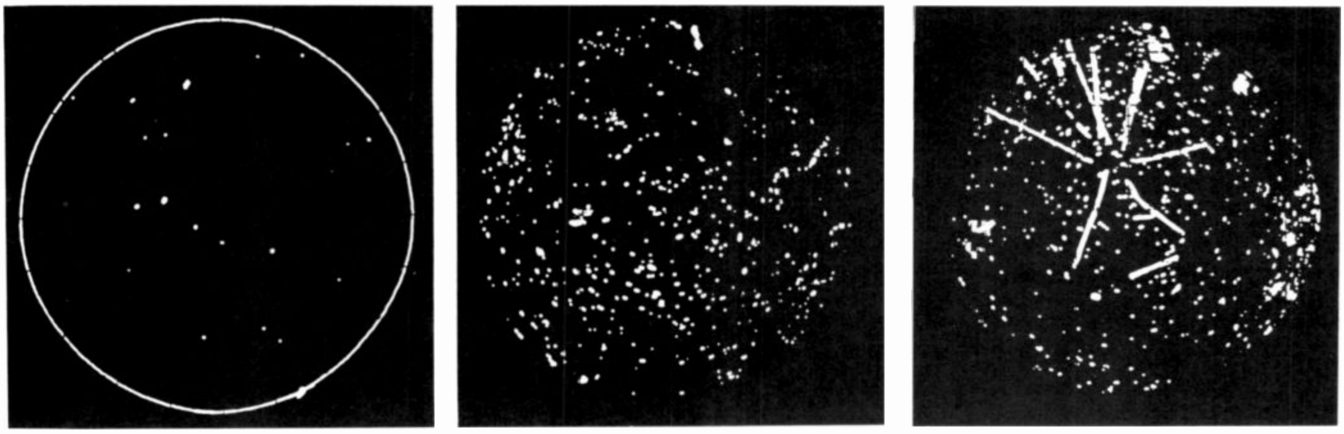


Fig. 3. Wafer surface testing is done routinely by this scanner. Storage oscilloscope at left contains output; see Fig. 4 for typical displays.



Clean Dirty Scratched

Fig. 4. Scanner output quickly determines quality of wafer surface.

scanners were delivered to Princeton, Somerville, and Lancaster for wafer-testing integrated circuits (ICs), silicon-on-sapphire (SOS) ICs, and charged-coupled devices (CCDs) (Fig. 3).

All five scanners are now being used routinely. Figure 4 shows the results from a clean wafer, a dirty wafer, and a wafer with scratches. Because of the great interest in the scanners, we are building more, especially for SOS production control. Furthermore, since it could be shown that masks can be tested for pinholes, besides dust particles and scratches, we are also designing a machine for chrome mask control for the MEBES machine in Somerville.

Film thickness monitor

An extremely simple film-thickness monitor (Fig. 5) was built for Princeton, Somerville, and Mountaintop. Comparing the unknown optical thickness of one film with the optical thickness of a wedge-shaped calibration standard in a fully automatic way, one can determine the thickness of the sample in a few seconds. The range of usefulness is between about 1000Å and a few microns, with a precision better than ±10Å. The instrument was found to operate very satisfactorily on the following systems: SiO_2 on Si, Si on sapphire, SIPOS on sapphire or quartz, photoresist on chrome, and TiO_2 on glass. In other words, this instrument will be of great use for IC work. Also, photoresist on steel for kinescope mask manufacturing was found to work. This monitor's simplicity, its low cost, and speed of measurement are so impressive that we have received many requests (more than two dozen) for an instrument from groups within RCA. Figure 6 shows its principle of operation.

White light from an incandescent lamp is reflected successively from a circular wedge (of SiO_2 on Si) and from the unknown film. Due to interference within the SiO_2 wedge, a certain set of wavelengths is strongly reflected from the wedge, depending on its thickness. Generally, this set is not the same as the set of wavelengths strongly reflected from the unknown film. If, however, the unknown film has the identical thickness, then it will reflect precisely the same set of wavelengths and so the signal V_1 measured by detector D1 will be a maximum. The wedge is rotated uniformly, thus varying its thickness, and the point in the rotation at which the maximum in V_1 is observed then determines the unknown film thickness. (A second detector D2 normalizes the output signal, but is not essential for understanding the principle of operation.)

Silicon growth rate monitor

An optical interterferometer is being used to measure the in-process growth rates of silicon film (for example, epi silicon on sapphire). Tests are being made at RCA Laboratories, Princeton, in conjuction with new rotary disk reactor, and all new reactors are planned to eventually be equipped with this interferometer. This instrument operates by simply counting interference fringes, which then gives the thickness of the deposited film as a function of time when the refractive index is

Fig. 5. Film-thickness monitor determines the thickness of a sample in seconds.

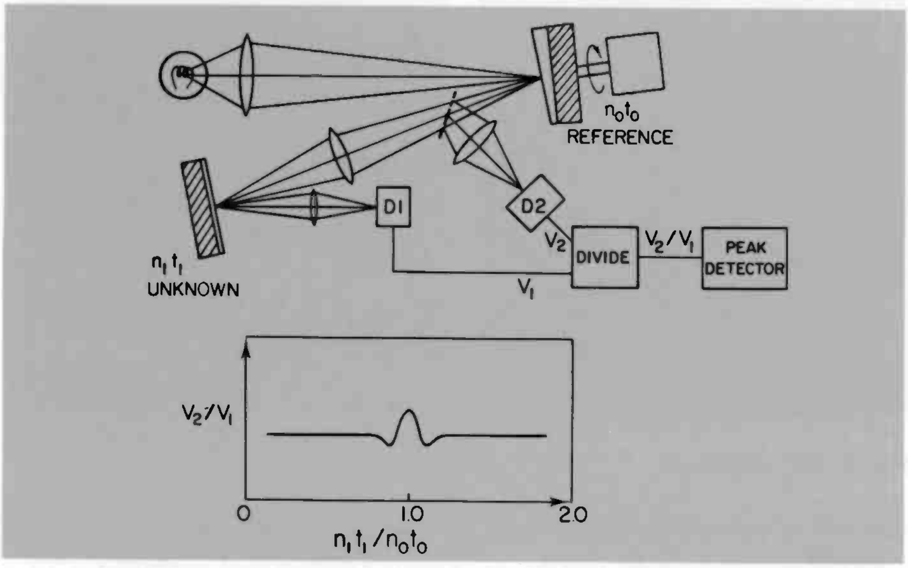


Fig. 6. Film-thickness monitor works by reflecting light off-reference and sample, then comparing the voltage outputs (V_1 and V_2) of detectors (D_1 and D_2) sensing the reflected set of wavelengths from each. Reference is wedge-shaped, and is rotated until the quotient V_2/V_1 is a maximum, indicating the thicknesses are equal.

known. Thicknesses up to about 30μm can be controlled.

High-resolution pattern transfer by dry etching

Problems with wet etching

Advances in modern lithographic techniques for silicon integrated circuits have dramatically reduced the feature size in resist films. By using electron-beam or X-ray lithography, features with micron and submicron dimensions can be defined in radiation-sensitive resists. Conventional wet-chemical etching can no longer be used for the pattern transfer because its isotropic nature usually produces severe undercutting. Dry etching is rapidly gaining acceptance in the microelectronics industry because of its inherently better resolution.

Our work on dry etching started a few years ago during the Zero Order Diffraction (ZOD) microfiche program. We were required to transfer square wave gratings from photoresist onto an underlying substrate; the grating periods were typically of the order of 1 to 5 microns and the required depths were between 1 and 2 microns. None of the techniques known at that time was suitable to obtain the required resolution — wet chemical etching yielded badly undercut structures and conventional rf-sputter etching of SiO_2 in Ar gave faceted structures with linewidth/space ratios distorted by redeposition.

Dry etching success

However, substituting a fluorinated hydrocarbon like CF_4 or CHF_3 for Ar, produced a high-fidelity pattern transfer. Etchings produced by this process are highly anisotropic because of the strong directionality of the incoming ions. The process also has no redeposition effects because the reaction products of the CF_4-plasma and the SiO_2 (SiF_4 and CO_2) are all volatile and are pumped away by the vacuum pumps. Figure 7 shows a scanning electron microscope (SEM) micrograph of a 1 micron periodicity square wave grating etched into SiO_2 in a CHF_3 plasma. The linewidth is 0.3 microns, the depth 2 microns. Figure 8 shows an SEM micrograph of two superimposed square-wave gratings etched subsequently into SiO_2. The periodicity in this case is 3 microns and the depths of the two patterns are 1.4 and 1.8 microns.

Dry etching in IC manufacturing

This reactive sputter-etching process used for etching ZOD patterns is obviously of great interest for IC-manufacturing. Here, we have the additional requirement that the process also has to be very selective — the etch rate for the SiO_2 layer should be fast, but minimal for the underlying Si. We found that reactive sputter etching in CHF_3 is highly selective: although the etch rate for SiO_2 and Si_3N_4 is 300 Å/min, it is only 20 Å/min for Si. Therefore, this process can directly be used to etch contact openings in dielectric films on Si. Figure 9 shows an SEM micrograph of such a structure in which we have etched through approximately 0.5 micron of SiO_2 and 0.1 micron of Si_3N_4.

Structures with very steep sidewalls are desirable, since they allow high packing densities to be obtained. However, continuous metal step coverage over vertical sidewalls is extremely difficult to achieve. Therefore, it is highly desirable to tailor the slope angle of etched structures according to a particular requirement. We have developed two methods which can be used to vary the slope angle of single-crystal Si, poly-Si, and SiO_2 anywhere between 25 and 90 degrees.

The first method consists of using a "reactive" mask for etching. Normally, one likes to work with "non-reactive" masks, which do not change their dimensions during etching. A "reactive" mask, however, changes its dimensions: it becomes thinner and narrower during etching. This lateral shrinkage produces sloped sidewalls in the substrate.

Another method of producing sloped

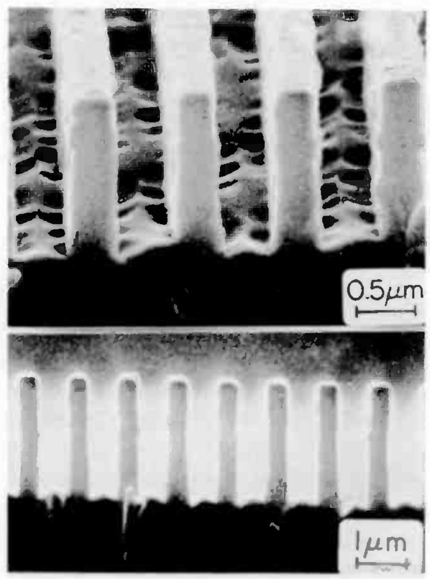


Fig. 7. SEM picture of a square wave grating with 0.3 micron line width and 2 microns depth.

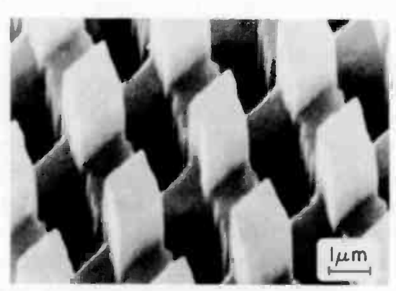


Fig. 8. Dry-etch pattern has periodicity of 3 microns, depths of 1.4 and 1.8 microns.

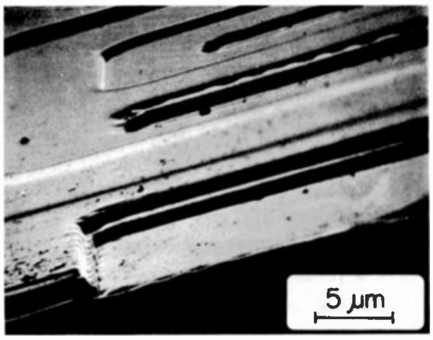


Fig. 9. Selective etching is possible with dry etching. SiO_2 was etched 0.5 micron, Si_3N_4 was etched 0.1 micron.

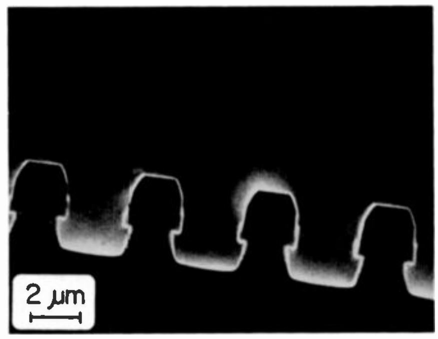


Fig. 10. Tailor-made sloping sidewalls were produced by dry-etching.

sidewalls consists of working with "controlled undercutting" by etching in a gas which — if undiluted — leads to a large amount of undercutting. If we now dilute this "reactive" gas with a large amount of "inert" gas, we might get a large anisotropic contribution caused by the sputter-etching effects of the inert gas. Sloping sidewalls in single-crystal Si have been produced in a mixture of SF_6 ("reactive" gas) and N_2 ("inert" gas). Depending on the concentration of SF_6 in N_2 slope angles between 65 and 90 degrees can be obtained. Figure 10 shows an SEM micrograph of a square-wave grating structure with a periodicity of 5 microns etched into (100)-Si in a mixture of 85 percent N_2 and 15 percent SF_6. The etch mask in this case was SiO_2.

These examples illustrate the potential of dry etching for high-resolution pattern transfer. In our present and future work at the Zurich laboratories, we are concentrating on improving the selectivity and profile control of the various etch processes. We are working closely with SSD and advising them on introducing dry etching into manufacturing. We hope that this project will also help improve integrated-circuit yields.

Light scattering as a tool in research and application

Light scattering using advanced laser technology is one of the best techniques for studying vibrational spectra and magnetic and electronic excitations in solids. The vibrational excitations of a crystal consist of acoustic phonons and optical vibrations in which the atoms of a unit cell move against each other. The coupling mechanism between the electromagnetic radiation to the lattice vibrations can result in direct absorption of light by phonons or in scattering of light by phonons. This scattering can be inelastic, with the scattered photon of different energy, or elastic, with no change of photon energy.

There are two experimental techniques: *Raman* scattering, which measures the inelastic scattering of light from optical lattice vibrations, and *Brillouin* scattering, from acoustic vibrations. Experimental observations of scattered light require high spectral resolution and high contrast. In Raman scattering this is achieved by a triple spectrometer. In Brillouin scattering new concepts have been developed at the Zurich laboratories. One method is the multipass technique, in which the beam of scattered light is passed up to five times through a Fabry-Perot interferometer, thereby increasing the contrast by about six orders of magnitude. More recently, a tandem arrangement of two multipass interferometers of different free spectral range has been developed, yielding a much larger total free spectral range.

Recently, we have investigated materials which undergo electrically-driven phase transitions, the so-called Peierls transitions in nearly one- or two-dimensional systems. Below the transition temperature, a periodic lattice distortion along the chain of the linear chain salt $K_2Pt(CN)_4Br_{0.3} \times 3.2\ H_2O$ and within the plane of $2H\text{-}TaSe_2$ can be observed, giving information about the nature of the phase transition.

Thanks to the above-mentioned newly-developed Fabry-Perot interferometer, we are able to study other kinds of excitations in highly light-absorbing materials, such as acoustic magnons or spin waves in magnetically-ordered crystals. Many materials, for example GaP and Si, were found to show a previously undetected mode of quasi-elastically scattered light, although these materials do not show a phase transition. The typical spectrum shown in Fig. 11 was measured on a polished silicon surface and shows light scattered from longitudinal and transverse bulk sound waves (L, T), from surface sound waves (R), and also the new broad feature, which is interpreted as being caused by light scattered from entropy fluctuations.

The existence of our high-sensitivity interferometer opens up a number of new investigations in solid-state physics. For this reason, a number of well-known research institutes are working together with us in the study of new phenomena.

In addition to its use in fundamental research, light scattering can also be put to use in practical applications. For example, small-area carrier concentrations in semiconductors can be determined without contact by using light scattering from free carriers. A second example employs the effect of elastic light scattering from imperfections or defects located on silicon wafers or chrome masks — the method used in the light scanner described in an earlier section.

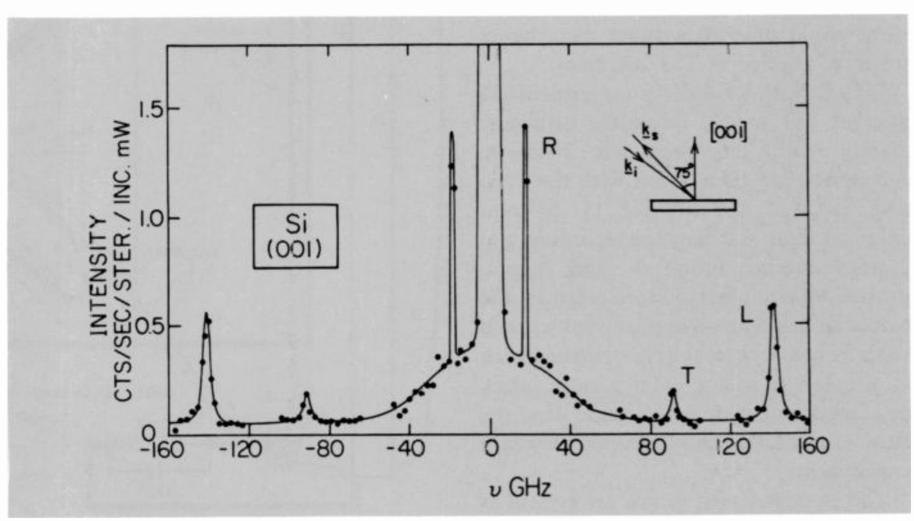


Fig. 11. Highly sensitive interferometer makes this plot of light scattering in silicon possible. Broad scattering feature was previously undetected.

Engineering

R.A. Mills

When the laboratories in Zurich were established in 1955, the engineering activities comprised a Technical Service Laboratory (TSL), whose primary tasks were to disseminate technical information on new developments or new services originating within RCA to all RCA licensees in the consumer electronics field and consult with licensees to help solve their particular engineering problems. The latter service is entirely confidential between TSL and the individual licensee. In the early days of the Zurich laboratories, there was considerable interest by European consumer-electronics companies in the technical developments taking place within RCA in this field. It was then a relatively straightforward job to take this raw information and to condense it into a form that was meaningful to the European industry. The information was then presented to RCA licensees either in report form or at specially organized symposia.

By the mid-1960s, the specific interest of European licensees had diverged considerably from the engineering trends in the U.S.A. Europe was standardizing on the Phase Alternation Line (PAL) and sequential á mémoire (SECAM) color-television systems, as opposed to National Television System Committee (NTSC), and there were many other differences in the design objectives for receivers. As a result, more and more advanced development work was required to be done in Zurich to permit a high level of support for licensees. A Development Group was established so that the advanced development could proceed without disturbance from the routine of TSL activities.

Liaison with RCA divisions resulted in a number of special projects, originally mainly with the Broadcast Division. Assistance has been given with the PAL and SECAM circuitry for 11 different color cameras, 4 video tape recorders, and various studio monitors and signal-processing equipment. More recently, the emphasis has been on applications work to support new technical developments, such as wide-angle in-line color picture tubes, new semiconductor devices and ICs, the RCA VideoDisc, and Teletext/Viewdata experiments.

The examples that follow are typical of the broad spectrum of Zurich laboratories' work, chosen to illustrate work on specialized measurement techniques and circuits for color receivers.

Simulating picture-tube arcing

Problems with flashovers

Flashovers occasionally occur in a television picture tube, discharging a large amount of stored energy and possibly causing sensitive receiver components to fail. When flashover occurs, the capacitor, composed of the inner and outer aquadag layers on the glass cone, is very rapidly discharged — discharge currents in the range 300 to 1300 A peak, with di/dt values of 6000 to 25,000 A/μs, have been measured. These very fast, high-amplitude current pulses produce interfering currents and voltages that may attain destructive values in the conductors of printed circuit (PC) boards and at the semiconductor devices themselves. Furthermore, since the discharge current flows through the center of the deflection yoke, interfering voltages are also induced in the horizontal and vertical deflection coils, which may add to the voltages mentioned previously.

Picture-tube manufacturers have made significant progress in reducing the incidence of arcs by improving the electron-gun structure. Also, by increasing the internal resistance of the tube, the peak amplitude of the discharge current has been reduced to below 100 A. However, improvements and testing go on, so it is still necessary for the receiver manufacturer to have a reliable and repeatable method of simulating a picture-tube arc and appropriate procedures for measuring the resulting discharge currents and disturbances in the chassis.

Triggered flashover generator

Spark gaps have been used for a number of years as a means of simulating the effects of flashover in picture tubes. The various types of spark gap were placed above or alongside the TV receiver under test; consequently, the lead inductance was appreciable. Every additional centimeter of lead length influences the discharge current, as can be demonstrated by measurement with a fast storage oscilloscope. The conditions with this type of

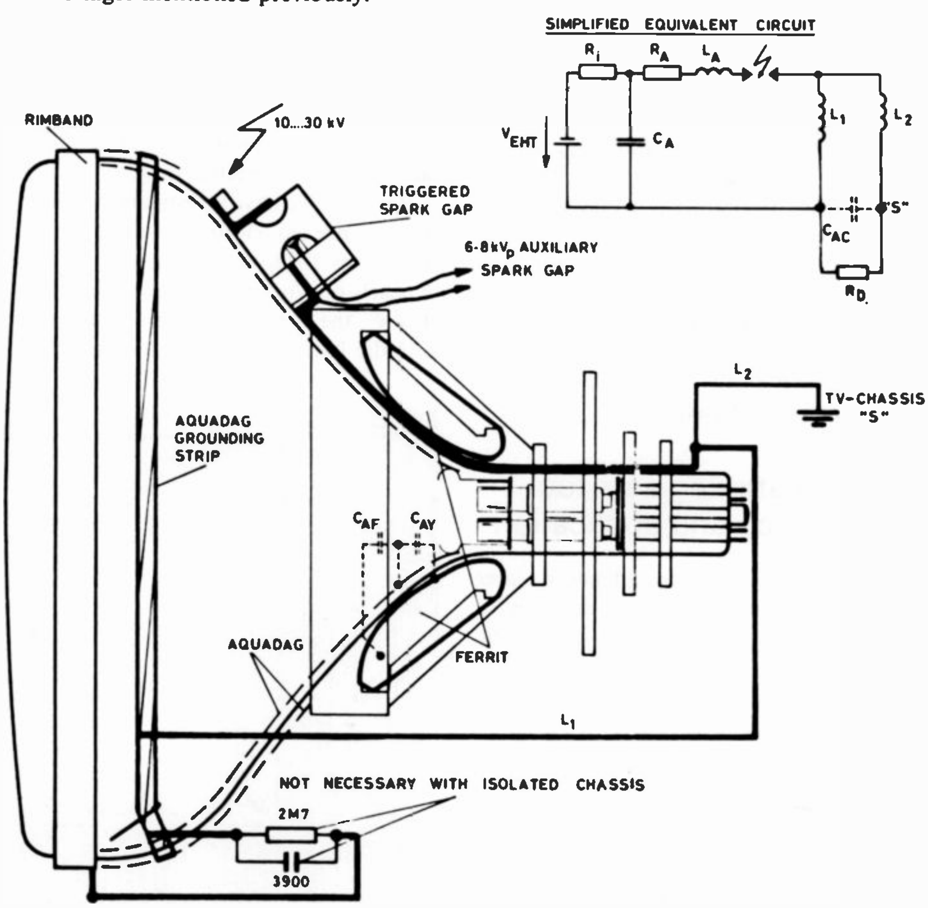


Fig. 1. Flashover simulation setup keeps lead length from spark gap as short as possible, thus, giving more accurate results.

spark gap, therefore, deviate seriously from those of a true flashover.

For best results, the connections to the spark gap should follow the path of an actual flashover as closely as possible. This led to the mechanical layout shown in Fig. 1. The most important component is the triggered spark gap comprised of a main gap between two hemispheres and a concentric trigger gap. In operation, a pulse of 6- to 8-kV is applied to the auxiliary gap, causing the main gap to flash and discharge the picture tube through the paths indicated in Fig. 1.

The vulnerability of a power transistor to damage is usually greatest at the instant of turn-off. Therefore, when testing a receiver chassis, particular care must be taken to investigate the situation at these vulnerable instants. The triggered flashover generator designed for this purpose has an 8-kV pulse generator similar to a television-receiver high-voltage circuit, driven by a deflection thyristor. The generator gives out the trigger pulse when it receives a drive signal from a timing generator. Timing is derived from composite TV sync, taken from the receiver under test. Appropriate delays may be introduced, with respect to horizontal and vertical sync, by adjusting front-panel controls.

When testing switched-mode power supplies not synchronized to the horizontal deflection frequency, pulses from the power supply are used to trigger the flashover generator, instead of the horizontal and vertical pulses. In addition, an automatic trigger mode is provided, producing flashovers at 3- to 4-second intervals.

Measurements on the receiver under test are made with a storage oscilloscope having suitable shielding against direct pick-up from the stray field of the primary arc. Great care must be taken in the selection of current and voltage probes, and the avoidance of ground loops or capacitive loading, to ensure accurate results.

Typical measurement results

The discharge current through a color picture tube, during an arc, is shown in Fig. 2. The example is for a tube having a low internal resistance of about 45 Ω. The peak discharge current is 550 A but, in particular, the fast rate of rise should be noted, resulting in a di/dt of 22,500 A/μs. Figure 2b shows the arc current through a modern tube having some 300 Ω internal resistance. The increased resistance results in a proportional reduction of the peak current and a dramatic reduction of the di/dt.

The picture-tube discharge current causes currents to flow in the receiver chassis by electromagnetic coupling or because of common impedances in the discharge path. Great care must, therefore, be taken with the grounding and circuit layout to minimize these effects. Damaging currents and voltages may, even so, be impressed on sensitive receiver parts so that protective components may be required. Also, secondary effects can occur. For example, the power-supply regulator may react anomalously to the sudden peak load, caused by the arc, resulting in short-duration but high-amplitude fluctuation in the B+ voltage. These problems can be minimized with the help of simulated arc testing.

New kine drive systems

Conflicting goals and a compromise solution

Recent developments in the area of video output systems have concentrated on:

1. Increasing the amplifier bandwidth, mainly in view of the increasing use of home TV receivers for alphanumerical and graphical display;
2. Increasing the video drive amplitude to allow the use of higher picture-tube cutoff levels and, hence, improved focus quality;
3. Reducing the power consumption for increased reliability; and
4. Automatic black-level setting and stabilization.

However, the third requirement in the above list conflicts with the first two requirements. A good compromise, however, is possible if the conventional Class A video amplifier is replaced by either complementary Class B or AB circuits or by the quasi-complementary Class AB circuit, which is often referred to as "active load amplifier." With this circuit, bulky transistor heatsinks and power resistors are avoided, which facilitates the mounting of the RGB amplifiers on the kine socket module of the receiver.

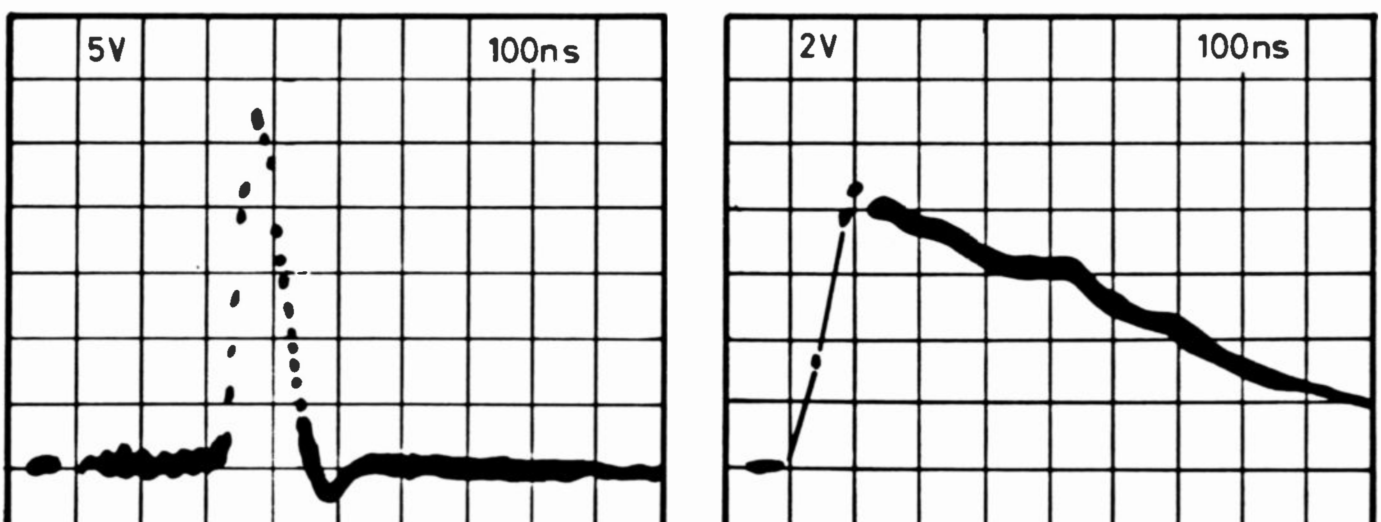


Fig. 2. Tube with low internal resistance (left) has high discharge current and very high di/dt. Tube with high internal resistance has much lower peak current and di/dt.

Ronald Mills, Director Engineering, Laboratories RCA Ltd., Zurich, Switzerland, after working in England, first on the design of aeronautical communications and navigation equipment and later on television development, joined RCA in Zurich in the summer of 1959. He has been responsible for the engineering work at Zurich and was appointed Director Engineering in 1974. Ronald is a member of the Institute of Physics of Britain, the Royal Television Society, the Swiss Electrotechnical Association, and as Chairman of IEC committee 12A, Receiving Equipment, has been concerned with international standardization.

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Walter Merz, Director of Research Laboratories RCA Ltd., Zurich, Switzerland, joined RCA in the spring of 1956, and after a one-year indoctrination period became manager of the research laboratory of Laboratories RCA Ltd., Zurich, Switzerland. In these years, with the exception of 1964/65 when he again spent one year at the RCA Laboratories at Princeton, he has been responsible for the research work at Zurich. In 1968, he was appointed Director of research. Dr. Merz has published more than 50 technical papers and a book on ferroelectricity. He is a Fellow of the American Physical Society and the Institute of Physics of Britain, and is a member of the Swiss, German, and European Physical Society.

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Active load amplifier for RGB drive

The active load amplifier is basically composed of a Class A common-emitter stage T1 and an emitter follower stage T2, as shown in Fig. 3. In such an arrangement, the minimum possible output-signal fall-time is determined by the output load capacitance C_{LOAD} and the current through R_E with T2 cut off. In order to eliminate the fall-time limitation by R_E, diode D is introduced to allow fast discharging of C_{LOAD} through T1. R_E is then dispensed with, and the feedback signal is taken from the output of the emitter follower. To avoid slew-rate limiting with positive output transients (rise time limitation), R_L must be small enough to allow charging of the parasitic collector capacitance C_C within the required signal rise time. With modern video transistors (C_{cb}, < 1.8 pF) and careful circuit layouts, a large signal bandwidth of 4 MHz (−3 dB, 120 V_{pp}) may be realized for R_L = 33 kΩ.

The voltage gain (white balance) is adjusted by P1. P2 determines the working point (grey scale adjustment). The gain adjustment P1 (white balance) does not influence the working point provided that the input black level equals the base dc level of T1. In practice this situation is obtained by means of a Zener diode in the emitter path of T1.

R_p provides output short-circuit protection. C_p is a bypass for the high-frequency components of the video signal.

High-frequency boot-strapping may be used to compensate for the stray capacitance of R_L (8-15 pF from output to midpoint of R_L).

In order to minimize thermal drift caused by T1, an active load cascode arrangement is recommended. In conjunction with an automatic black level system, however, any drift will be continuously corrected for, so that the basic arrangement of Fig. 3, right half, may be used.

Automatic background color balance

The block diagram of the automatic black level system is given in Fig. 4. At the end of vertical retrace, but before the start of the active field, a short positive voltage pulse P_G is applied to grid G1 of the picture tube, thereby, causing a cathode output pulse P_C, provided that beam current is flowing. In this instance, the picture tube may be regarded as a cathode follower producing a cathode output signal due to a grid input pulse. Shifting the working point of the tube towards cutoff decreases the amplitude of the cathode output pulse, until zero output results precisely at tube cutoff. The amplitude of the cathode output pulse is sampled and amplified. The resulting dc level is applied to the base of the video transistor, which in turn shifts its working point unitl tube cutoff is obtained.

As with any practical feedback control system, certain control errors are to be expected. They show up in form of:

- cutoff errors which are common to the

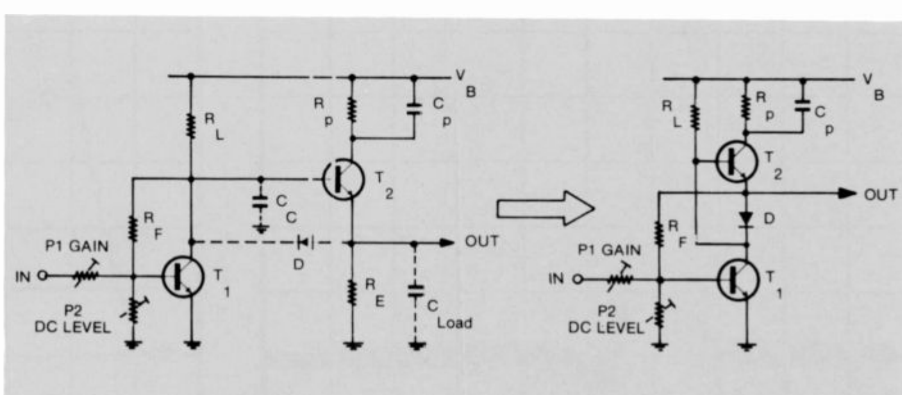


Fig. 3. Active load amplifier avoids bulky transistor heatsinks and power resistors in the video amplifier. Adding diode D, changing feedback pickoff location on circuit at left produces circuit on right.

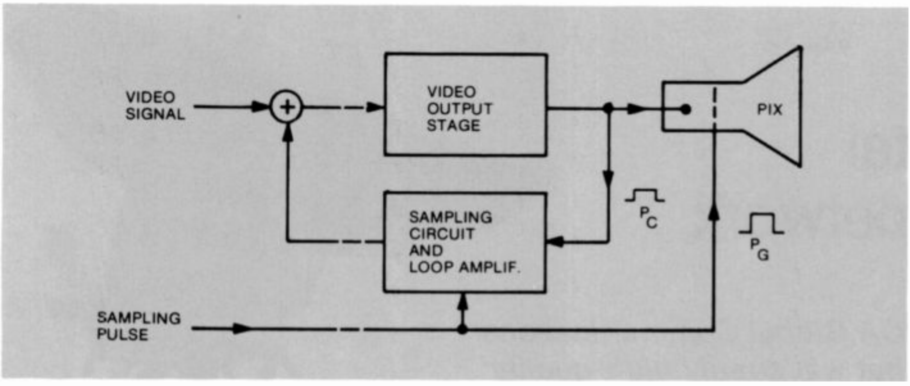


Fig. 4. Automatic background color balance system provides automatic cathode biasing, gives color balance during warm-up, and reduces the spread of low-brightness color temperature from receiver to receiver.

three chroma channels, caused by the non-infinite loop gain, and

- differential cutoff errors, caused by g_m tolerances of the three guns (slope differences of the drive characteristics).

Both types of errors are gradually decreased with increasing loop gain and may be neglected in practice.

With certain tubes, cathode currents might differ from the real beam currents because of parasitic cathode-heater leakage currents. As a result of the pulsed differential mode of operation, however, the accuracy of the cutoff adjustment is not degraded by cathode-heater leakage.

The automatic background color balance system is able to:

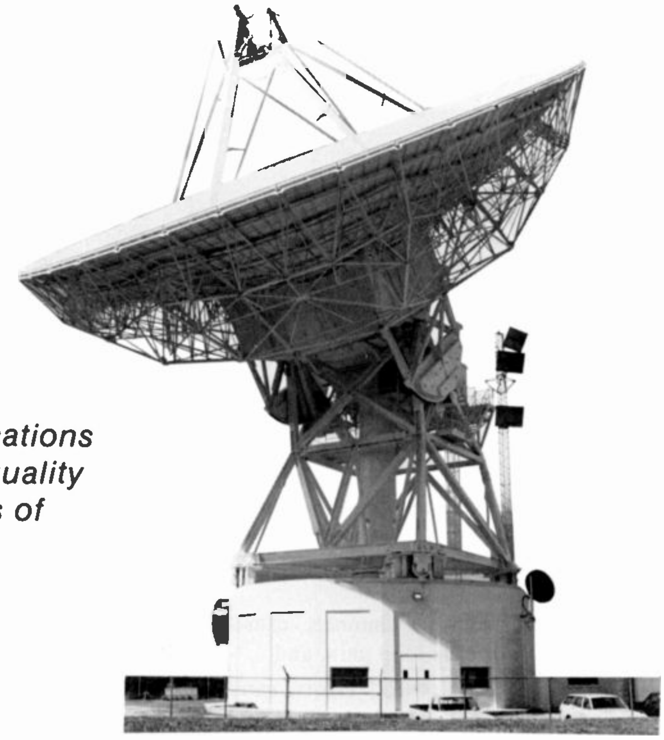
- Provide stable automatic cathode biasing for tube internal cutoff tolerances of more than 60 V (a worst-case tolerance of 39 V is guaranteed for PIL tubes in case of a maximum cutoff voltage of 150 V);
- Provide color balance during warm-up;
- Reduce the spread of low-brightness color temperature from receiver to receiver that is typical with the conventional manual alignment system.

In a receiver using this system, the three cutoff potentiometers as well as the usual service switch may be dispensed with.

J.M. Kellers

Pacific Basin digital communications network

Within a five-year time frame, RCA Global Communications is proposing a digital network that will supply high-quality communications between Pacific island communities of small population densities.



Pulantat earth station.

Abstract: *To implement a modern communications network in the Pacific Basin, RCA Global Communications had to propose a system that would be cost-effective. The system that was chosen incorporates the latest digital technology. The development of this digital communications network could serve as the forerunner of the regional satellite system proposed by RCA Corporation Chairman of the Board, Edgar Griffiths. This article describes the Pacific Basin proposal for this communications network and the configuration of the network.*

The foundation for the development of an RCA Global Communications Regional Satellite Communications Network in the Pacific began more than ten years ago. The capability has existed since RCA Global Communications filed with the Federal Communications Commission in 1968 to build and operate the Pulantat Standard "A" earth station in Guam.

The design of such a communications facility is not new. A similar system was implemented by RCA Alascom four years ago to provide modern telecommunication facilities to the people in Alaska's bush country. However, in seeking to implement a modern communications network in the Pacific Basin as well, RCA Global Communications' engineers have continually found problems in cost justification. Therefore, in this area today, only high frequency radio sporadically links a few Pacific island populations to the outside world.

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Changing the Pacific communications scene

But this situation may soon change. Now RCA Global Communications has developed a way to provide a more viable cost-effective communications network. The system design involves the construction of a satellite communications facility which is unique in all standards, yet is completely compatible with existing telecommunications systems throughout the world.

The network is unique because it incorporates the latest digital technology and offers the most cost-effective means to serve the Pacific island populations.

The development of this digital communications network could serve as the forerunner of the regional satellite systems proposed by RCA Corporation Chairman of the Board, Edgar Griffiths. Mr. Griffiths, in his address to the Third World Telecommunications Forum in Geneva, Switzerland, last September, suggested that a network of domestic satellites around the earth could effectively serve the needs of developing nations. Following are two excerpts from his presentation, which was entitled "Promise and Practicality:"

> "*... Yet for all the present and projected growth, modern telecommunications has simply not penetrated major areas of the world. Whole regions and peoples remain ignorant of the simplest things that could improve their lives because there is no structured way to com— municate to them. Trade between neighboring countries stagnates for want of information. There has been a failure thus far to plan our satellite con— figurations in support of the most pressing of human needs....*"

> "*... The United Nations has proposed that 1983 be designated as World Com— munications Year. That should provide us with a focal point around which we can mount an intensive appeal to government and political leaders for necessary financial and technical support....*"

The Pacific Basin proposal

Not waiting until 1983, RCA Global Communications has already taken the initiative to satisfy the communications requirements in the Pacific Region. Recently, several visits were made to the U.S. Pacific Trust Territories to examine facilities firsthand and to discuss the immediate communications needs with the elected political leaders in the six Micronesian district centers.

The result of that effort was the development of a system proposal which was entitled "Telecommunications Proposal for Micronesia." Because of the interest shown by political entities beyond the six Micronesian countries, the scope of the proposed digital communications network has been extended to include the entire Pacific Basin.

Laying the groundwork

In setting out to develop the system proposal, RCA Global Communications relied on its extensive sixty-year experience in providing international communications services in the Pacific. In 1951, high-frequency (HF) radio toll telephone services were first used to interconnect the telephone exchange in the United States mainland with the Pacific/Far East region. At the close of World War II, underseas cables were extended from the United States mainland to Guam and beyond. Later, satellite facilities blanketed the area.

With these extended facilities, Guam became the communications hub of the Pacific. RCA Global Communications replaced the island's manual switchboard system with a semi-automatic international telephone switching system in 1970. The Pulantat earth station, located just on the outskirts of Yona, Guam, was built in 1969. It has been staffed and operated since its inauguration by eleven RCA Global Communications technicians and managers.

Currently, the RCA Global Communications facilities, in place on Guam, are comparable to the modern communications facilities found on the United States mainland. They include uninterruptible power systems and the use of digital communications. RCA Global Communications provides several 56-kilobit satellite circuits to the NASA tracking stations at Dandan, Guam, via an RCA Global Communications terrestrial microwave system between Pulantat and Dandan.

With significant growth in commercial and government communications on Guam, the company installed a new International Telephone Switching (ITS) system in the RCA Global Communications central office in Agana, Guam.

This switching system today provides DDD access to one hundered fifty countries throughout the world by cable and satellite and is a key element in the RCA Global Communications proposal for a modern Pacific communications network. The telephone switch provides the means to establish single hop satellite connections between telephones within the digital network. (This system appears as though the switching functions were taking place within the satellite itself.)

Establishing the specifications

The proposed Pacific Basin communications network provides for services found in all the more progressive countries of the world. These are bi-directional video with sub-carrier program audio, toll quality voice, facsimile, mailgram telex and narrow- and wide-band leased services. Voice encrypting would also be available for sovereign security purposes. Developed to meet long-term needs, the proposal also includes expansion to "Thin-Route Satellite" capabilities.

To meet the objective of providing these services to the remote capitals in the Pacific region within a reasonable time frame, the initial space segment facility proposed for use is the Intelsat Global Beam Pacific Satellite, Intelsat IV F8. The network is configured to utilize 11-meter standard "B" auto track earth stations at the remote locations and the existing 30-meter Intelsat standard "A" earth station at Pulantat, Guam. The remote standard "B" earth stations are engineered for unattended operation. They include full redundancy with auto switch plus remote monitoring control and alarm reporting.

The digital system proposed is a time division multiple access (TDMA) mesh network in both the send and receive modes. A digital pipe line utilizing a 2-MHz frequency division multiplex (FDM) slot in a 36-MHz satellite transponder is provided to interconnect the earth stations within the network. At Guam, the digital pipe line is extended from the RCA Global Communications managed standard "A" earth station, located in Pulantat, via microwave to the RCA Global Communications central office located in Agana, Guam.

The network can be configured to provide a mix of bit streams within each 2-MHz of FDM bandwidth to satisfy the variety of commercial service offerings mentioned earlier. Network efficiency is determined by the number of circuits available to the network at any given time, and the number of circuits available at any given time is determined by the number of remote earth stations accessing the network simultaneously.

Each earth station access requires overhead bits which are subtracted from the total bits available within each 2-MHz of bandwidth for digital voice/data transmission. As an example, for a network efficiency of 93 percent, twenty-nine full duplex voice/data circuits would be available to serve ten earth stations. Each earth station can avail itself of the number of circuits it requires to meet peak hour demand. The network capacity can be doubled by adding a second 2-MHz of FDM bandwidth; however, the single hop capability within the network is still retained by a technique known as intermediate frequency (IF) frequency hopping.

The digital configuration

The digital configuration provides:

1. Full connectivity (mesh network);
2. Dynamic allocation of user bandwidth (on a per-call basis);
3. Forwarding of in-band (SF) signaling from remote sites to the reference site (for assignment and billing purposes);
4. Forwarding of on/off hook-status of calling/called parties to the reference site (for requests and billing purposes); and
5. IF hopping (minimum 2 carriers).

Mesh network

A block diagram of the mesh network is shown in Fig. 1. Specifics of the baseband hardware are as follows:

1. 2.048 Mbps modem rate;
2. No forward error correction;
3. 62.5 msec frame rate;
4. One, two or four sub-bursts per frame;
5. Open-loop synchronization (min. guard time = 300μs);
6. Reference signaling = 512 bits (64 bytes); and
7. Remote signaling = 88 bits (11 bytes).

Based on the above, on a per-carrier basis, the TDMA frame efficiency (hence available information bandwidth) can be determined for any N= number of accesses (earth stations).

Using one burst per frame and allowing for the guard times between bursts, the time given up for reference signaling and the remote signaling, efficiencies can be calculated as shown in Table I.

This demand assigned communications capability is particularly attractive because of improved utilization of the space segment and associated switching facilities when considering the time zone difference across the network.

At the time when the network is expanded to include small antenna, bush-type earth stations (which require a regional spot beam Satcom-type satellite), the low-density traffic projected would encourage sacrificing efficiency to serve more earth station terminals. This, however, may not be necessary due to the time zone difference between the small developing nations participating in the proposed regional network.

Table I. Efficiency per number of accesses.

No. of accesses	*Efficiency*	*Avail. BW (Mbps)*	*No. of Simplex 32 kb circuits*
2	.98	2.013	62
3	.98	1.999	62
4	.97	1.985	62
5	.96	1.971	61
6	.96	1.957	61
7	.95	1.943	60
8	.95	1.929	60
9	.94	1.915	59
10	.93	1.901	59
15	.89	1.831	57
20	.86	1.762	55
25	.83	1.692	52
30	.79	1.622	50

In-network calls

Each political entity within the proposed network will be identified by its own three digit area code, and each remote island within a political entity is identified by a unique three-digit central office code, which conforms to ITU standards.

Community of interest type telephone calls, such as a call originating in the network, are routed to the RCA Global Communications, Guam, international telephone switch (ITS). The ITS (Fig. 2), identifying an in-net call, generates a unique origin/destination code to the digital network controller. The memory map is reconfigured to assign digital blocks between the calling and called parties for single hop operation (Fig. 3). The call, while in progress, is timed for billing purposes by the RCA Global Communications ITS facility. It is based on the call connect and the originator's holding time while connected.

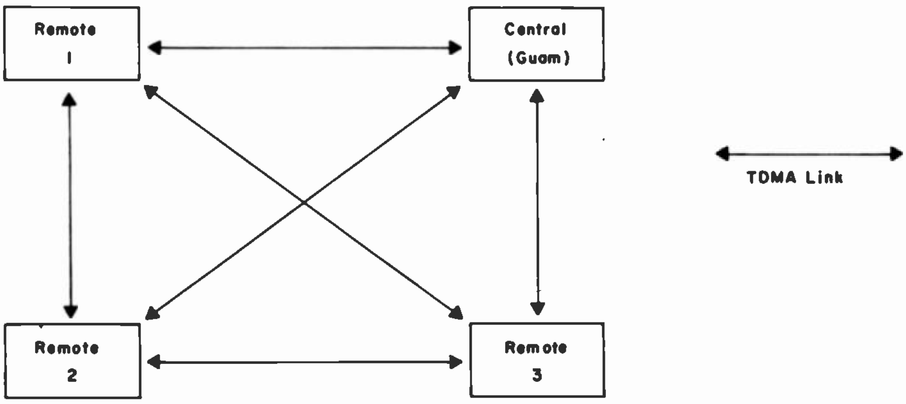


Fig. 1. The TDMA frame efficiency, on a per-carrier basis, can be determined for any number of earth stations.

Calls beyond the network

For calls originating or terminating beyond the network to any of the one hundred-fifty countries served directly by the RCA Global Communications, Guam, ITS system, two considerations are addressed.

The first consideration is the outbound call. Because the existing toll trunk facilities in Guam are both cable and satellite, the ITS will automatically establish first priority to a cable circuit in order to eliminate double hop connections to overseas destinations where choice exists.

The second consideration is the inbound call. If it should arrive at Guam via cable, this will also be a single hop call into the network. Essentially, only those calls passed to Guam via satellite and extended into the network will be double hop transmissions.

Planning for the future

Additional economies of scale are realized in the RCA Global Communications Regional Proposal. Commonality of equipment offers convenient subassembly maintenance and spare-part storage, which would be provided by RCA Global Communications in Guam. This offers reduced inventory and quick repair turn-around to the member nations operating in the regional network at lower cost.

The remote 11-meter earth stations would be owned and staffed as desired by the participating national administrations.

Within a five-year time frame, using a high power Satcom type satellite with spot beam capability, inexpensive small antenna earth station installations for over-the-horizon islands are planned to be implemented. At that time, the existing 11-meter earth stations in the network will access the new regional satellite. Auto tracking will no longer be required, and economic high quality communications will be available between Pacific island communities of much smaller population densities.

The scope of the RCA Global Communications proposal includes the installation of new digital telephone switching systems adjacent to the remote earth stations and expansion of the local telephone plant distribution system, using cable as well as microwave radio, to islands within line of sight of the national capitals.

Because of the level of technology proposed, RCA Global Communications is also offering to the participating nations (Post Telephone and Telegraph (PTT) entities), management and technical support on a contractural basis until a level of communications expertise is established by local citizens within the soverign member country.

Conclusion

The program, outlined in the RCA Global Communications Pacific Regional Satellite Network Proposal, realistically is beyond the ambitions of any single small developing nation. Only by the sharing of costly facilities among several sovereigns and purchasing in quantity can economic justification be realized or expansion to bush-type earth station terminals be achieved.

RCA's four-year experience in the bush system of Alaska, which is today providing medical assistance, health care and education to communities with as few as twenty-five citizens, has prompted this proposal. There is little question that the need exists in this area of the globe where our fellow man is rarely heard from and seldom hears from us.

This proposed digital communications network, making use of satellite communications, may indeed be a forerunner of the regional satellite networks of the future.

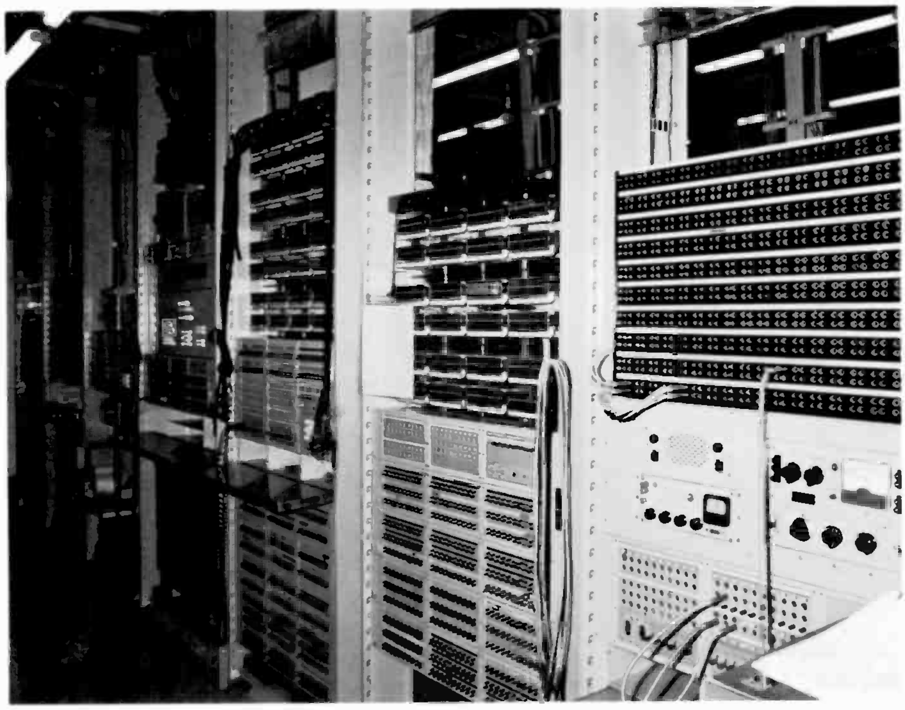
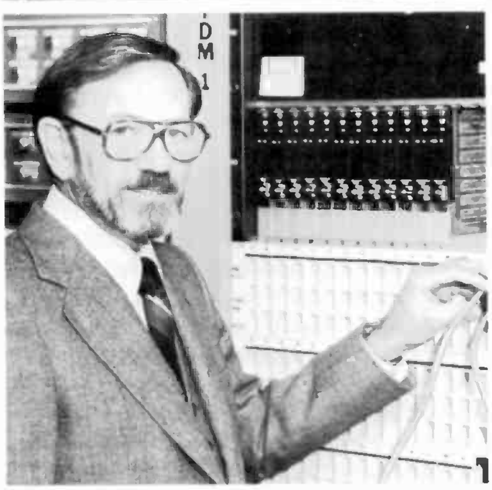


Fig. 2. Calls originating in the network are routed to this International Telephone Switch at RCA Global Communications, Guam.



Jay Morgan Kellers joined RCA as Principal Member Engineer in 1976. His responsibilities are earth station engineering and systems development. He recently returned from the People's Republic of China, where he assisted in arrangements for Marisat satellite tests. He is also secretary of the Satellite Technical and Operational Committee (STOC-TV), an organization of U.S./Canadian common carriers and broadcasters. Using an air transportable earth station, he has directed on-site televised operations for NASA's Apollo and Skylab splashdown and recovery.

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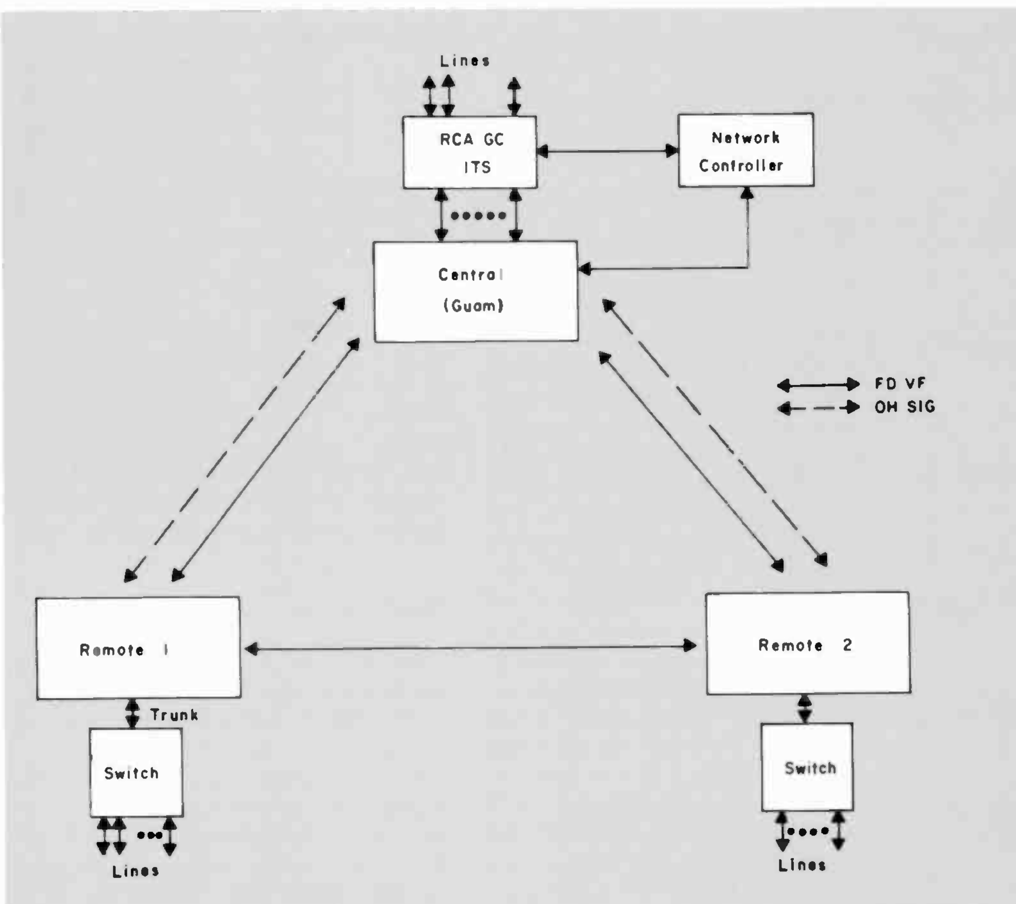

Fig. 3. The International Telephone Switch identifies an in-net call and generates a unique origin/destination code to the digital network controller.

L. Szijj

The teleprocessing network at the Solid State Division

The unique four-corner positioning of the Comten units used in SSD's teleprocessing network provides alternate routes in the event of any link malfunction.

Abstract: *The Solid State Division has established an international teleprocessing network for the remote processing of information. This network, including the hardware, operation and advantages, is desicribed. The back-up system is discussed that makes possible a reroute of all teleprocessing lines to the functioning computer.*

The management of information is critical to the successful operation of any business enterprise. This task assumes even greater importance when an enterprise spans the entire globe.

The Solid State Division (SSD) manufactures electronic components throughout the world and distributes them to customers across the globe. An individual device, during its manufacturing cycle, may be processed and distributed from three different locations. A finished product could have passed through as many as eight different locations! Such diversity demands that each location management have up-to-date information on the status of work-in-process, finished goods, and the order-board demand for these products. It is equally important that headquarters management in Somerville, N.J. have visible daily information on product, shipment, and order board. The collection, verification and dissemination of data from SSD's ten remote locations are accomplished through a worldwide teleprocessing network that assures the availability of accurate information on a timely basis.

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The teleprocessing applications supported by SSD are: Remote Job Entry (RJE), Customer Information Control System (CICS) and Time Sharing Option (TSO). RJE is primarily used for transmitting and retrieving large amounts of data. CICS is a transaction-oriented interactive system used for the maintenance of on-line files. TSO, on the other hand, is a command-oriented interactive system that permits utilization of the facilities of the computer. All of these applications allow for the remote processing of data from the two different types of terminals described below.

The SSD network consists of over a dozen RJE work stations, over fifty CICS terminals and over a hundred TSO terminals. On a daily basis, this network handles more than two million lines of type which must be printed by the remotes, over seventeen thousand transactions entered from CICS terminals, and over five hundred TSO sessions. In addition, the SSD host computer must process about one thousand batch jobs submitted from both the local and remote locations.

Components

The RCA teleprocessing network consists of computers, Comtens (control units and concentrators), and terminals that are interconnected by data links.

The computers employed in the RCA network are IBM 370/168 systems (Fig. 1), and are located in Somerville, N.J. at the RCA Solid State Division headquarters and at Cherry Hill, N.J. at the RCA Corporate Center. The SSD computer was installed at Somerville in early 1975 to replace the existing IBM 370/158 computer system. As a result of this change, the processing capability at SSD was increased by four-fold. Since this initial upgrade, SSD has continued to expand its processing capability by adding hardware and software to keep pace with a growing workload (Fig. 2).

The RCA teleprocessing network includes four Comtens. Two of these are Comten 3650s located in Belgium and Great Britain; the other two are Comten 3670s which are located in Somerville and Cherry Hill, N.J. The Comten 3670 is a system designed to enable the IBM system 370 to communicate with terminal devices over a wide range of communication facilities. More precisely, the Comten is a central processing unit (CPU) that processes and directs the flow of data between the communication lines and the IBM System 370. Like the Comten 3670, the Comten 3650 is also a communications controller. Smaller in scale than the 3670, the 3650 is primarily used to bunch communication lines.

Terminals are devices by which data may be entered into a computer and information may be retrieved. The terminals in the RCA network are of two types: batch terminals and interactive terminals. The batch terminals are mostly Data 100s. These are utilized as RJE work stations, and transmit jobs to be processed by a host computer. Once data is processed, the output is transmitted back to the batch terminal where it is printed. The interactive terminals are used for CICS and TSO applications. These terminals consist of IBM 3277 and 3278 type tubes and teletypes. As their name implies, in-

Fig. 1. IBM 370/168 computer system console and field engineering panel. The operator is shown viewing the tube on which system messages are displayed for his action. The operator is responsible for communicating with the system and performing duties which neither hardware nor software can provide.

Fig. 2. Shown are the IBM 2177 display station and 3400 tape drives. The tape librarian is demonstrating the mounting of a tape for processing by the system.

teractive terminals allow for the immediate processing of data.

Data links, paths for the transmission of information between terminals and Comtens, are provided by switched and leased communication lines. Switched lines are a commonly used data link. These lines support terminals that dial-up the computer (Fig. 3). The term "switched" is applied to them because the placement of a telephone call is necessary to establish the data link. Leased lines, on the other hand, are permanently established.

Transmissions over communications lines take the form of analog signals. The computer, however, accepts only digital signals. The device needed to transform the signals from the digital to the analog state and vice versa is called a modem. Most modems utilized in the network have an added multiplexor feature. Multiplexing permits the dividing-up of the line speeds among the different applications.

The speed at which bits of information (0s and 1s) are transmitted is measured in bits per second (bps). Most terrestrial leased lines in the network have the capability of transmitting at 9600 bps. The two satellite links connecting Taiwan and Malaysia can transmit data at 4800 bps. Table 1 lists the locations of leased-line terminals; the line speeds at each location are provided along with a breakdown of line speed per application.

Scope and advantages

Figure 4 presents graphically the extent of the current SSD network. There are many advantages to this network. The primary ones are those of flexibility and reliability through the availability of back-up resources. The most significant advantage stems from the rectangular positioning of the four Comten units; should the link between any two Comtens malfunction, all system units could still be reached by alternate routes. This arrangement earns the system its nickname, "the four corner network." In order that additional back-up be provided, a second leased line has been established between Cherry Hill and Somerville. This second leased-line increases the data rate between these locations to 19200 bps.

The ability of the Comtens to provide either automatic or manual switching of lines allows terminals to access either the Somerville or Cherry Hill computers. Automatic switching permits the terminal operator to select the host computer by entering the appropriate switching characters. Manual switching places the selection of the data link path in the hands of the Comten operator.

In the rare event of an extended failure of one of the two main computers, the Comtens allow for a complete back-up of the SSD teleprocessing system. The Comtens

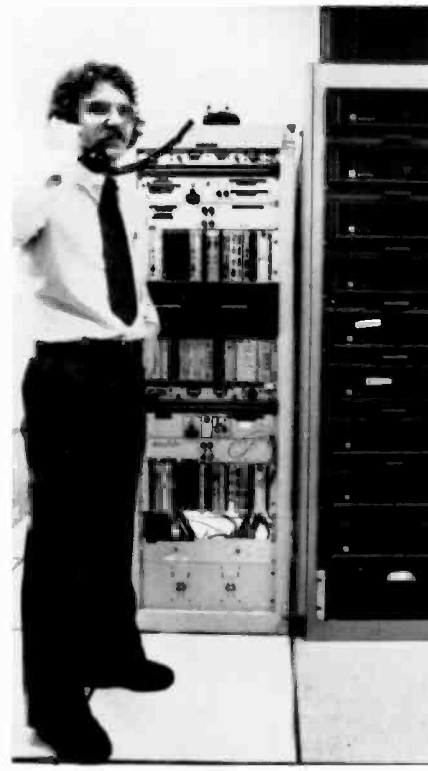

Fig. 3. Stan Carlstadt, the data communications analyst, is shown talking to the operator in Malaysia. The communications link to Malaysia may be used for either voice or data transmission. In the cabinet to Stan's immediate right is housed the equipment to communicate with Malaysia and Taiwan. The adjacent cabinet houses modems used for binary synchronous communications with the SSD remote locations.

Table I. Some RJE stations of the SSD network.

No.	*Location*	*Line speed*	*Application*
1.	Mountaintop, Pa.	1-9600 2-9600	RJE 4800 - CICS 2400 - TSO 2400 - Other Uses
2.	Findlay, Ohio	1-9600 2-9600	RJE 4800 - CICS 2400 - TSO 2400 - RJE
3.	Lancaster, Pa.	9600	4800 - RJE 2400 - CICS 2400 - TSO
4.	Palm Beach, Fla.	9600	4800 - RJE 2400 - CICS 2400 - TSO
5.	Taiwan	4800	2400 - RJE 1200 CICS 1200 - TSO
6.	Malaysia	4800	2400 - RJE 1200 - CICS 1200 - TSO
7.	Avoca, Pa.	9600	4800 - CICS 4800 - TSO
8.	Somerville, N.J.	9600	RJE
9.	Somerville, N.J.	9600	RJE
10.	Brussels, Belgium	9600	RJE/CICS/TSO
11.	Sunbury, England	9600	RJE/CICS/TSO
12.	Quickborn, Germany	4800	2400 - RJE 2400 - CICS/TSO

Laszlo Szijj joined the Systems Programming staff at the RCA Solid State Division in 1976. Initially, he was responsible for the establishment of the Communications Network System (CNS) between Somerville, N.J.; Leigo, Belgium; and Sunbury, England. He has had responsiblity for the modification, conversion, and maintenance of a number of software packages. His current responsibilities include software support to the Management Information System, the Customer Information Control System, and PL1 maintenance.

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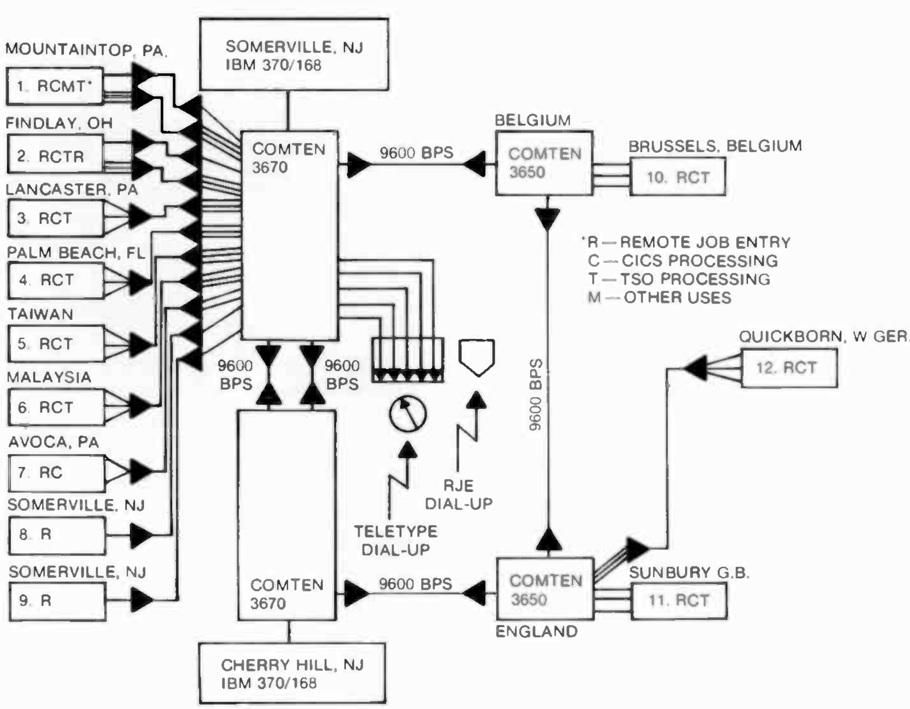

Fig. 4. This graphical representation of the SSD network shows that the terminal equipment in both Brussels and Sunbury is directly connected to the Comten without modems. Computers, Comtens and leased-line terminal locations are indicated by rectangles; each data is designated by a connecting line. Modems are displayed as arrowheads. Multiplexing by the modems is represented by the conversion of several lines to a single line and vice versa. Also shown are RJE and teletype dial-up facilities.

in Somerville and Cherry Hill are equipped with software that makes possible a reroute of all teleprocessing lines to the functioning computer.

The success of the SSD teleprocessing network is largely the result of the efforts and technical expertise provided by the Corporate Telecommunications and Computer Services (TACS), which is headed by John P. Macri, Staff Vice President. Typically, when SSD requires a new teleprocessing facility or service, it submits this request to Corporate TACS. There, it is received by Telecommunications Systems Development and Operations and is analyzed and implemented in the most cost-effective manner. Edward J. Tomko, Director of Telecommunications Systems Development and Operations, is responsible for this function.

Corporate TACS provides many other telecommunication services to SSD, including timely resolutions to telecommunications problems. The TACS personnel are the telecommunications experts within RCA Corporation, and put all the pieces of this extensive network together so that it can operate at maximum efficiency. Without their expertise, the optimum teleprocessing performance currently being achieved by SSD would not be possible.

W.P. Lustina

WELS—an international approach to range instrumentation support

An international group of test range users achieves efficient, cost-effective maintenance of instrumentation radars through a cooperative approach to engineering and logistics support.

Abstract: *Reliable, on-demand operation of precision tracking radars is a key element in supporting critical missions on today's test ranges. These radars (nearly 100 of them RCA-built) are scattered widely at various sites around the world, thereby complicating the problem of keeping them operational. This article describes a unique, inter-agency approach to this problem—the WELS (Worldwide Engineering and Logistics Support) Program. The scope and operation of the Program are outlined, including the diversity of range user requirements and the engineering/technical assistance and logistics support provided by RCA.*

Military systems—even relatively simple ones—are produced for deployment, for on-site repair, and for long-term operation and maintenance, all by military personnel. Because of the continuous readiness requirements of tactical forces, this approach has proved to be effective for those systems built in sufficient numbers to justify the special training, the comprehensive Operating and Maintenance manuals, the highly structured configuration control and drawing control programs, and the elaborate spare parts support required to keep the systems operational.

But what of the one- or two-of-a-kind systems designed and developed for special missions that are subject to frequent change? How should *these* systems be operated and maintained? What is the relative cost-effectiveness of fully developed support programs for systems that may lie unused for weeks, or even months at a time, and then on short notice be required to support some especially critical mission?

An effective and economical approach to such a problem is the subject of this article—WELS (Worldwide Engineering and Logistics Support)—a success story of inter-agency cooperation to build a workable program for keeping an international collection of precision tracking radars operating to meet a wide variety of tasks for a diverse user community—all at minimum cost.

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Background

Military test ranges must be equipped to test and verify the latest forms of weapons, sensors, and countermeasures. The problems facing the test ranges today may readily be extrapolated back to the 1950s. At that time supersonic aircraft, rockets, and missiles were placing extraordinary demands on the relatively modest capabilities of existing instrumentation.

Additional impetus during that period came from the U.S. and Soviet experiments in space flight. This early work and the projections of its impact on future years added another dimension to the requirements for precision range instrumentation—especially for radars capable of high-accuracy tracking at great distances.

Radar systems designed for this kind of specialized application tend to be one of a kind. They are *not* designed for tactical deployment by operating military forces; they are *not* manufactured in large numbers with tightly controlled configurations; they are *not* documented in enough detail for repair and maintenance by military technicians. Rather, they are tailored to perform a class of specific functions, using, perhaps, a common antenna and pedestal configuration, but with most other subsystems specifically designed for the special requirements of the individual range user.

Because these systems are purchased in very small numbers, they have little documentation that would facilitate on-site repair and maintenance by anyone unfamiliar with the design details. A major question, then, is how to keep these precision tracking radars operational.

In 1960, the United States Air Force Air Materiel Command (now Air Force Logistics Command) faced that specific problem in a number of RCA-built precision tracking radars. These radars had been procured to instrument the Atlantic Missile Range (now known as the Eastern Test Range) off the Florida coast. A pilot project was undertaken by the Air Force for depot-level maintenance by the contractor (RCA MSR). This project included consolidated, centralized stocks of peculiar parts, single-source responsibility for repair of high dollar-value reparable components, and periodic depot-level overhauls. The goal of this pilot project was to achieve a common radar

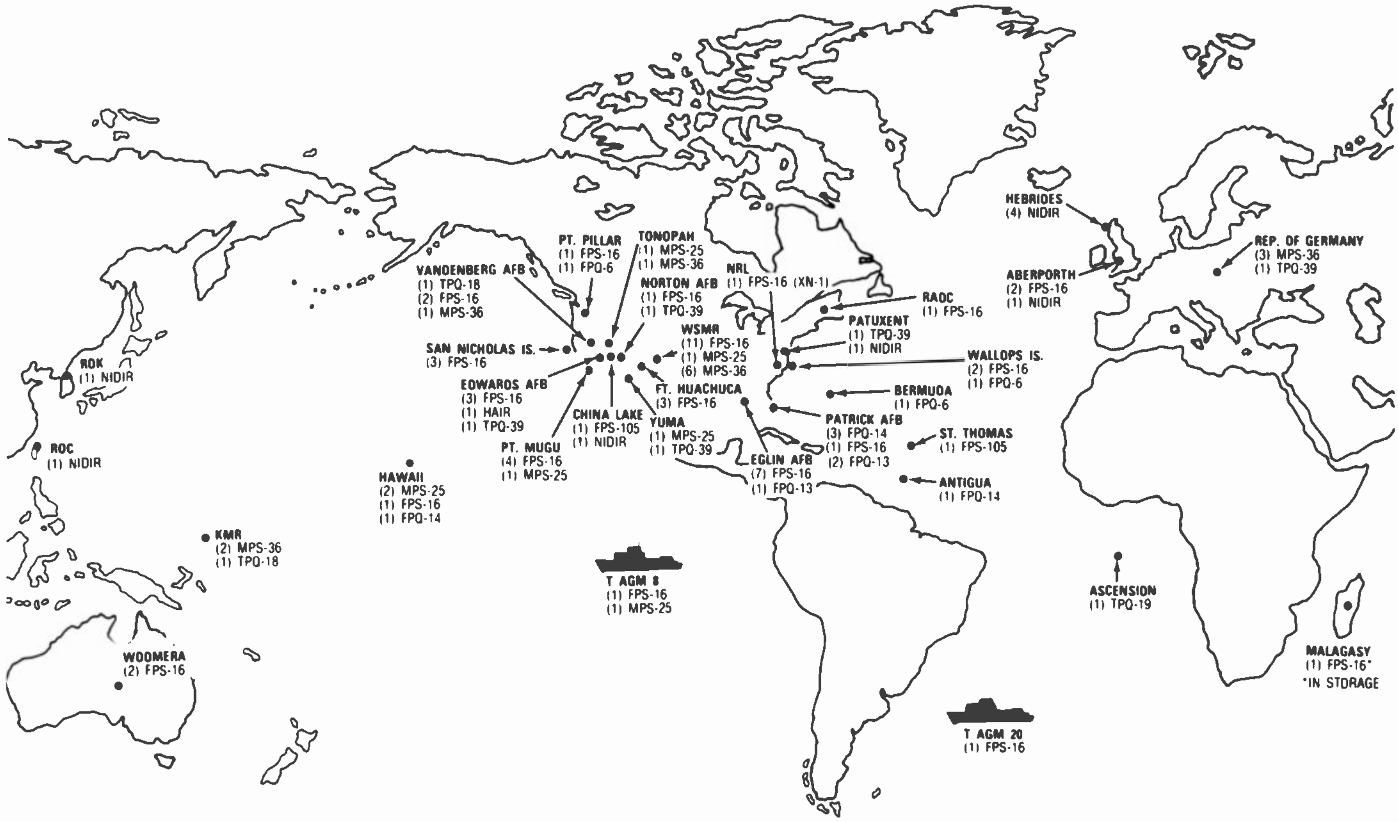


Fig. 1. The numbers and geographic dispersion of instrumentation radars in the WELS Program graphically illustrate the complexity of the engineering and logistics support problem.

maintenance program that would be more efficient and less costly than programs operated independently by each range user.

The anticipated efficiencies and economies were realized almost immediately, and in 1961, three agencies operating 15 radars were participating in the program. A key to the success of the program was single contractor responsibility. Since RCA had become pre-eminent in the production of specialized C-band instrumentation radars, virtually all the equipment involved in the program was RCA-developed.

As each new generation of RCA radar became available over the years, the range users could feel assured of a continuing support program to keep the equipment operational and capable of meeting the changing requirements. Indeed, in many cases, range user procurement decisions were influenced heavily by the availability of this continuing support. The success of this range user "co-op" is reflected in the growth of the program from the three agencies and 15 radars in 1961 to the current level of 23 participating agencies supporting 94 instrumentation radars.

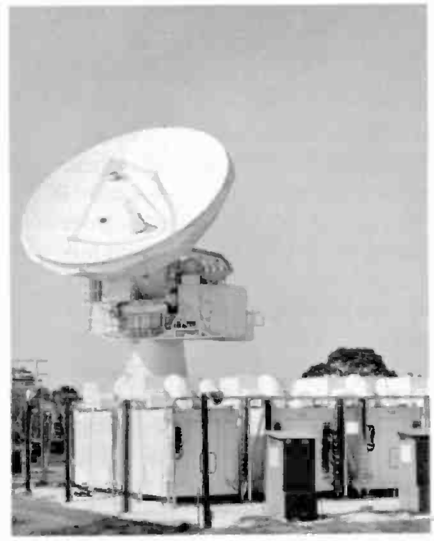
Figure 1 shows the geographical dipersion of the radar systems involved and the complexity of the support problem; Table I indicates the diversity of U.S. and foreign user agencies. The radars themselves, ranging from the 1955-vintage AN/FPS-16 to the late 1970s NIDIR systems, are described in capsule form in Fig. 2.

Table I. WELS participants.

Participating ranges/agencies	*Location*	*Participating ranges/agencies*	*Location*
Army Electronic Proving Ground	Arizona	NASA/Wallops F.R.C.	Virginia
Kwajalein Missile Range	Kwajalein	D.O.E. Tonopah Test Range	Nevada
White Sands Missile Range	New Mexico	Pacific Missile Test Center	California
Yuma Proving Ground	Arizona	Atlantic Fleet Weapons Training Facility	Puerto Rico
Eastern Space & Missile Center	Florida	Naval Air Test Center	Maryland
Air Force Flight Test Center	California	DFVLR	Germany
Air Force Systems Command	Washington	Ministry of Defense	Germany
Armament Development Test Center	Florida	Royal Aircraft Establishment	United Kingdom
Rome Air Development Test Center	New York	Royal Army Artillery Range	United Kingdom
Western Space & Missile Center	California	Agency for Defense Development	Republic of Korea
NASA/Dryden F.R.C.	California	NAFEC (FAA)	New Jersey
NASA/Goddard S.F.C.	Maryland		

(a)

(b)



(c)

(d)

(e)

(f)

(g)

Fig. 2. The principal members of RCA's family of instrumentation radars. Many of the older radars have been modified extensively to meet today's operational range requirements, and several variations exist within each type shown here. **(a)** AN/FPS-16 radar installation at MSR, Moorestown. This unit is used as a test bed for system modifications in support of the world-wide range instrumentation network. **(b)** AN/FPQ-6 radar, designed in the early 1960s, remains one of the most accurate of all instrumentation radars. **(c)** AN/TPQ-18, the transportable version of the FPQ-6, is shown set up on transportable shelters. **(d)** AN/FPS-105 mountaintop installation at Ely, Nevada. This was one of the first range instrumentation radars to provide extra reliability and compact packaging by using integrated circuits. **(e)** AN/MPS-36 mobile radar. This modern range tracker combines precision, range, and mobility for a wide variety of range applications. **(f)** AN/TPQ-39(V) radar, designed specifically for small, low-budget ranges. Known as the Digital Instrumentation Radar (DIR), it is one of the first radars to incorporate functional computer control. **(g)** NIDIR installation. The basic Nike Hercules X-band antenna/pedestal is modified with updated DIR electronics to fulfill today's range needs at low cost.

How the program works

With so many agencies and so much equipment involved, the problems of estimating and controlling technical activity and cost become formidable. The solution to these problems, based on nearly 20 years of experience, is *active* cooperation among the participating agencies.

Overall management of WELS is provided by the United States Air Force, Eastern Space and Missle Center (ESMC), at Patrick Air Force Base, Florida. ESMC also provides financial management, and procurement support. The Air Force WELS Program Manager serves as the focal point for all matters pertaining to the program, interfacing with both the participating agencies and with RCA. Each participating agency or range user designates a WELS Range Program Manager who is responsible for all matters that relate to WELS and the range.

Prior to the beginning of each fiscal year, all participants submit their estimated requirements for the new program year. These include the number of radars to be supported and estimates of the number of requisitioning actions, components to be returned to WELS for repair, overhauls to be performed, and man-weeks of engineering services that will be required. These requirements are based largely on actual historical data for the various radar types supported by WELS. Budgetary cost information is provided to each participant so that adequate funding can be requested for the fiscal year. This information is consolidated by the Air Force WELS Program Office and forms the scope of work that ultimately results in a negotiated contract with RCA MSR. The Air Force WELS Program Manager then allocates the costs of the fiscal year contract in accordance with the requirements of each participant and the agreed-upon allocation formula.

During the program year, the Air Force WELS Program Manager and each participant receive monthly cumulative status reports on all material transactions for the individual users. From this data, an individual range manager can review actual versus projected requirements and use this information for estimating and adjusting the next year's requirements. If a participant has underestimated a requirement, the Air Force WELS Program Manager can authorize an exchange of requirements from a range that overestimated its requirements for the year. This, in turn, provides the participants with a form of contingency backup support.

RCA's role is to provide the material support, consultation, and services required by the ranges. The MSR WELS Program Manager maintains staffing, facilities, and supplies appropriate to the broad Program requirements. He directs engineering/technical assistance, logistical support, component repairs, emergency on-site engineering services, on-site overhauls, program data, and radar improvement modifications as required.

Implicit in these requirements is the need for an extraordinarily wide range of radar engineering and logistics skills. Accordingly, the WELS Program engineering staff draws heavily on the skills of Moorestown's radar technology specialists for assistance in meeting special requirements and upgrading radar capabilities.

In addition to the headquarters staff at MSR, the RCA WELS Program organization maintains three regional offices in areas with a high density of radars: Patrick Air Force Base in Florida, White Sands Missile Range in New Mexico, and Vandenberg Air Force Base in California. These offices provide direct, local support to the ranges and radars in their regions.

As a *depot-level* engineering and support program, WELS complements the existing on-site operations and maintenance staffs who man the radars worldwide on a day-to-day basis. Operationally, the WELS Program is divided into two major components: Engineering/Technical Assistance and Logistics Support. The functions of these service groups are described in the following paragraphs.

Engineering technical assistance

A small permanent staff of experienced engineers and technicians is responsible for all the technical aspects of the program. The staff engineers, supported as required by MSR's Design and Development engineering staff, are responsible for field overhauls of radars, component repairs, reliability and maintainability improvements, and installation of product improvement modifications to enhance the original equipment performance. They also provide emergency on-site engineering services as required by the participants. Still another important responsibility is the selection and evaluation of replacement parts for the radars. (Some of the radars in the field are more than 20 years old, and many of the original parts and assemblies are no longer available.)

Direct contact with the radar sites is an important aspect of the program. It is standard practice for a range to call for assistance in any area, from troubleshooting a system problem to planning support for a mission. The WELS Emergency Engineering Services function is set up specifically to provide support in these areas. With the problem defined, the appropriate support personnel are selected and dispatched to the site. Response time in these situations is often critical, since most of the test ranges contract with various DoD and NASA agencies to support precisely scheduled testing. An aborted mission due to an inoperable sensor could have serious operational and cost impact. The goal of the ranges and of WELS personnel, therefore, is the earliest possible resolution of problems to eliminate or at least minimize downtime.

Communication and data exchange with the sites are not limited to emergencies. WELS Field Information Bulletins keep the participants abreast of technical and logistical information pertinent to their radars. These bulletins also provide status reports on various WELS technical investigations and serve as a vehicle for exchange of operating experience among range users.

Modification and improvement programs

Emergency engineering support is a vital part of the WELS Program; however, the longer-term radar modification and improvement program is the key to the continued effectiveness of many of the older radars in supporting the demanding requirements of today's test ranges. The WELS engineering staff, working closely with MSR design and development engineers, has developed a variety of product modifications/improvements. The result is systematic upgrading of the original designs with state-of-the-art components. This modernization process derives from MSR's Independent Research and Development programs, from special technology developments for new-generation radars, and from continued progress in solid-state technology. The resulting modifications, available to all program participants, have not only extended the active life of many systems by years, but also have provided important performance enhancements.

As they are developed, these modifications are checked out and tested on the government-furnished radar test beds located at MSR's Moorestown plant. A complete AN/FPS-16 system is available, plus a partial AN/FPQ-6, and an operational AN/TPQ-39(V) NIDIR system. These test beds are used to test repaired or overhauled components and assemblies, evaluate replacement components, simulate problems reported by the field, and test and evaluate radar improvement modifications.

The NIDIR test bed system, which is readily transportable, makes an ideal radar for ranges with mission support programs of short duration that do not justify the acquisition of a permanent installation. Two operation and maintenance personnel, plus support by WELS, are also provided for the period of the loan. The Air Force WELS Program Office determines priority of usage, and the user contracts for these services and any interface equipment required for integration with other range equipment.

Field overhauls

An operational radar, like any other complex system, requires periodic overhaul. Unlike many other systems, however, the radars in WELS are often located in remote areas; their size and complexity further militate against their being dismantled and shipped to a depot for overhaul. Accordingly, the depot-level overhauls of WELS Program radars are normally implemented in the field.

The engineering and logistics problems attending such an undertaking are formidable, but the WELS Program staff has evolved a number of special approaches and techniques over the years that have yielded notable efficiencies. As an example, on-site overhaul of an AN/FPS-16 radar required 24 days in the early 1960s; today the same overhaul is accomplished in an average of 13 days.

One of the keys to this efficiency is careful planning and scheduling. Approximately 12 weeks prior to a scheduled overhaul, the radar is inspected to determine the operations and materials required to restore it to factory specification levels. A report to the cognizant WELS Range Program Manager details the recommended tasks. When these tasks are approved, the radar is scheduled for a specific period of downtime to accommodate the overhaul process.

The actual work is performed by a team consisting of an engineering team leader, a logistics specialist, and a complement of radar technicians. The personnel, materials, and field overhaul van arrive on site in accordance with the scheduled downtime. The mobile overhaul vans (Fig. 3) are fully equipped with tools, materials, machine shop facilities, and test equipment to enable radar overhauls and modifications at semi-remote sites. A pre-operational check is made as part of the overhaul to determine the radar baseline test data. On completion of the effort, the radar is subjected to a final test and checkout. An on-site meeting is held wih the appropriate user personnel to review the overhaul efforts and to ensure that the radar meets all of the original performance specifications.

Logistics support

The sheer number — and variations — of radars supported by the WELS Program establish a bewildering complexity of configurations and spare parts requirements. With nearly 100 radars in the field — each tailored to a specific requirement and then, perhaps, modified for other uses — the support requirements become awesome.

This support task is the assignment of the WELS Program logistics staff, an experienced group of program support analysts who are responsible for acquisition and distribution of all materials for the program. Responsibilities include stock maintenance, routine and emergency parts requisitioning, component repair, and data bank maintenance.

The key element of this support is quick-reaction supply of components and assemblies to keep the radars operational. The logistics staff, therefore, maintains a year-round, 24-hour-a-day requisition service to meet the immediate needs of any site. The goal in responding to *emergency* requisitions (radar down, no spare on site) is to have the part en route to the site within 24 hours. For *routine* requisitions (replenishment of or addition to on-site spares), the goal is to deliver the material to the site within 30 days.

Stock facility

This kind of response would clearly be impossible without a large stock of spare parts. On the other hand, program efficiency dictates reasonable limitations on the number and variety of spares retained in the inventory. A cornerstone of the program, then, is a stock facility that is large but not all-encompassing (an average 80 percent of line item requirements can be filled from stock). Moreover, the use of items is reviewed annually for deletions, additions, and modifications of stock level in the inventory.

The WELS stock facility (Fig. 4) is located at MSR in Moorestown, and contains approximately 35,000 line items of support materials — all government property and bonded for the exclusive use of WELS participants. This stock is of special importance to foreign range participants who do not have access to standard parts readily available to U.S. agencies through the Federal Supply System.

Reparables

Many of the components and assemblies that are replaced in an operational radar can be repaired and retained in stock as fully qualified spare parts. These are defined as "reparables," subject to return to WELS stock upon replacement. Each of these items is inspected on its return for repairability. If the estimated repair cost

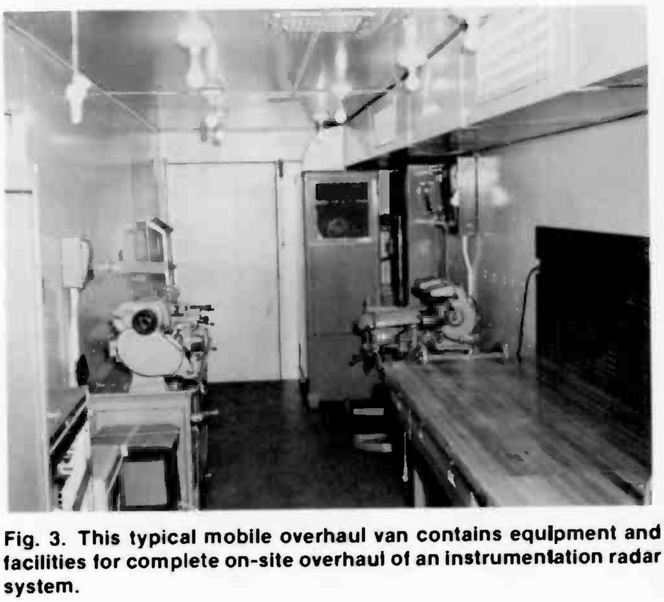


Fig. 3. This typical mobile overhaul van contains equipment and facilities for complete on-site overhaul of an instrumentation radar system.

Fig. 4. The bonded stockroom at RCA's Moorestown facility includes 35,000 line items of spare parts for the exclusive use of WELS Program participants.

exceeds 65 percent of replacement cost, the item is scrapped (unless the item is a critical inventory asset). For items determined to be repairable the WELS logistics staff determines whether in-house or vendor repair is appropriate and authorizes the work. After repair, the item receives RCA and government quality inspections and is returned to stock.

Special challenges

The WELS Program presents both technical and geographical challenges. For example, the dispatch of men and equipment by helicopter for emergency repairs on a range tracking ship in the middle of the Pacific adds, at a minimum, an extra dimension of complexity in transportation arrangements. Even straightforward logistics support becomes a special challenge when the emergency material must be delivered expeditiously to a radar range in the Australian outback or the United Kingdom's Outer Hebrides.

Other challenges arise from special range needs. Such requirements as dismantling, refurbishing and relocating an entire radar system from a remote Caribbean island to another remote island in the Pacific call for extra measures of planning and implementation. Similar challenges arise in the on-site conversion of a fixed-site radar to a van/mobile configuration. Another example is the emplacement and overhaul of a radar system on a 10,000-foot snow-capped mountain peak.

Conclusion

The success of the WELS Program over a period of nearly 20 years demonstrates that a carefully-planned approach and active cooperation among the participants can yield outstanding results. The original Air Force pilot program concept of 1960 was a sound one for a small group of agencies with closely related needs. The successful expansion of this program over the years to embrace many more radars, and many more U.S. and foreign agencies is a tribute to the Air Force WELS Program Office.

Today, an international cooperative of 23 agencies participates in this range instrumentation support venture, enjoying the benefits of mutual htlp and support in keeping these range radars operational at affordable cost.

Bill Lustina, a Unit Manager in MSR's Range Systems Program Management Operations, is assigned as the Program Manager for the Worldwide Engineering and Logistics Support Program (WELS) and is responsible for the overall direction of the program. Mr. Lustina joined RCA in 1952 as a laboratory assistant. After graduating from La Salle College with a B.S. in Electronics Physics, he held several design assignments in the RCA Camden Defense Electronics Products, Airborne Fire Control Department, and the Airborne Closed Circuit Television Group. Transferring to RCA Missile and Surface Radar in 1959, he was assigned to Field Product Assurance until 1967 when he began his present assignment.

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H.W. Hutchison

A 1980 electronics industry procurement outlook

During the 1980s, demand will continue to exceed supply for the electronics industry and the manufacturer must take steps to plan for this problem realistically.

Abstract: *Material shortages will have an impact on the electronics industry during the 1980s, especially the semiconductor industry. Because of these shortages, one third of all integrated circuits will be built by users and not suppliers. Material shortages will cause delay in deliveries, high costs, and lower quality products. To confront these problems, the engineer must rely on his best skills and ingenuity. The assurance of adequate supply at competitive prices will be of major concern.*

Despite economists' agreement that a recession is now underway, the electronics industry is expected to remain strong during 1980 and, therefore, there will be a continued demand for products. In particular, the military aerospace, computer and telecommunications businesses will remain strong while consumer electronics are expected to decline. Many of the component suppliers are reporting that they are essentially "sold out" for 1980. Bookings are still exceeding shipments every month. Suppliers are hard pressed to meet their commitments. Quality also declines at times like this, and that too adds to material unavailability.

The semiconductor industry (which is really the cardiovascular system of electronics) has finally matured and has entered 1980 with a 28-30 week backlog even after chalking up a 36 percent increase in sales during 1979. Worldwide shipments by the U.S. semiconductor industry have reached $6.5 billion. The computer industry is expected to increase its need for semiconductors by 20 percent in 1980. The military/aerospace and telecommunication needs will increase by 17 percent and 12 percent respectively. Semiconductors now account for 4.7 percent of the value of electronic equipment, compared to less than 1 percent in 1970. Six percent of the cost of computers is for semiconductors and this is expected to increase to 12 percent in 1980.

Because of the heavy reliance on semiconductor technology, most major electronic manufacturers are investing heavily in in-house facilities and take-over of existing semiconductor manufacturers. By 1985 it is predicted that one third of all integrated circuits will be built by the *users* and not the *suppliers*. There are presently seven U.S. companies that are using over $100 million of semiconductors annually. Three years ago, there was only one. By 1981, there will be seventeen.

The semiconductor manufacturers and the users, therefore, are tightening their bonds. The manufacturers are choosing their customers with care and are turning away those with requirements for low quantities and/or custom parts. The manufacturers that were technology driven are now shifting to being balance sheet driven. The success of the electronics industry also brings with it an unavoidable problem — demand exceeding supply.

There is a severe shortage of many of the materials needed by the electronics industry. The purchase of semiconductors for 1980 requirements will be difficult because of this material shortage. Silicon, which was on allocation all of last year, will continue to be in short supply at least through the first three quarters of 1980. Hydrofluoric acid is also in short supply. Semiconductor tooling is sold out for six months. Delivery of logic testers requires 32 weeks. Wire bonders require a wait of 26 to 50 weeks. The newest projection and direct step systems are being quoted for 12 to 18 months. The risk and uncertainty of obtaining semiconductors in 1979 will prevail through 1980.

There are dozens of other materials that will continue to be in short supply during 1980. Titanium forgings are being quoted for 65 week delivery cycles. (Both Camden and Hightstown purchase titanium castings.) Tantalum powder required for tantalum capacitors has been on allocation for two years. In addition, the price of tantalum has increased tenfold during the past year. Tantalum capacitor deliveries run from 10 to 30 weeks. Some mica capacitors require 30 weeks for delivery. Relays are being quoted for delivery in 35 to 52 weeks. Resistors, even the most common carbon compositions, take as long as 22 weeks to obtain. Metal films take as long as 30 weeks. Switches require a wait of 28 weeks and some types of bearings

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require a wait of 68 weeks. Diesel oil, castings, motors, cobalt, transformers, test equipment, and paper all continue in short supply.

A related industry, the connector industry, also has not been able to grow fast enough to meet the demand for product. The sales growth of connectors in 1979 increased by 20 percent and lead times of 60 weeks for some types are still being quoted. The "run-of-the-mill" types are averaging 25 to 30 weeks for delivery. New plant capacity scheduled for production early in 1980 is already sold out. Connector deliveries will remain critical during 1980.

These problems, caused by the fast pace of electronics-industry growth, call for the application of the engineer's best skills and ingenuity. Business must be done differently than it has been done in the past. Long lead times must be taken into consideration. The user can no longer depend on material lying on a shelf waiting to be ordered. Material acquisition and production must be scheduled in accordance with realistic lead times. Planning must reflect realistic and timely forecasts. Planning must also recognize that custom parts are almost impossible to obtain and are the most inflationary. The use of standard parts must be emphasized. This calls for maximum application of Value Engineering techniques. Adequate planning includes long-term contracting for price and delivery of all critical materials from our major sources of supply. Single and sole source suppliers should be avoided. Only through the use of multiple sources can we assure that we are buying at competitive prices.

To accomplish the planning needed in today's market, all business disciplines, Materials, Marketing, Manufacturing and Engineering, must communicate and be fully aware of the problems that will persist due to the continuing growth of the electronics industry. The assurance of adequate supply at competitive prices is the responsibility of all disciplines. 1980 is going to be a real challenge!

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What influences the precious metal cost-fluctuation problem?

Electronic News, Vol. 26/No. 1274 (Feb. 4, 1980) states, "By most accounts, the chronic shortage of semiconductors will stretch well into the year, yet equipment manufacturers are planning to buy more parts this year." Contributing factors to semiconductor shortage are the automobile and toy industries, relatively newcomers to the semiconductor market. The competition in the procurement of parts will be emphasized by these new industries as they continue to increase their semiconductor buying.

The consumer electronics industry will continue to increase its demands for random access memories when production for consumer products for the Christmas season becomes prominent in May and June. The parts shortage is causing production limitations and many electronic industries are trying to establish longer-range contractual agreements with their suppliers. Increases of 20 percent in purchasing volume are not uncommon, despite the supply shortage.

Domestic buying attempts are being blocked by manufacturers' allocation programs, and the current precious metal situation adds to procurement problems. Some manufacturers expect suppliers to levy precious metal adder charges on the price of semiconductors. Some suppliers have already begun to tack on the adders at the time of shipment. With the constant fluctuation of the base price of gold and silver, buyers can expect a variety of surcharges that can increase component cost by more than 50 percent.

Some buyers have seen precious metal surcharges since last November. According to *Electronic News*, a typical surcharge "... uses $300 an ounce as the base price for gold, and multiplies the difference between the base and the current price of gold by a factor of either 0.00007 (for packages with 18 or fewer pins) or 0.00017 (for packages with 20 or more pins)." The administrative burden of the surcharge is being felt not only by the customer but also by the manufacturers.

The task of computing adders has become chaotic for manufacturers. Not only do they need to take into account a number of metals, including gold and silver, but also the varying amounts of each in different components. Some manufacturers have begun to abandon surcharges in favor of quarterly price hikes where backlog orders will be priced at the current quarter's level. The suppliers who are computing the difference between a base price of gold and the current price, then applying a multiplier to that difference, are dealing with a never ending task of computing adders.

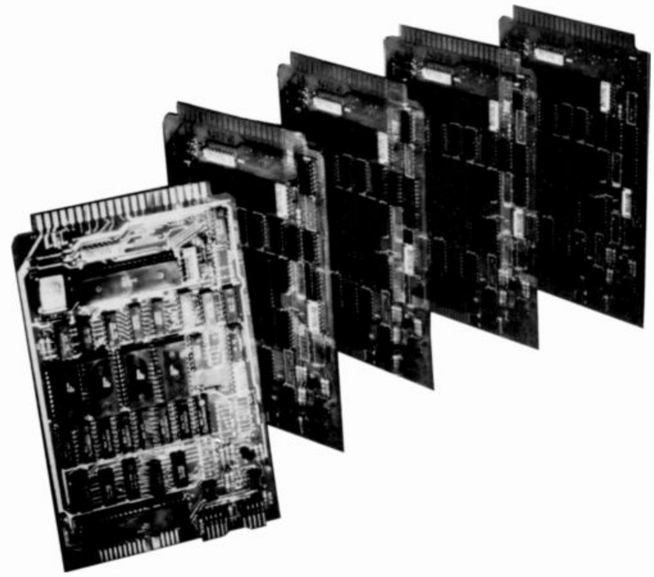
Some indications point towards straight price hikes to replace the surcharge. Many buyers are reluctant to place orders for parts without definite prices. The continuation of surcharges will definitely be a disadvantage to the cost-accounting machinery of the Buyer.

B.L.S.

R.W. Ahrons

CMOS Microboards: the board-level computers

The CMOS Microboard series, a new RCA product line, provides the design engineer with a ready-made alternative to starting from scratch when building a computer system.



Abstract: *CMOS Microboards offer the RCA engineer a fully supported board-level computer product with low power-supply cost, high noise margins and efficient packaging features. Board-level computers are a middle option between component purchasing and the purchase of a complete electronic system. The choice between buying Microboards or making the entire system is determined by the amount of in-house resources and allotted design and manufacturing qualification time. The low power dissipation, small size, and low cost of the CMOS Microboards offer many advantages. A wide range of support equipment and software tools are available for the Microboards.*

The RCA Microboard series[1] is a line of CMOS board-level computers that include single-board computers plus a variety of expansion memory and I/O boards and accessory hardware. These boards may be combined to provide customized microcomputer systems for specific applications. The low-power CMOS computer boards are engineered and tested to reduce the time required for the user to develop his over-all system.

The high noise immunity, low power consumption, and wider supply-voltage tolerance of the CMOS technology work together to reduce the cost and optimize the performance of Microboard-based products. Boards are small in size, e.g., 4.5 in. x 7.5 in. (114.3mm x 190.5mm), and interconnect by means of the compact Microboard Universal Backplane which, together with the negligible heat generation of CMOS, makes possible the implementation of systems of small physical size.

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Board-level computers offer the system manufacturer a middle option between the purchase of components and the purchase of a complete electronic system. This option provides opportunities for quick, economical system design. RCA's Microboard line of board-level computers using CMOS components achieves the cost advantages of CMOS circuits, advantages that offset the somewhat higher cost of the CMOS components. Furthermore, with a lower-cost power supply, or with battery operation, and the elimination of cooling fans, the system has even more versatility. This new board-level computer line employs the 1800 Series Microprocessor and I/O components, taking advantage of some of the new large scale integration (LSI) I/O parts in the line.

The board-level approach shifts the burden of much of the hardware design and configuration to the vendor. The designer selects his boards and designs only his special interface, thereby minimizing his hardware involvement. Although this approach represents for him a hardware "buy" rather than "make" option, it is still a *software* "make" option, and follows the patterns of the microprocessor era of customizing through software.

The new RCA Microboard line features a full set of board-level computers, special I/O boards and memory boards. In the latter case, read-only memory (ROM) boards, random access memory (RAM) boards and battery back-up RAM boards are available. Table I shows a list of boards available now and some presently in the design phase.

All Microboard modules are designed to plug into the RCA COSMAC Development Systems, which provide editor, macro-assembler, compilers, and debugging facilities to speed product development.

The "make" or "buy" decision

In determining whether to "make" or "buy," a system, resources and the timing of the design program must be evaluated. Subtle points, such as putting resources into the area of greatest expertise and keeping the design investment down, weigh more heavily on the side of the buy decision. However, the buy portion of the design is less secure from copying by a competitor and less unique to the design. If the volume of usage is high, it may be more economical to build a more tailored design. On the other hand, the design risks, which enter into consideration of production delays, are reduced with the buy option.

Invisible overhead costs, such as drafting, layout, and factory documentation costs, are the ones easily overlooked in the make/buy decision. Even when shared by many programs, they still add to the overall cost of the system. If all programs went from a buy to a make decision, the increase in work force would increase the overhead as well as the direct-labor costs.

The CMOS Microboard line is available worldwide, and a replacement board, for service, can be considered a "worldwide replacement part," i.e., a standard plug-in replacement available from a local RCA distributor. The cost of spare-part inventory and documentation is thereby reduced for the equipment manufacturer.

The disadvantage of standardized boards is that they contain either excess circuits or not quite enough. A cost analysis, shown graphically in Fig. 1 and detailed in Table II, can only give the breakout for a make/buy decision for an exact match of circuits on a board to those needed in a system. The breakover is at about the 500-board level. The decision to buy allows the system manufacturer to put his best expertise in his areas of uniqueness. Thus, he maximizes his return on investment and minimizes his risk factors in the timing related to product introduction.

The CMOS Microboard

The CMOS Microboard has, as mentioned above, many valuable features. Because it is based on the CMOS technology, it is characterized by low power dissipation and, therefore, dissipates less heat. The latter feature increases reliability since, classically, high temperatures lead to high failure rates in semiconductors, as well as in most other components. In addition, in most cases, the designer who employs Microboards can eliminate cooling fans from his design, and thereby reduce the cost of his power supply.

The CMOS Microboards have a greater noise margin than other technologies because the logic swings rail-to-rail; i.e., a logic 1 is 5 volts and a logic 0 is 0 volts rather than a nominal 2.2 and 0.4 volts, as for a TTL bus. This greater noise margin is very advantageous in industrial environments with noisy electrical backgrounds.

Another feature of the RCA CMOS Microboards is their small size, which allows for compact volumetric packaging.

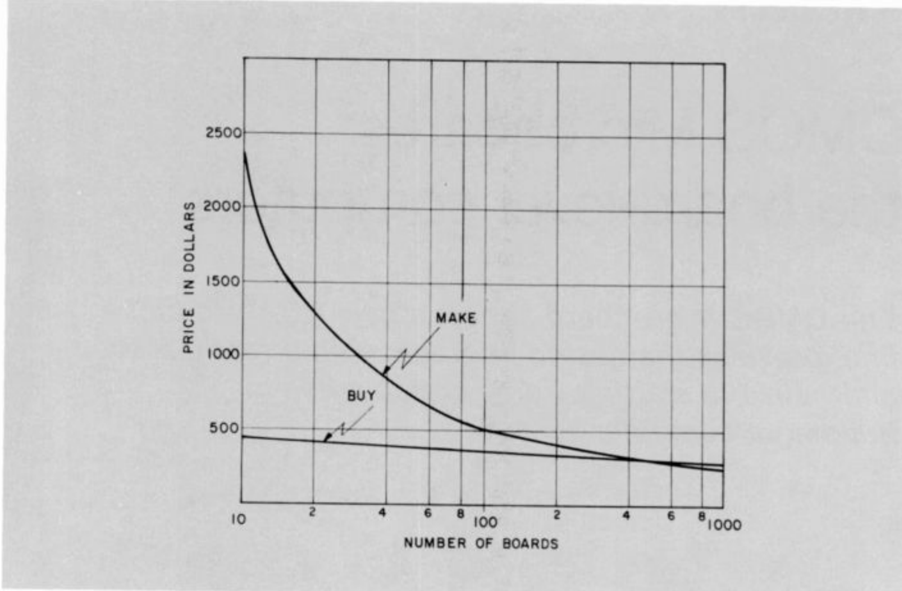

Fig. 1. The cost factors of Table II provide the plot for a typical make/buy price curve for board-level computers.

Table I. RCA CMOS Microboards.

	RCA part number	*Description*
CPU	CDP18S601	Microboard computer w/4-K RAM, 4-K/8-K ROM/PROM sockets
	CDP18S602	Microboard computer w/2-K RAM, 2-K/4-K ROM/PROM sockets
	CDP18S603	Microboard computer w/1-K RAM, 4-K/8-K ROM/PROM sockets
	CDP18S604	Microboard computer w/512 RAM, 1-K/2-K ROM/PROM sockets
Memory	CDP18S620	4-K static RAM
	CDP18S621	16-K static RAM
	CDP18S621V1	16-K static RAM
	CDP18S622	8-K static RAM/battery back-up
	CDP18S623	8-K static RAM
	CDP18S624	4-K static RAM/battery back-up
	CDP18S625	8-K/16-K/32-K ROM/PROM
Comb. memory & I/O	CDP18S660	40 I/O lines, 2-K RAM, 4-K/8-K ROM/PROM sockets
I/O	CDP18S640	Control/display module
	CDP18S641	UART interface
	CDP18S642	12-bit D/A converter
	CDP18S643	12-bit A/D converter
	CDP18S644	Comb. A/D-D/A converter
	CDP18S646	Parallel I/O and peripheral interface
	CDP18S661	Video-audio-keyboard interface
	CDP18S659	Breadboard w/prewired power and GND
Prototyping systems	CDP18S691	Microboard prototyping system for CDP18S601/603 computer board
	CDP18S692	Microboard prototyping system for CDP18S602 computer board

Table II. Make/buy cost comparison.

Number of boards	10	50	100	500
		Units in $		
Tooling* (drafting, layout, setup)	300	80	40	8
PC board-double layer	80	25	20	15
Board stuffing	50	30	20	18
Semiconductor content (including stocking, and incoming mark-up of 15%	230	154	148	125
Other components	30	18	16	14
Test, burn in and retest	120	80	60	50
Manufacturing cost total	810	387	304	230
Estimated yield loss-15% (return and service included)	122	58	46	35
Non-recurring engineering and production documentation cost*	1500	300	150	30
Cost Factors				
Total make cost	2432	745	500	295
Total buy cost	446	396	346	297

*Per board

While the CMOS circuitry contributes to the compactness of the boards — for example, 16-K bytes of static RAM can be packaged on one Microboard, mainly because of the need for far fewer capacitors than are required with other technologies — the primary reason for the small size of the boards is the architecture of the interface. The CMOS boards are designed so that one edge plugs into the Microboard Universal Backplane. (Connections to the outside world are provided, when required, on the opposite edge of the board.) The backplane communicates with other boards in the line and facilitaties interchangeability; it is very economical in pin count, with only 44 contacts, and supports one microprocessor per bus. By use of I/O and/or DMA for communication, the Microboard interface could support any number of processors. In many cases this approach may represent the better way of handling distributed processing. A second alternative would be to use a more complex bus, such as the Multibus,™ which is becoming a *de facto* standard, to support multiprocessor communication. The Multibus,™ with its 86 contacts, has a board size of 6.75 in. x 12 in.

System development support

Three levels of equipment development aides are available to support the designs using CMOS Microboards: (1) Prototype Kit, (2) Development System, and (3) Micromonitor.

The prototype kit shown in Fig. 2 allows the designer, with a minimum investment, to design with CMOS Microboards. The kit (CDP18S691) has a 5-slot chassis and is supplied with a CDP18S603 computer board, a control and display board, and a blank board for special-purpose breadboarding. A small power supply is also included. Other memory and I/O boards can be purchased as required.

The COSMAC Development System (CDS), either the CDP18S005 shown in Fig. 3, or the CDP18S007 features plug-in capability for Microboards. With the hardware and software capability provided by this system, the designer can develop the board set required for his equipment. The CDS, either the CDS18S005 with the COSMAC Disc Operating System upgrade package (the CDS18S837) or the CDS18S007, includes disc operating-system hardware and software for more software-intensive designs and use of higher-level languages.

The Micromonitor (CDS18S030), either by itself or in conjunction with the CDS systems, provides in-circuit emulation as well as debug capability, and a means of testing a complete system. The Micromonitor is shown in Fig. 4. The Micromonitor cable can be plugged into the CDP1802 microprocessor socket to

Fig. 2. The prototype kit allows the designer to design with CMOS Microboards with a minimum investment.

Fig. 3. The COSMAC Development System features plug-in capability for microboards.

Fig. 4. The Micromonitor provides in-circuit emulation as well as debug capability.

incorporate the Microboards into a final system, ready for testing. The addition of the COSMAC Micromonitor Operating System (MOPS) adds symbolic debugging and an automated test and data-logging capability.

A detailed CMOS Microboard description

The CDP18S601 and CDP18S603 offer a combination of on-board ROM and RAM as well as a parallel and serial I/O. Table I summarizes the on-board capability. Figure 5 shows the CDP18S601 board with placement of the various functions. The parallel I/O is programmable using the CDP1851 Programmable Input Output (PIO) LSI chip. The 4-K byte RAM utilizes the newest CMOS 4-K RAM components, and the ROM sockets are wired for the industry standard ROM/EPROM pinouts. The computer boards require only 7-mA (not including ROM/EPROMs or 20-mA serial interface).

CMOS Microboard Systems have memories as large as 65,536-bytes. Additional RAM is divided into two categories: RAM and battery back-up RAM. RAM is offered in 4-, 8- or 16-K-byte boards. The 16-K-byte static board is shown in Fig. 6. This board is very compact and consumes only 11 mA operating at 2.0 MHz. Memory-board sizes can be mixed within a system.

The battery back-up board is available in 4- or 8-K bytes. A photograph of the board is shown in Fig. 7. This board, with an additional rechargeable cell added to the battery, can supply power to a complete system. Another feature of this board is its ability to retain storage of a program even after it has been removed from the system. By transporting the board to a master storage chassis, a library can be generated and maintained. A program can be readily erased or altered, one word at a time, a feature not available with EPROMs. A switch on the board shuts off the write mode to prevent accidental overwrite or erase.

Parallel I/O, serial I/O and RAM/ROM combination boards are also available; their capabilities are summarized in Table I. Additional boards such as multichannel A/D and D/A types with 12-bit capability are part of the line. These boards allow communication from the analog to the digital world and vice versa. To communicate with both the keyboard entry world and the visual world, a video-information system board interfaces a full alphanumeric keyboard and a video display with the microprocessor. A complete "smart" color terminal, customized to the user's application, can be designed. In industrial applications, commands or warnings can be displayed to the operator of equipment. The low power of the CMOS board set allows for a trim, compact CRT terminal with a large memory. Many more I/O special functions, such as power drive and opto-coupling, are presently in the planning and design phase and will expand the line.

The CMOS Microboard line is built to

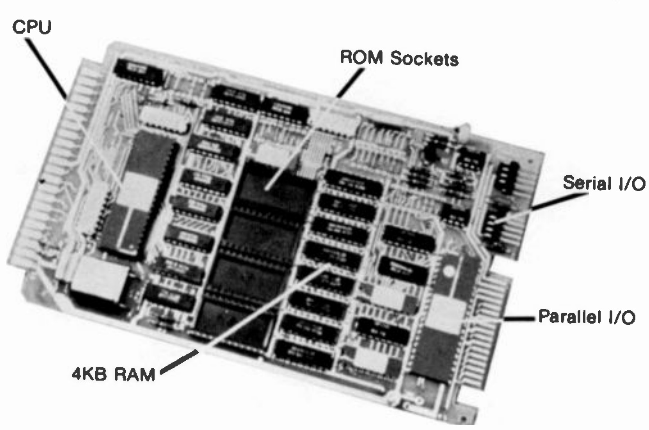

Fig. 5. The CDP18S601 computer board offers a combination of on-board ROM and RAM as well as parallel and serial I/O.

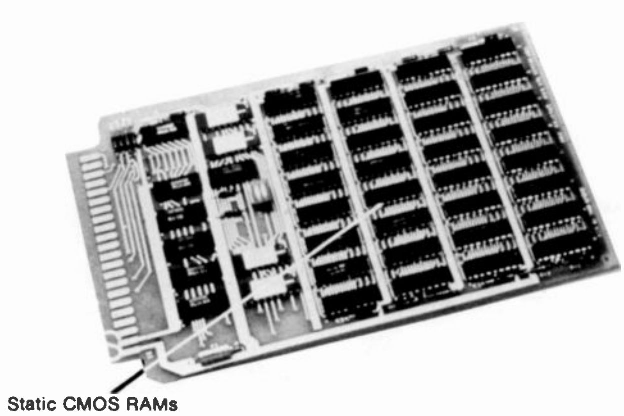

Fig. 6. The 16-K-byte static memory board is very compact and consumes only 11 mA when operating at 2.0 MHz.

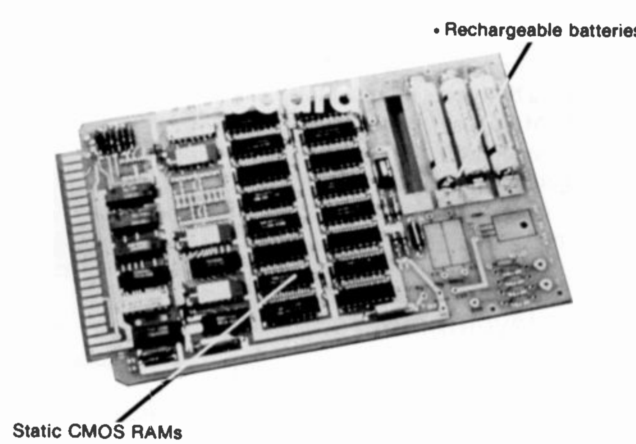

Fig. 7. The battery back-up memory board can retain storage of a program when disconnected from the system.

Table III. Comparison of 8-bit board-level computer lines.

	CMOS Microboards	*STD bus boards*	*SBC boards*
Manufacturer	RCA	Mostek Prolog	Intel National ETAL
Type - μP logic	CMOS CMOS	NMOS TTL	NMOS TTL
Size (inches)	4.5 x 7.5	4.5 x 6.5	12.0 x 6.75
Complexity	High	Medium	High
Bus	44 pin CMOS universal	56 pin Std bus	86 pin Multibus™
Any board — any slot	Yes	Yes	No
Multiprocessor bus	No	No	Yes
Typical operating power (mA)*	8	1000	4700
Bus line noise margins	High (CMOS)	Medium (TTL)	Medium (TTL)
Development systems support • hardware • software • emulation	 Yes Yes Yes	 No Yes Yes	 No Yes Yes

*Processor Board

industrial grade. The boards are extensively tested and burned-in for 72 hours under power and then fully retested. This sequence of tests assures the designer of high quality and low infant mortality (early failure) rates.

Software — a major key in design

The role and cost of software design in the use of microprocessors has become a major factor. Good tools are available to aid the development of machine-language software in developmental systems; machine language is most economical in terms of board hardware costs. However, development of software in higher-level languages requires additional hardware (memory) cost. But in more and more applications, this cost tradeoff is the cost-effective approach because "silicon is cheap" compared to software development. The implementation of BASIC 1, BASIC 2, and PLM for CMOS Microboards is in various stages of planning, development, and availability. BASIC 1 and BASIC 2 are less complicated from the user's point of view, but they are the least silicon efficient. PLM is one of the better matches, and is a language developed with microprocessors in mind. Compilers and interpreters are usable. The availability of higher-level languages for microprocessors is increasing rapidly, and most of the languages are usable in board-level products. Continuing improvements over the next decade can be anticipated, and will provide more efficient code and more flexibility of use.

Other board families

Table III compares three major 8-bit microprocessor board lines: the Microboards (RCA), Standard-Bus Boards (Mostek, Prolog), and SBC Boards (Intel, National, *et al.*) This table reveals that the RCA CMOS boards offer the advantage of low power and very compact bus structure. The tradeoff for this compact bus is the one-microprocessor-per-bus restriction (see Table III, "Multiprocessor bus"). All the lines are in the same price category except for the CMOS static memory, which is more expensive than NMOS dynamic memory. However, packaging economics and the requirement for cooling fans should always be considered in any cost analysis.

Conclusion

CMOS Microboards, a new RCA product line, offer the engineer a hardware "buy" rather than a "make," fully supported by equipment development aides and machine-language tools. Higher-level languages are available and more are under development. The low-power features of CMOS offer the designer low power-supply cost, high-noise margins, and a good system-packaging factor. The boards are industrial quality: burned-in and extensively tested. The CMOS Microboard line represents a wide choice of board product for the "buy/not-make" designer.

Dick Ahrons rejoined RCA in 1978 as Manager in the Microprocessor/Memory activity at the Solid State Division after three years with Motorola as manager in their CMOS operation and a number of years of Vice President, Engineering, with OPCOA, a company that he founded. Dr. Ahrons had previously spent ten years at the RCA Laboratories, where he worked on a variety of programs, and five years at the Solid State Division as Manager, Advanced Applications and Devices. He has been involved with RCA microprocessor and memory programs as well as with microprocessor systems since 1978 and, as Manager of the Microprocessor Systems group, piloted the introduction of the CMOS Microboard line in 1979. He is currently Manager, Microprocessors and Memories, in the LSI operation at the Solid State Division.

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Reference

1. "COSMAC Microboard Computer Systems," RCA Solid State Catalog CMB-250A. Contains CMOS Microboard specifications.

D. Hampel

Application of VLSI to "smart sensors"

Techniques now exist for a complete CMOS/SOS VLSI processor, including analog conditioning, A/D conversion, microprocessor, multiplier, ROM and RAM.

Abstract: *A family of "smart sensors" is described for implementation with VLSI, and for use in both information gathering and munitions fuzing systems. The sensors are based on a micro-signal processor technique capable of identifying, detecting, and/or classifying particular target signatures in real-time with a high degree of reliability and flexibility while meeting system constraints of low cost, small size, and very low power dissipation. Applications are described using seismic and acoustic inputs for information gathering and mine fuzing, and hydrophone inputs for underwater acoustic processing. The algorithms used in these "smart sensors" are based on signal processing using spectral analysis.*

A system of "smart sensors" is needed by the U.S. Army for target classification and munitions fuzing. This system must be capable of sophisticated pattern recognition of time-series waveforms from their transducers. These functions must be performed in "real-time," i.e., fast enough to process input data in a given interval and make a decision before a target disappears. The main application areas are:

1. *Classification*. This seismic/acoustic sensor must have the capability of detecting and classifying personnel, wheeled vehicles and tracked vehicles in a variety of environments. Physical security or intrusion detection systems represent a related application area.

2. *Munitions fuzing*. Requirements exist for "smart sensors" capable of selective target recognition from seismic/acoustic signatures for effective mine systems.

3. *Underwater acoustics*. The sensor must have the ability to aid in underwater target classification.

Prior attempts at realizing such sensors with relatively simple signal processing have resulted in undesirable performance levels.

The ability to perform spectral analysis is the key to reliable discrimination. Therefore, the Fast Fourier Transform (FFT), which is employed in spectral analysis, and its speed of execution are important parameters in determining the processor requirements.

In order to extract the necessary intelligence from the transducer signals, an algorithm, or procedure, is derived, specifying all of the processing steps to be performed to identify or classify the nature of the input signals. Figure 1 is a general flow diagram for a sensor, indicating the major processing steps and their associated functions. Not all steps are required for each application; the basic micro-signal processor is programmed according to the specific algorithm derived by a combination of heuristic and statistical analysis performed on a data base of representative signatures.

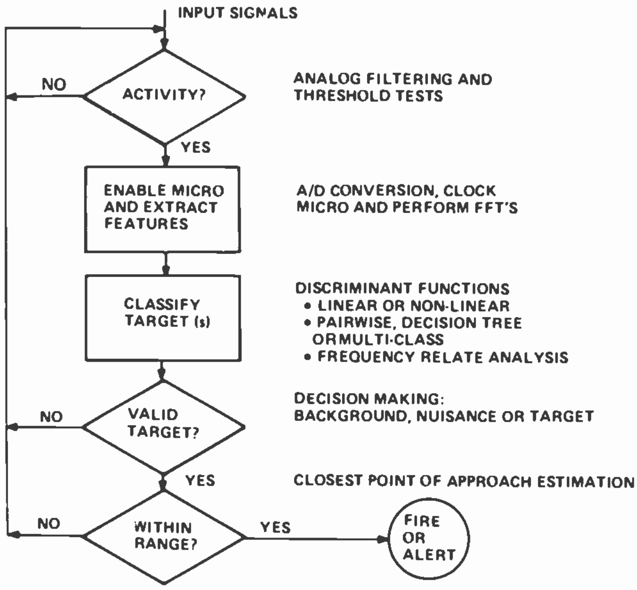

Fig. 1. A flow diagram, indicating the major processing steps and their associated functions, incorporates the algorithm approach.

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Nature of the algorithm

Prior to digitizing the input signals and performing feature extraction, the very low power dissipation applications require an activity detection state. This is done because the feature extraction, based on spectral analysis using FFT, is essentially the most demanding computational task, and its execution is minimized by performing it only when there is a target to determine. Before decisions can be reliably made, the feature extraction phase usually involves integration of multiple FFTs for signal to noise improvement. Following feature extraction, specific spectral components are operated on in a so-called series of discrimination tests. This is illustrated in Fig. 2 where the input analog signal can be traced through "analog conditioning," FFT, and discrimination phases. A discrimination test determines whether a specific class of data is a target, or a background nuisance class. Some sensors do not need a discrimination phase *per se* but merely examine the relationship of certain spectral components. If a target is present, in certain cases, an attempt is made to determine whether or not it is within a lethal range of the munitions, or is moving into a lethal range. The range test generally uses the cross-correlation functions. If no target is evident after a series of such calculations, after a delay (to allow the disturbing influence to decay), the activity detection state will again be entered.

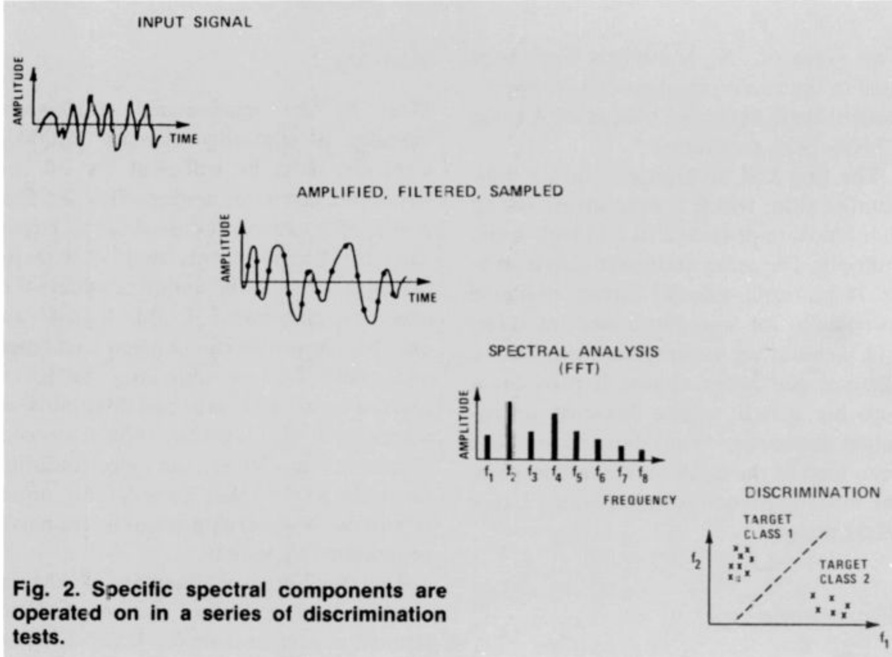

Fig. 2. Specific spectral components are operated on in a series of discrimination tests.

The functional devices of the signal processor

Each of the applications has a microprocessor-based signal processor, as shown in Fig. 3. This common set of blocks will be described prior to a discussion of brassboard feasibility models and the design transition to VLSI.

Analog conditioning

First of all, "analog conditioning" is needed, i.e., all of those functions required to couple the transducer outputs to the microprocessor's bus. These functions include:

1. *Amplification* — Automatic Gain Control (AGC) provides for signals with dynamic ranges greater than 8- to 12-bit monolithic A/D converters can accommodate, since dynamic ranges of 100 dB or more are of frequent interest.
2. *Presampling filtering* — Low Pass Filters are used to prevent aliasing. Sharp cutoffs, requiring six poles or more are frequently necessary to minimize the sampling rates.
3. *Activity detection filtering* — Bandpass Filters are used to monitor energy in given bands to control turn-on of the higher power consuming microprocessor circuitry prior to attempting target classification. Two pole configurations are generally sufficient for this function.
4. *Analog multiplexing and conversion* — Multiplexer and Analog-to-Digital Converter are used for coupling the multi-channel inputs into the common converter, providing a sample-and-hold function for the sampled inputs, conversion itself (using a successive approximation A/D converter with a D/A ladder), and the interface for the microprocessor bus.

While, for the last two years, the final analog function has been available in CMOS form, in standard ICs, the other functions, amplification and filtering have recently been adapted to CMOS LSI circuitry. This development, crucial to any VLSI implementation for the "smart sensors" will be shown, after describing the feasibility models.

Multiplier

The remaining signal processing functions are all digital in nature. Because of the need for relatively high-speed computations (particularly the FFT), a hardware multiplier is required to augment the microprocessor. Software multiplication would be far too slow and/or power consuming.

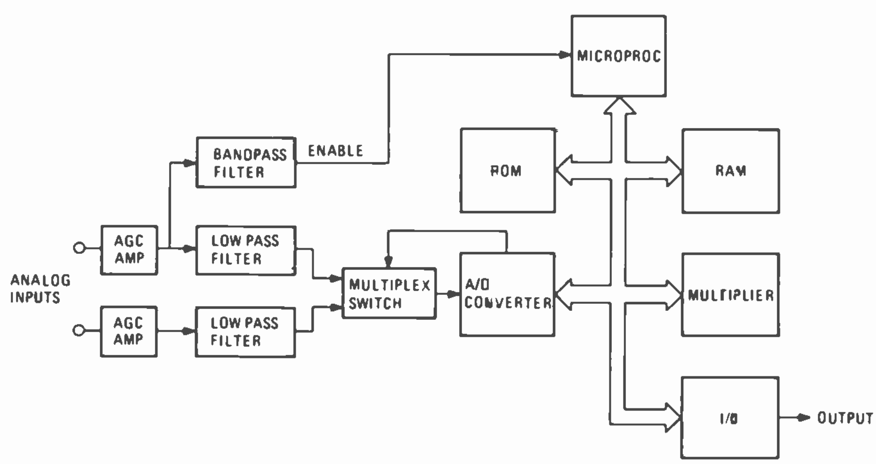

Fig. 3. Each application has a microprocessor-based signal processor.

Two types of LSI multipliers have been used in the micro-signal processor models. Both of these have been built at RCA using CMOS/SOS technology.

The first LSI multiplier is an 8 x 8-bit parallel chip, which is expandable (using four chips) to provide a 16 x 16 high-speed multiply. The other multiplier chip is an 8- or 16-bit serial-parallel circuit designed specifically for microprocessor interface, and includes an accumulate function. In balance, the latter approach provides a superior match to the low-cost micro-signal processor. While both types have been used in the RCA brassboard models, the latter approach is incorporated in the VLSI design.

Microprocessor

Our original micro-signal processors were based on the commonly available, low power CMOS, 1802 microprocessor. The VLSI design will incorporate the features of the new 1804 microprocessor; an SOS version which is software compatible, but also contains a clock source as well as area for ROM and RAM. (In the custom VLSI design, these areas will be modified for optimum memory partitioning, as discussed later.) Using the SOS process, this design is twice as fast at about the same power dissipation level, providing greater signal-processing flexibility.

Although we use an 8-bit micro, some of the calculations are done in double precision, when necessary.

Memory

Most of the micro-signal processor's memory is read-only memory (ROM). Capacity must be sufficient for all instructions, constants, and coefficients. The sensor applications discussed in this paper have ROM requirements from 2-K bytes to 8-K bytes. Our initial design considers the mask programmable ROM, which can only be changed by running new part types and trade-offs are ultimately made to assess whether or not the cost differential is warranted for given applications. However, in VLSI, an electronically alterable ROM takes considerably more (about two-to-one) chip area than the mask programmable variety.

The random-access memory (RAM) is used for data collection and intermediate storage; capacities from 0.5-K to 3-K bytes are sufficient for these sensors. This is fortunate since the area per bit for RAM is significantly higher than that for ROM.

Packaging the LSI design

Brassboards have been built for each of the application areas using state-of-the-art LSI components. The "analog conditioning" requirements were met with low-power active filters using discrete resistors and capacitors and operational amplifiers. The microprocessor used was the CMOS 1802, the multiplier was one of the CMOS/SOS parts discussed previously, and the memory included both CMOS ROM and RAM. Miscellaneous control logic and input/output circuitry was incorporated in each brassboard for specific test, evaluation, and demonstration purposes.

Two of the models are shown in Figs. 4 and 5. The first brassboard is used for mine fuzing, where, using seismic and acoustic signatures, given targets are detected and classified.

The hardware for the first brassboard includes duplicate RAM for accepting the ROM contents, for ease of algorithm modification in the laboratory or in the field using a micro-terminal. The first board contains the "analog conditioning" circuitry, while the other three boards contain the microprocessor, clock, memory, and associated digital circuitry. Note the relative complexity of the analog board and the importance of applying VLSI technology to these functions, as well as to the traditional digital subsystem, for a low-cost sensor.

The first brassboard was programmed to perform all detection and classification functions for low-power-disappation mine fuzing. The functions performed include activity detection, spectral analysis using 64-point FFTs on both seismic and acoustic channels, evaluation of discriminant functions or threshold tests using specific features, cross-correlation for range estimation, and decision making. Tests were conducted in a laboratory environment using analog tape recordings and in the field using actual seismic signals, indicating the viability of the approach and the potential for highly reliable operation.

The brassboard in Fig. 5 was constructed for sonobuoy application on 10-centimeter-diameter wafers, in conformance with a standard "A" configuration buoy, for interface with a hydrophone. Tests made from analog tape signatures, where the outputs of the micro-signal

Fig. 4. Typical brassboard micro-signal processor for mine fuzing.

Fig. 5. Brassboard for acoustic micro-signal processor.

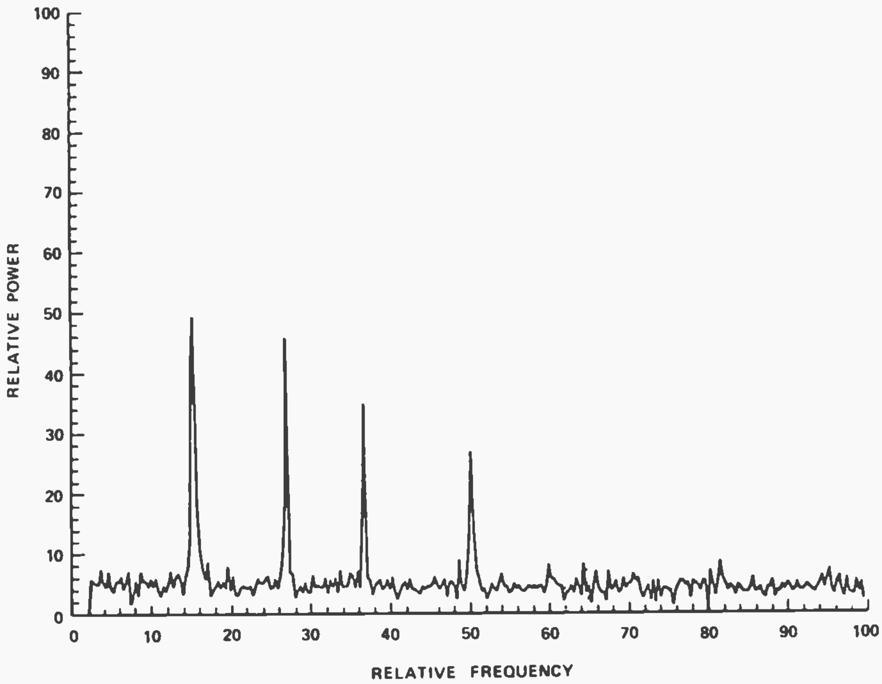

Fig. 6. The spectral outputs from the acoustic processor were plotted for testing.

processor were plotted, as shown in Fig. 6. Using the same basic family of ciruicts, this 410-cubic-centimeter volume assembly dissipates 50 milliwatts when fully operational and has been demonstrated in the performance of FFTs, integration, and frequency relationship analysis.

Transition to VLSI design

While most of the functions described are quite compatible with improved IC processing technology, the key to a complete VLSI design is the incorporation of the analog conditioning. We have developed low power dissipation monolithic analog conditioning using CMOS operational amplifiers (which have already been proven in A/D converter designs as well as other linear ICs) and switched capacitor techniques to simulate accurate resistors. The principle is shown in Fig. 7. By switching the current in and out of the input capacitor, C_1, of an op-amp with a feedback capacitor, C_3, it is seen that an RC equivalent, or "pole", is achieved which depends solely on a capacitor ratio (the precision of which is easy to achieve in MOS technology) and the switching frequency. Not only can well-defined poles, which are the building blocks of filters, be built, they can, if desired, be moved under clock control from a crystal source and divider chain.

An LSI array of such cells has been built for demonstration and test. Figure 8 shows a chip containing 12 poles and two programmable amplifiers which were connected to meet typical "analog conditioning" requirements for a "smart sensor." The different input capacitor areas are noted for different filter responses. The poles were interconnected to provide a sharp-cutoff 6-pole low pass filter for presampling, two 2-pole bandpass filters for activity detection in given bands, and a 2-pole low filter for feature extraction purposes. The uncommitted amplifiers on the right side of the chip are programmable in 6-dB steps and can provide up to 42 dB of gain.

By extracting from each of the functions those essential components that are required for a typical sensor and eliminating those elements on each that were there for interface and general use, the custom VLSI design shown in Fig. 8 can be derived. This is a conservative design using device geometries and areas based on the existing 4- to 5-micron* technology used in each of the present LSI counterparts.

Table I shows the densities of each individual area for the layout of Fig. 8. The packing densities are derived from existing designs. They reflect the differences between the very regular (memory) and relatively irregular logic portions (the microprocessor's arithmetic logic unit (ALU) and programmable logic array (PLA), as well as the multiplier/accumulator). The analog function areas depend largely on the amplifier geometries and the capacitors, which represent the capability for a typical application based on the developmental LSI discussed previously.

Extension to 1.5-micron technology (to be available within the next four years) will not only speed up the circuitry on this chip substantially, but reduce chip area (and hence cost) and power dissipation.

These developments will result in increased capability, permitting additional features such as adaptive filtering for noise reduction and expanded memory to improve classification for a variety of sites. More reliable decisions can be made at reduced power-dissipation levels leading to new systems applications.

The single-chip design also leads to a minimization of interconnections (and

*MOS transistor channel length and interconnect metal widths and spacing.

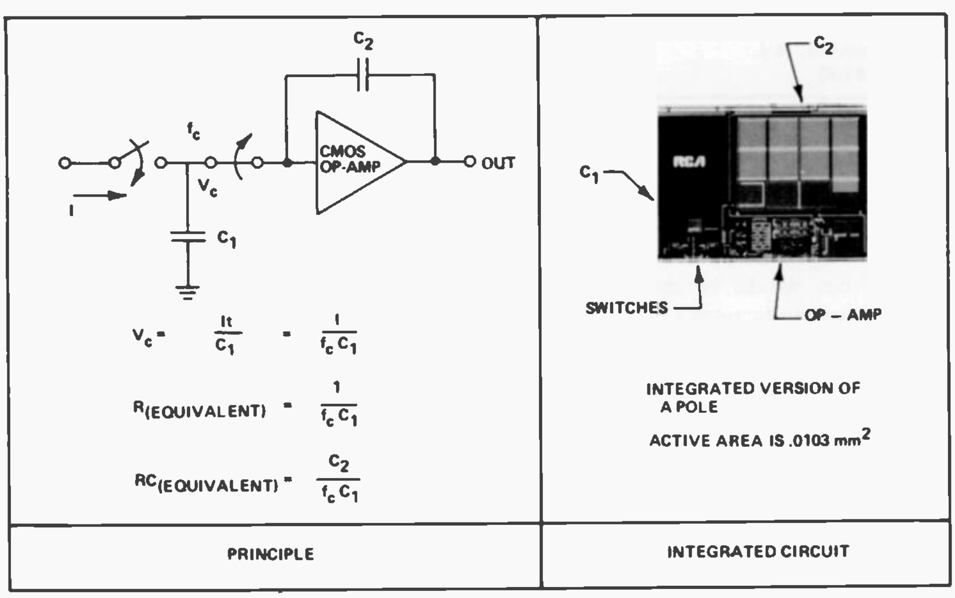

Fig. 7. The key to a complete VLSI design is the incorporation of analog conditioning.

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hence improved reliabilities) since virtually all connections are integrated. In theory, there need only be one or two inputs and a single output activation or signal lead. (In practice, provisions for access to the "internal" bus would be made for test and monitoring functions.)

The universal nature of this deisgn (resulting from the commanality of functions it provides for the applications discussed) provides another dimension of economy. Reprogramming the chip's ROM and changing the clock rates for certain filters on the front-end would make the same chip useful for a number of tri-service munitions and surveillance applications.

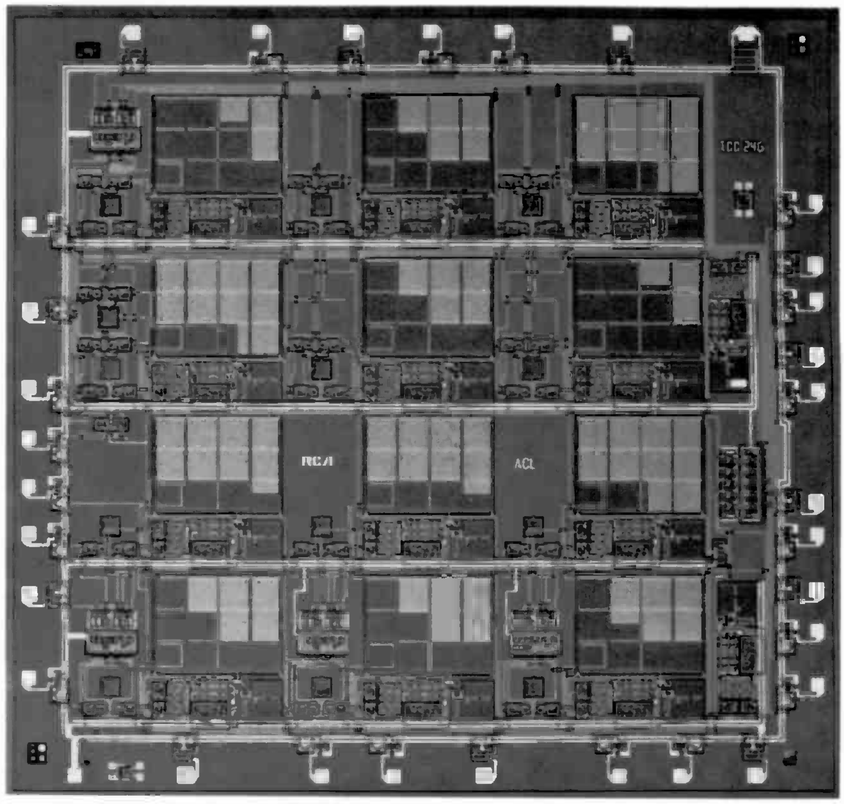

Fig. 8. This LSI filter/amplifier chip is used for analog conditioning for smart sensors.

Summary

The implementation for these "smart sensors" must be low cost and have low power dissipation for system effectiveness. For the most part, the brassboards, along with their capabilities and performance, use existing LSI parts. Power dissipation levels from 5 to 80 milliwatts and FFT sizes from 64 to 1024 points have been demonstrated as were related discrimination function computations.

The one missing link, up to now, in converting these designs into an effective VLSI circuit is the ability to monolithically integrate the analog conditioning functions of amplification and filtering along with the digital functions. This step has recently been completed using switched-capacitor CMOS arrays.

Techniques now exist for a complete CMOS/SOS VLSI micro-signal processor, including analog conditioning, A/D conversion, microprocessor multiplier, ROM and RAM. First, these six functions can be assembled in a transitional leadless hermetic package (LHP) array on a 12.5-cm^2 ceramic carrier to provide a state-of-the-art miniature sensor.

The areas of existing LSI designs are apportioned to form a composite VLSI layout. Even with present, modest, 4- to 5-micron device geometries, a stand-alone chip is feasible for a general-purpose use. Average memory capacity is allotted and more demanding requirements can be met by simple outboard expansion.

Table I. VLSI chip densities.

	No. of devices	*Chip area (mm^2)*
"Analog conditioning"	700	9.8
A/D converter (and MUX)	600	9.5
Microprocessor	10,000	9.3
Multiplier	3,000	9.4
ROM	32,000	9.8
RAM	5,000	3.5
Total	51,300	51.3

Results of the LSI hardware, algorithm software and VLSI projections indicate that better performance sensors (lower cost *and* lower power dissipation) are not only possible, but that they will be smarter than existing counterparts. More inherent flexibility and pattern-recognition capability will have a profound effect on the future of munitions and intelligence sensors.

Acknowledgment

The support of GCS management and the achievements of the ACL team headed by K.J. Prost, in the development of the sensors discussed in this paper are gratefully acknowledged. Also, the efforts of J.L. Moffa in coordinating and marketing are appreciated.

J.P. Mergler

A natural command language for C³I applications

Development of a natural command language and a control and analysis console provides the required interface between equipment and operator for C³I applications.

Abstract: *In the field of Command, Control, Communications and Intelligence (C^3I), the key interface is the point at which the human operator interacts with the system. To make this interface more efficient, RCA is developing a natural command language and a control and analysis console designed to simplify the operator's tasks. The heart of the console is the DEC LSI-11 microcomputer, supported by 16-K words of memory, a serial interface component which connects the console with a host computer, an audio interface for voice communication, and a keyboard. The author describes the language which utilizes English and a natural syntax, and explains how it integrates with the hardware. He concludes that results have demonstrated the effectiveness of this natural command language.*

Command, Control, Communications and Intelligence (C^3I) has become increasingly sophisticated and highly automated, employing the most advanced technological state-of-the-art hardware and software systems. The most critical part of the C^3I system centers on the interaction of an operator with the system and the operator's ability to control its functions to best serve its purpose.

C^3I systems are highly volatile due to the normally unpredictable external influences they must accommodate. These systems operate in highly time-sensitive environments at varying volume rates that tax the system's capabilities, often to supersaturation. They then must operate in an accelerated "catch-up" mode for a minimal time period. It is during this condition that the results of effective man-machine interaction design are most clearly demonstrable.

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The automated C³I system

Every automated C^3I system typically contains a central processor (Fig. 1). Depending upon the system's application, tactical or strategic, and the overall size of its mission, the central processing system may consist of large-scale computers, mini- or microcomputers or hybrid configurations containing any combination of each. The systems may function as central or distributed processing systems and selected central processors may provide various specific capabilities: front-end communication processing, formatting, event recognition and complex calculations providing assessments and predictions.

Large-volume, fast, on-line mass storage devices and bulk storage units, such as magnetic tape, are essential to retain current and historical data.

Output media vary but cathode ray tube (CRT) or plasma displays are widely used because of their ability to rapidly display highly time-sensitive (and perishable) data to a human for review. High speed printers are also employed to provide hard copy records, and for distribution.

The man-machine interface

The focal point of a C^3I system is the Controller or Analyst Console — the point where man and machine interface. Here the system meets the requirements to support the mission. The console is not a terminal, *per se*, but is in the midst of the processing system. Incoming data are routable to the console. The operator may access and display any stored data through it. Subsequent disposition of data are controlled by the console operator.

The console is minimally equipped with alphanumeric monochromatic displays (CRT or plasma). Advanced consoles contain full graphic displays capable of digital and analog data representation. Monochrome displays are sometimes replaced by full color capabilities providing additional dimensions of recognition and comprehension.

The console contains a standard keyboard which may be augmented by additional keys designated to perform

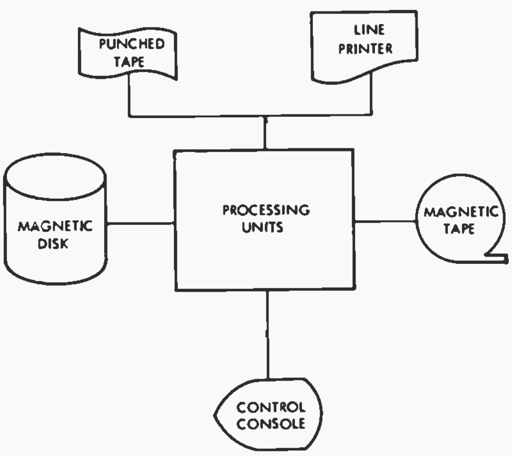

Fig. 1. Every C³I system typically contains a central processing unit, mass storage devices, output media, and a control console.

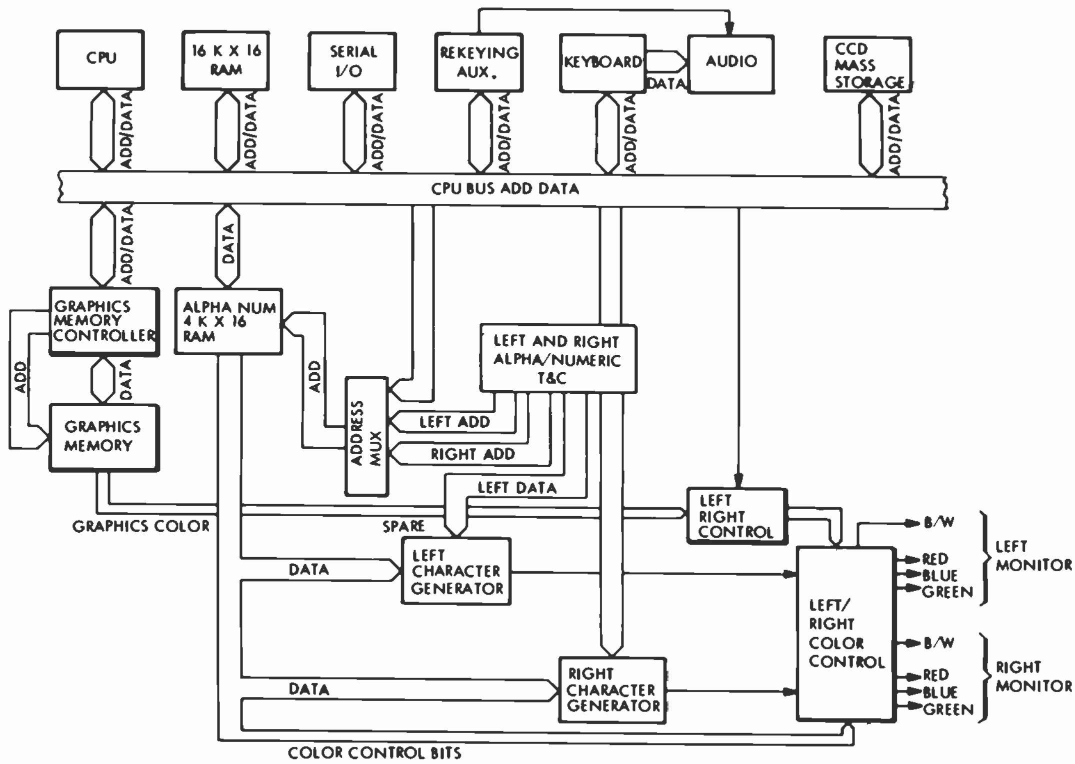

Fig. 2. The heart of the RCA control console is a DEC LSI-11 microcomputer, a serial interface, an audio interface and a keyboard.

specific pre-definable functions which an operator may very easily initiate. These pre-defined functions are usually those which are repeated often or would otherwise slow the operator's interaction by forcing definition of algorithmic parameters to fixed or semi-fixed routines.

RCA's Control and Analysis Console

RCA is developing a Control and Analysis Console capable of performing the above functions. Figure 2 shows the architecture of the RCA console. The heart of he console is a DEC LSI-11 microcomputer supported by 16-k words of memory, a serial interface part which connects the console with a host computer, an audio interface for voice communication and a keyboard. Also shown is the expansion capability of the console. A charge coupled device (CCD) memory is under development and will be implemented into the console design providing a fast, accurate and inexpensive mass storage device. Also connected to the central processing unit (CPU) bus is the alphanumeric refresh buffer associated with dual CRT monitors. This provides the means to display data by operator action or automatically from the data base. The graphics memory controller and graphics memory provide the operator with inputting, storing and retrieving graphic display capability. Graphic displays may be selected by depressing a console function key. The Control and Analysis Console is shown in Fig. 3. All components of the console (i.e., computer, memory, and the graphics generator) are integrated into the console, providing stand-alone flexibility and versatility.

Console simplification of the analyst's job

One use of the C³I system is to monitor the early warning detection reflections of penetrating non-friendly aircraft from various sensors. Location, speed, heading and identification data from each sensor must be received, assimilated, verified and analyzed to ascertain threat potential and, if justified, to plan and direct reaction missions to counter the threat.

Time is of the essence and the Controller/Analyst must be capable of accurately and easily interacting with the event. He will be required to read the reports and determine which comparative data he must retrieve from the system's storage, initiate complex algorithmic processes and evaluate their results. He may then need to originate communications as a report or a task.

To facilitate these many actions the Controller/Analyst needs assittance from whatever sources are available. The Control and Analysis Console is a beginning. It makes his job easier by its human-engineered layout and construction. Depression of single specialty-function keys activates procedures almost without further operator intervention. Some of the keys condition the software to establish logical steps to guide the operator through sequential actions of processing steps.

Operator and machine interaction in a C³I system

No C³I system is, nor should be, designed to make "command decisions" automatically. Instead, the system should assimilate the pertinent factoral data, algorithmically process them and present qualified alternatives to the real "decision maker." The true master of the C³I system is the operator with whom the system interacts.

The operator must function expeditiously, accurately and effectively. This implies a working knowledge of what he must do or wants to do, and of the associated terms, acronyms and unique jargon used. All of this will be facilitated by the ease with which the operator learns the method to interact with the system and the manner in which he executes his functions.

Because of the critical nature of manual intervention in terms of time and system direction, the operator's tasks must be both minimized and simplified. The most obvious area requiring optimal design considerations is the linguistic dialogue between the man and the machine.

The machine can be made to react to almost any language that it may receive, within certain constraints imposed by the actual architecture of the hardware and/or the software employed. Nevertheless, a true basic premise is: the operative language design is less important to the machine than it is to the operator who must use it.

Development of C^3I command language

Combining the hardware capabilities of the RCA Control and Analysis Console with the operational needs of a C^3I system, the development of a command language evolved. The precepts addressed above guided the direction taken. The priority items considered during development of the command language are the following:

1. Ease of learning and operational use.
2. Natural language and common thought-process structuring.
3. Commands provided to perform all required C^3I operator tasks.
4. Flexibility to adapt to changing requirements.

Identification and categorization of commands

A set of commands was identified which enabled the system to perform those functions for which it was intended. They were screened for originality and non-duplication. Although each function could be performed in either the same or many ways, it was determined that an operator should be taught (allowed) only one way. This eliminates possible time-consuming confusion and allows a common resolution which becomes "second nature." Selection of the singular approach was always predicated on its ability to be expressed in the most unencumbered manner. Interchangeability of terms to express the same function is allowed in some instances and will be addressed later.

Categories of commands

Four major categories of commands are identifiable to hardware/software processes. However, they are transparent to the operator who views the categories as chronological or logical steps in the accomplishment of the task he wants to perform. Table I shows the categories of specific commands identified as essential to operation of a C^3I system and designed to complement the RCA Control and Analysis Console.

Fig. 3. The integration of all related hardware components into the console provides flexibility and versatility.

Command instruction syntax theory

When developing a natural language command instruction set, the semantic rules of grammar should be followed to take advantage of the user's inherent skills — the ability to communicate in a familiar language — in this case, English. Other languages may force variations to the syntax or format, but realistically adhere to a similar pattern.

All of the commands follow a basic syntactical structure (Table II). The structure allows the user to formulate the command instruction logically and in a "thought-process" manner.

The *command* is always an action *verb* and may be thought of as *WHAT* to do.

The *object* of the command is always a *noun* and may be thought of as *WHICH* data are to be acted upon.

The *adjective* or *adverb descriptors* (parametric values or delimiters) of the object may be included to make the data conditional. Boolean logic and relational

Table I. C^3I commands by category.

Initiate	*Manipulate*	*Dispose*	*Control*
Create	Analyze	Delete	*Abort/End/Stop
*Find/Search/Query	Compare	Display	Alter
Format	Edit	List	Assign
*Get/Select	Change character	Plot	*Clear/Erase
*Magnify/Zoom/Expand	Change word	Print	Cursor mark
Menu	*Delete/Erase character	Punch	Cursor move
Read	*Delete/Erase line	Purge	Execute
	*Delete/Erase word	*Send/Pass/Transfer	Help
	Insert character	Store	Hold
	Insert line	Transmit	Name
	Insert word	Type	Page ahead
	Mathematical operators	Update	Page back
	Merge	Write	Reassign
	Move		Rename
	Scale		Reset
	Sort		Restart
			Resume
			Scroll down
			Scroll up
			Sign off
			Sign on
			Skip

*Synonyms

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Table II. All of the commands follow a basic syntactical structure.

Command	*Object*	*Descriptive*	*Disposition*
VERB	NOUN	ADJECTIVE/ADVERB	VERB
WHAT	WHICH	(CONDITIONAL) WHEN	WHERE
FIND:	FIX-FILE;	LOC-5K/TU1246;	DISPLAY/SYM
PURGE:	ACTIVE-FILE;	STATUS=C, DATE<790923;	
QUERY:	TECH-FILE, TARGET-FILE;	FREQ=134.7.M;	LIST: ALL

operators may be used; therefore, the descriptors may be thought of as (conditional) *WHEN*.

Each command instruction must specify (in fact or by default) the disposition of the result of the execution of the command. This is *WHERE* the result may be located for retrieval or subsequent processing.

Therefore, an operator, by utilizing a thought-process, becomes conditioned to interact through a natural command language to express *What* to do with *Which* data *When* they meet certain conditions and *Where* they should be placed for their intended use. This has been found to be easily comprehended and eliminates the need for the user to be versed in the regimented formats known and used by programming-oriented personnel.

The rules of punctuation serve, naturally, to discriminate between the parts of the syntax. Colons are used to separate the main parts of the instruction (the command). Semicolons discriminate between parts of lesser importance while commas indicate interruptions (but continuity) of thought or structure. These punctuation marks are also used to make software development easier and functionally quicker than passing individual commands and comparing words and clauses to lexicons for recognition.

Command instruction software

Each command instruction is independently coded as a separate procedure providing a macro function. FORTRAN was chosen as the higher order language for implementation of these functions. Depending upon the memory capacity of the Control and Analysis Console, the individual procedures normally reside within the host processor and are downloaded as called.

The processing sequence

The adaptability to a wide range of C^3I applications is easily attained by the use of this technique. First, the operator initiates the desired command instruction. This is done manually or through activation of specialized function keys located on the console. Required parametric data is entered and the EXECUTE key is depressed.

Next, the entire command instruction undergoes a pre-process edit performed by a console-resident application program. This program is basically a tabular match of anticipated parameters. Should errors in format or data names and values be detected, the console returns the command instruction, with errors noted, to the operator for correction and re-execution.

If the command instruction is found to be correct, the console-resident software generates a call to the host processor requesting the appropriate routine be downloaded to the console where the command instruction is translated into a series of command messages to the host computer for subsequent execution and final disposition as directed by the operator's command instruction.

Software

Utilization of table-driven software has simplified both the development and interchangeability of the basic command language set. Actions desiring common results are often called or named differently by varying users. These terms are essentially synonymous and can be identified as replacements for each other. Such command groups as FIND, SEARCH, QUERY or SEND, PASS; and TRANSFER usually imply the same result is expected for each group. The application program is designed to react identically regardless of the actual synonymous command given. This capability is attained by use of an off-line initiated table into which an operator may load specific terms related to specific actions. At the time the command is edited, the table is searched and translations are made and the correct command message is passed to the host processor. Table-driven software expands the software's total capability and provides very flexible applicability.

Many optional software techniques have been incorporated into the development of command languages. These include in-line translation-compilers which consume valuable processing run time. Others divert all processing away from "dumb" terminals and burden the host processor, the effect of which is to severely hamper the host's ability to optimize system service. Our approach to a natural C^3I command language simplifies the original generation and subsequent modification through change, addition or deletion. The approach taken apportions the mundane tasks to the least significant point in the processing system and utilizes the services of the host processor most efficiently.

Summary

The natural thought-process command language presents a simple method to teach an operator to interface effectively with an extremely demanding C^3I system. It is logical and adaptable and can be incorporated with the assignment of special console function keys for frequently-used commands in order to expedite the entire through-put of a C^3I system. The natural command language, described above, has been demonstrated to provide effective results.

D.H. Pritchard|J.J. Gibson

Worldwide color TV standards — similarities and differences

Three major color TV systems are used worldwide. As a first step toward direct program interchange, we must understand how these systems work.

Abstract: *A tutorial discussion is presented of the NTSC, PAL, and SECAM color-television broadcast standards pointing out the basic similarities as well as main differences in areas such as bandwidths, field and frame rates, synchronizing approaches, and color-encoding techniques. The intent of this material is not to compare system performances, but rather to review the technical standardization characteristics pertinent to the topic of international exchange of images.*

The picture performance of a motion-picture system in one location in the world is generally the same as in any other location. Thus, international exchange of film programming is comparatively straightforward. Not so in the case of broadcast color-television systems. The lack of compatibility has its origins in many factors, such as constraints in communications-channel allocations and techniques, differences in local power-source characteristics, network requirements, pickup and display technology, and political considerations relating to international telecommunications agreements.

A concise summary of the similarities and differences in the ever-changing color-television-system techniques and standards employed throughout the world is difficult to achieve, as evidenced by the efforts of the International Radio Consultative Committe (CCIR) in attempting to establish the elusive "universal" system. Nevertheless, it is hoped that this tutorial review and update may be useful for those who desire a conceptual overview of the technical situation.

The intent of this material is to provide a tutorial review of the technical standardization characteristics pertinent to the problem of international exchange of images — not a systems performance comparison.

Background

The most outstanding, as well as controversial, effort of the XIth Plenary Assembly of the CCIR, held in Oslo in 1966, was an attempt at standardizing color-television systems by the contributing countries of the world. The discussions pertaining to the possibility of a universal system proved inconclusive. Therefore, the CCIR, instead of issuing a unanimous recommendation for a single system, was forced to only issue a report describing the characteristics and recommendations for a variety of proposed systems. It was, therefore, left to the controlling organizations of the individual countries to make their own choices as to which standard to adopt.

This outcome was not totally surprising, since one of the primary requirements for any color-television system is compatibility with a co-existing monochrome system. In many cases, the monochrome standards already existed and were dictated by such factors as local ower-line frequencies — relevant to field and frame rates — as well as radio-frequency channel allocations and pertinent telecommunications agreements.

Thus, such technical factors as line number, field rate, video bandwidth, modulation technique, and sound-carrier frequencies were predetermined and varied in many regions of the world. The ease by which international exchange of program material may be accomplished is thereby hampered and is accomplished at present by means of standards conversion techniques, or "transcoders," with varying degrees of loss in quality.

On the other hand, these techniques have provided surprisingly good service in more recent years, with the growing use of "satellite relays" coupled with the advances in digital signal-processing technology for both video and audio. This situation is expanding rapidly, and even more countries are arriving at the decision point every year, particularly in Latin America (Region II). Therefore, those involved in international live television broadcast and film/video-tape programming exchange must have a clear understanding of the implications of system variations.

The data quoted herein is referenced to the recent recommendations of XIVth Plenary Assembly of the CCIR, held in Kyoto, Japan in 1978. It should be recognized that the situation is continually shifting in nature and future decisions can and no doubt will alter some of the details.

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"Monochrome-compatible" color TV systems

The U.S.A. system — NTSC

To successfully introduce a color-television system, the color system must be fully compatible with the existing black-and-white system. That is, monochrome receivers must be able to produce high-quality black-and-white images from a color broadcast, and color receivers must produce high-quality black-and-white images from monochrome broadcasts. The first such color-television system to be placed into commercial broadcast service was developed in the United States. On December 17, 1953, the Federal Communications Commission (FCC) approved transmission standards and authorized broadcasters, as of January 23, 1954, to provide regular service to the public under these standards. This decision was the culmination of the work of the National Television System Committee (NTSC) upon whose recommendation the FCC action was based.[5] Subsequently, this system, now referred to as the NTSC system, was adopted by Canada, Japan, Mexico, and others.

Twenty-six years later, in 1980, these standards are still providing color-television service of good quality, which testifies to the validity and applicability of the fundamental principles underlying the choice of specific techniques and numerical standards.

The existing monochrome-television standards provided a foundation upon which to build the necessary innovative color-television techniques while simultaneously imposing the requirement of compatibility. Within this framework, an underlying theme — that which the eye does not see does not need to be transmitted nor reproduced — set the stage for a variety of fascinating developments in what has been characterized as an "economy of representation."[5]

The European alternatives

The countries of Europe delayed the adoption of a color-television system, and in the years between 1953 and 1967, a number of alternative systems that were compatible with their 625-line, 50-field existing monochrome systems were devised. The development of these systems was to some extent influenced by the fact that the technology necessary to implement some of the NTSC requirements was still in its infancy. Thus, many of the differences between the NTSC and other systems are due to technological rather than fundamental theoretical considerations.

Most of the basic techniques of NTSC are incorporated into the other system approaches. For example, the use of wide-band luminance and relatively narrow-band chrominance, following the teachings of the principle of "mixed highs," is involved in all systems. Similarly, the concept of providing horizontal interlace or reducing the visibility of the color subcarrier(s) is followed in all approaches. This feature is required to reduce the visibility of color-information-carrying signals contained within the same frequency range as the co-existing monochrome signal, thus maintaining a high order of compatibility.

An early system that received approval was one proposed by Henri de France of the Compagnie Francaise de Télévision of Paris. It was argued that if color could be relatively band-limited in the horizontal direction, it could also be band-limited in the vertical direction. Thus, the necessary two pieces of coloring information could be transmitted as subcarrier modulation that is sequentially transmitted on alternate lines — thereby avoiding the possibility of unwanted crosstalk between color-signal components. Thus, at the receiver, a one-line memory, commonly referred to as a 1-H delay element, must be employed to store one line and then be concurrent with the following line. Then a linear matrix of the red and blue signal components is used to produce the third green component. Of course, this necessitates the addition of a line-switching identification technique. Such an approach, designated as sequential color signals plus a memory — "sequential á mémoire" (SECAM), was developed and officially adopted by France and the USSR, and broadcast service began in France in 1967.

The implementation technique of a 1-H delay element led to the development, largely through the efforts of Walter Bruch of Telefinken Company of the Phase Alternation Line system, referred to as PAL. This approach was aimed at overcoming an implementation problem of NTSC that requires a high order of phase and amplitude integrity (skew-symmetry) of the transmission-path characteristics around the color subcarrier to prevent color quadrature distortion. The line-by-line alternation of the phase of one of the color-signal components averages any colorimetric distortions to the observer's eye to that of the correct value. The system in its simplest form (simple PAL), however, results in line flicker ("Hanover bars"). The use of a 1-H delay device in the receiver greatly alleviates this problem (standard PAL). PAL systems also require a line-identification technique.

The standard PAL system has been adopted by numerous countries in continental Europe and the United Kingdom. Public broadcasting began in 1967 in Germany and the United Kingdom using two slightly different variants of the PAL system (to be described later).

NTSC, PAL, and SECAM systems overview

In order to better understand the equalities and differences in systems used today, a familiarization with the basic principles of NTSC, PAL, and SECAM is required. As previously stated, many NTSC basic techniques are involved in PAL and SECAM; therefore, a thorough knowledge of NTSC is necessary in order to understand PAL and SECAM.

The same red, green, and blue pick-up devices and the same three primary color display devices are used in all three systems. The basic camera function is to analyze the spectral distribution of the light from the scene in terms of its red, green, and blue components on a point-by-point basis as determined by the scanning rates. The three resulting electrical signals must then be transmitted over a band-limited communications channel to control the three-color display device to make the *perceived* color at the receiver appear essentially the same as the *perceived* color at the scene.

Color's three characteristics — brightness, hue, and saturation

It is useful to introduce the definition of color as being a psychophysical property of light — specifically, the combination of those characteristics of light that produce the sensations of brightness, hue, and saturation as shown in Fig. 1. Brightness refers to the relative intensity; hue is the attribute of color that allows it to separate into spectal groups perceived as red, green, yellow, etc. (the dominant wavelength, in scientific terms); saturation is the degree to which a color deviates from a neutral gray of the same brightness — called purity, pastel, vividness, etc. These three characteristics represent the total information necessary to define and/or recreate a specific color stimulus.

This concept is useful to communication engineers in developing encoding and decoding techniques to efficiently compress the required information within a given channel bandwidth and to subsequently recombine the specific color-signal values in the proper proportions at the reproducer. The NTSC color standards define the first commercially broadcast process for achieving this result.

Assigning information to channels

The preferred signal arrangement that was developed gives reciprocal compatibility with monochrome pictures and is transmitted within the existing monochrome channel, as shown in Fig. 2. Thus, one signal (luminance) is chosen in all approaches to occupy the wide-band portion of the channel and to convey the *brightness* as well as the detail information content. A second signal (chrominance) representing *hue* and *saturation*, is assigned less channel width since human vision does not require full three-color reproduction over its entire range of resolution (commonly referred to as the "mixed-highs principle").

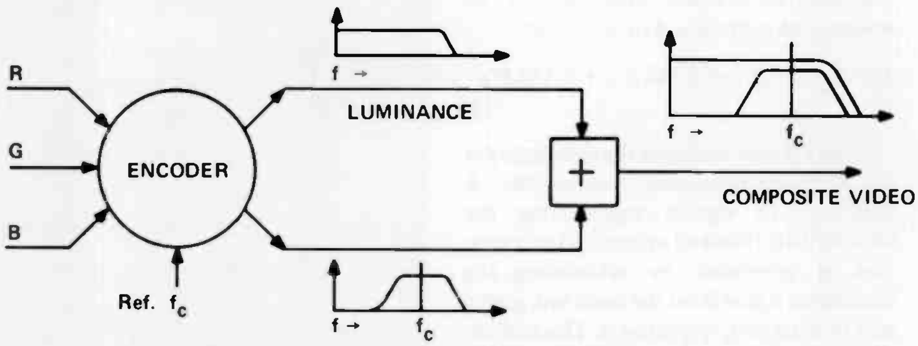
Another fundamental principle employed in all systems involves arranging the chrominance and luminance signals within the same frequency band without excessive mutual interference. Recognition that the scanning process, being equivalent to sampled-data techniques, produces signal components largely concentrated in uniformly spaced groups across the channel width, led to introduction of the concept of horizontal frequency interlace (dot interlace). The color subcarrier frequency is so chosen as to be an odd multiple of one-half line rate (in the case of NTSC) such that the phase of the subcarrier is exactly opposite on successive scanning lines, thereby substantially reducing the subjective visibility of the color-signal "dot" pattern components.

Thus, the major differences among the three main systems of NTSC, PAL, and SECAM are in the specific modulating processes used for encoding and transmitting the chrominance information. A summary is given in Fig. 3.

The following four sections discuss the basic television systems in some technical detail including some never actually implemented. A summary and comparisons of system standards and specifications are given at the end of the article.

BASIC COMMUNICATIONS CHANNEL PRINCIPLES APPLIED TO COLOR TELEVISION

- COMPATIBILITY WITH CO-EXISTING MONOCHROME SYSTEM.
- ENCODE WIDEBAND R, G, B COLOR PRIMARY SIGNALS.
  - WIDEBAND LUMINANCE (BRIGHTNESS)
  - NARROW-BAND MODULATION OF A COLOR SUBCARRIER (Hue and Saturation)



- SUBCARRIER FREQUENCY INTERLACE
  - ODD MULTIPLE OF ½H TO REDUCE VISIBILITY OF CHROMINANCE INFORMATION SUBCARRIER.

Fig. 2. For compatibility with black-and-white television, the NTSC color system uses two signals — luminance (for brightness and detail information) and chrominance (for hue and saturation information). Both signals are broadcast over the same frequency band. Subcarrier frequency interlace is done to avoid interference of the two signals. (Each broadcast system does this differently; the one shown is for NTSC.)

NTSC color system

The importance of the colorimetric concept of the three pieces of information — brightness, hue, and saturation — necessary to analyze or recreate a specific color value becomes evident in the formation of the composite color television NTSC format.

Color to color difference

The luminance, or monochrome, signal is formed by adding specific proportions of the red, green, and blue signals; it occupies the total available video bandwidth of 0-4.2 MHz. The NTSC, PAL, and SECAM systems all use the same luminance (Y) signal formation, differing only in available bandwidths.

The Y signal components have relative

PSYCHOPHYSICAL PROPERTIES OF LIGHT REQUIRED FOR COLOR IMAGE REPRODUCTION

- BRIGHTNESS (Luminance):

  RELATIVE INTENSITY OF THE COLOR

- HUE

  THE ATTRIBUTE THAT ALLOWS DESIGNATION IN TERMS OF RED, YELLOW, BLUE, etc. (Dominant wavelength).

- SATURATION

  DEGREE TO WHICH A COLOR DEVIATES FROM A NEUTRAL GRAY OF THE SAME BRIGHTNESS – PURITY, PASTEL, VIVIDNESS, etc.

Fig. 1. Basic definition of color is as a psychophysical property of light that produces these three sensations. The television viewer must *perceive* all three as being accurate reproductions of the color of the televised scene.

voltage values representative of the brightness sensation in the human eye. Therefore, the red (E'_R), green (E'_G), and blue (E'_B) components are tailored in proportion to the standard luminosity curve at the particular values of the dominant wavelengths of the three color primaries chosen for color television. Thus, the luminance-signal make-up for all systems, as normalized to white, is*:

$$E'_Y = 0.299\,E'_R + 0.587\,E'_G + 0.114\,E'_B. \quad (1)$$

Figure 4 also indicates the equations for the chrominance-signal components. A new set of signals representing the chromaticity (hue and saturation) information is generated by subtracting the luminance signal from the basic red, green, and blue signals, respectively. This new set of signals is termed the *color-difference* signals and is designated as *R-Y*, *G-Y*, and *B-Y*. These signals modulate a subcarrier that is combined with the luminance component and passed through a common communications channel. At the receiver, the color-difference signals are detected, separated, and individually added to the luminance signal in three separate paths to recreate the original *R*, *G*, and *B* signals indicated below:

$$\begin{aligned} E'_Y + E'_{(R-Y)} &= E'_Y + E'_R - E'_Y = E'_R \\ E'_Y + E'_{(G-Y)} &= E'_Y + E'_G - E'_Y = E'_G \\ E'_Y + E'_{(B-Y)} &= E'_Y + E'_B - E'_Y = E'_B \end{aligned} \quad (2)$$

In the specific case of NTSC, two other color-difference signals, designated as *I* and *Q*, indicated in Fig. 4, are formed at the transmitter and used to modulate the color subcarrier. The reason for the choice of *I* and *Q* signals is discussed later.

It may be noted that the *B-Y*, *R-Y*, and *G-Y* color-signal modulation components are the same in NTSC, PAL, and SECAM.

*The signal of Eq. 1 would be exactly equal to the output of a linear monochrome camera tube with ideal spectral sensitivity if the red, green, and blue camera tubes were also linear devices with theoretically correct spectral-sensitivity curves. In actual practice, the red, green, and primary signals are deliberately made nonlinear to accomplish gamma correction (adjust the slope of the input/output transfer characteristic). The prime mark (') is used to denote a gamma-corrected signal.

**The IEEE Standard Dictionary of Electrical and Electronics Terms notes that in constant-luminance transmission, the sole control of luminance is provided by the luminance signal and no control of luminance is provided by the chrominance signal. Noise signals falling within the bandwidth of the chrominance channel produce only chromaticity variations, which, if they are coarse-structured, are subjectively less objectionable than correspondingly coarse-structured luminance variations.

GENERAL COMPARISON OF WORLDWIDE TELEVISION SYSTEMS

- ALL SYSTEMS:
  - THREE-PRIMARY ADDITIVE COLORIMETRIC PRINCIPLES
  - SIMILAR CAMERA PICK-UP AND RECEIVER DISPLAY TECHNOLOGY
  - WIDEBAND LUMINANCE AND NARROW-BAND COLOR
- COMPATIBILITY WITH CO-EXISTING MONOCHROME SYSTEM:
  INTRODUCES FIRST ORDER DIFFERENCES
  - LINE NUMBER
  - FIELD/FRAME RATES
  - BANDWIDTH
  - FREQUENCY ALLOCATION
- MAJOR DIFFERENCES IN COLOR TECHNIQUES
  - NTSC – PHASE AND AMPLITUDE QUADRATURE MODULATION OF INTERLACED SUBCARRIER
  - PAL – SIMILAR TO NTSC BUT WITH LINE ALTERNATION OF "V" COMPONENT
  - SECAM – FREQUENCY MODULATION OF LINE SEQUENTIAL COLOR SUBCARRIERS

Fig. 3. Basic similarities and differences of worldwide color-TV systems. Differences are of two types: relatively minor variations in line number, frequency, etc., and differences in technique.

Another reason for the choice of signal values in the NTSC system is that the eye is more responsive to spatial and temporal variations in luminance than it is to variations in chrominance. Therefore, the visibility of luminosity changes caused by random noise and interference effects may be reduced by properly proportioning the relative chrominance gain and encoding angle values with respect to the luminance values. Thus, the principle of "constant luminance" is incorporated into the system standards.**

The voltage outputs from the three camera tubes are adjusted to be equal when a scene reference white or neutral grey object is being scanned for the color temperature of the scene ambient. Under this condition, the color subcarrier also automatically becomes zero. The colorimetric values have been formulated by assuming that the reproducer will be adjusted for "Illuminant *C*," representing the color of average daylight.

Figure 5 is a CIE chromaticity diagram indicating the primary color coordinates for NTSC, PAL, and SECAM. It is interesting to compare the television available color gamut relative to that of all color paint, pigment, film, and dye processes.

LUMINANCE:

$E'_Y = 0.299\,E'_R + 0.587\,E'_G + 0.114\,E'_B$

(Common for all systems)

CHROMINANCE:

NTSC

$E'_I = -0.274\,E'_G + 0.596\,E'_R - 0.322\,E'_B$

$E'_Q = -0.522\,E'_G + 0.211\,E'_R + 0.311\,E'_B$

$B\text{-}Y = 0.493\,(E'_B - E'_Y)$

$R\text{-}Y = 0.877\,(E'_R - E'_Y)$

$G\text{-}Y = 1.413\,(E'_G - E'_Y)$

PAL

$E'_U = 0.493\,(E'_B - E'_Y)$

$\pm E'_V = \pm 0.877\,(E'_R - E'_Y)$

SECAM

$D'_R = -1.9\,(E'_R - E'_Y)$

$D'_B = 1.5\,(E'_B - E'_Y)$

Fig. 4. Luminance signals are same for all three systems. Color difference signals (*B-Y*, *R-Y*, and *G-Y*) are same for each, but the signals used for modulation (*I* and *Q*, *U* and *V*, and the two *Ds*) are different for each system.

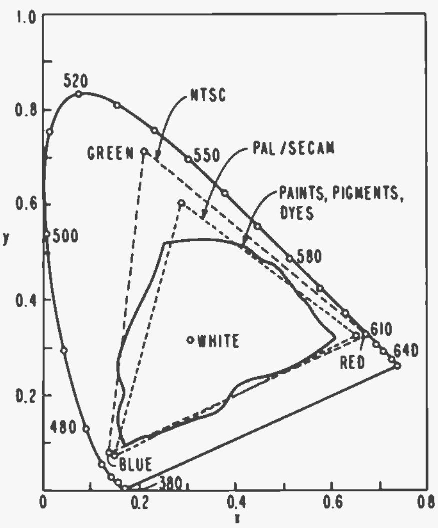


Fig. 5. Standard chromaticity diagram shows colors reproducible by NTSC, PAL/SECAM, and the entire gamut of paints, pigments, and dyes. Numbers are color frequencies in nanometers. (Note that equal distances on the diagram do not produce equal color differences.)

Modulation

In NTSC color standards, the chrominance information is carried as simultaneous amplitude and phase modulation of a subcarrier. This subcarrier was chosen to be in the high-frequency portion of the 0-4.2 MHz video band and is specifically related to the scanning rates as an odd multiple of one-half horizontal line rate, as shown by the vector diagram in Fig. 6. The hue information is assigned to the instantaneous phase of the subcarrier. Saturation is determined by the *ratio* of the instantaneous amplitude of the subcarrier to that of the corresponding luminance-signal amplitude value (references 2 and 5 for details of derivation).

The choice of *I* and *Q* color-modulation components relates to the variation of color acuity characteristics of human color vision as a function of the field of view and spatial dimensions of objects in the scene. The color acuity of the eye decreases as the size of the viewed object is decreased and thereby occupies a small part of the field of view. Small objects, represented by frequencies above about 1.5 to 2.0 MHz, produce no color sensation ("mixed-highs"). Intermediate spatial dimensions (approximately 0.5 to 1.5 MHz range) are viewed satisfactorily if reproduced along a preferred orange-cyan axis. Larger objects (0-0.5 MHz) require full three-color reproduction for subjectively pleasing results. Thus, the *I* and *Q* bandwidths are chosen accordingly and the preferred colorimetric reproduction axis is obtained when only the *I* signal exists by rotating the subcarrier modulation vectors by 33°. Thereby, the principles of "mixed-highs" and "*I*, *Q* color-acuity axis" operation are exploited.

At the encoder, the *Q* signal component is band-limited to about 0.6 MHz and contains the green-purple color-axis information. The *I* signal component has a bandwidth of about 1.5 MHz and contains the orange-cyan color-axis information. These two signals are then used to individually modulate the color subcarrier in two balanced modulators operated in phase quadrature. The "sum products" are selected and added to form the composite chromaticity subcarrier. This signal is in turn added to the luminance signal along with the appropriate horizontal and vertical synchronizing and blanking signals to include the color-synchronizing burst. The result is the total composite-color video signal.

Quadrature synchronous detection is used at the receiver to identify the individual color-signal components. When individually recombined with the luminance signal, the desired *R*, *G*, and *B* signals are recreated. The receiver designer is free to demodulate either at *I* and *Q* and matrix to form *B-Y* and *R-Y* and maintain 500-kHz equi-band color signals.

The chrominance information can be carried without loss of identity, provided that the proper phase relationship is maintained between the encoding and decoding processes. This is accomplished by transmitting a reference "burst" signal consisting of eight or nine cycles of the subcarrier frequency at a specific phase [−(*B-Y*)] following each horizontal synchronizing pulse, as shown in Fig. 7.

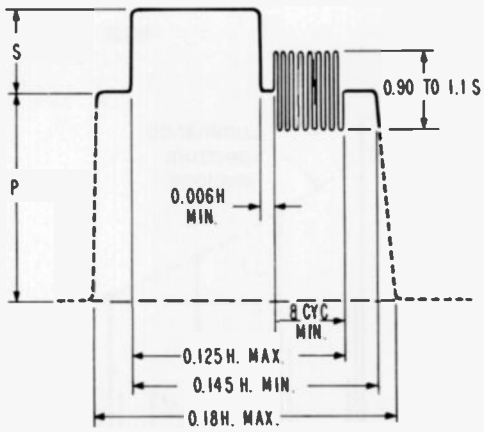


Fig. 7. Color synchronizing signal, or "burst," maintains proper phase relationship between encoding and decoding processes.

The specific choice of color subcarrier frequency in NTSC was dictated by at least two major factors. First, to reduce the visibility of the subcarrier, horizontal interlace is provided, which requires that the frequency of the subcarrier must be precisely an odd multiple of one-half the horizontal line rate. Figure 8 shows the energy spectrum of the composite NTSC signal for a typical stationary scene. This interlace provides line-to-line phase reversal of the color subcarrier, thereby reducing its visibility. Second, it is advantageous to also provide interlace of the beat-frequency (about 920 kHz) occurring between the color subcarrier and the

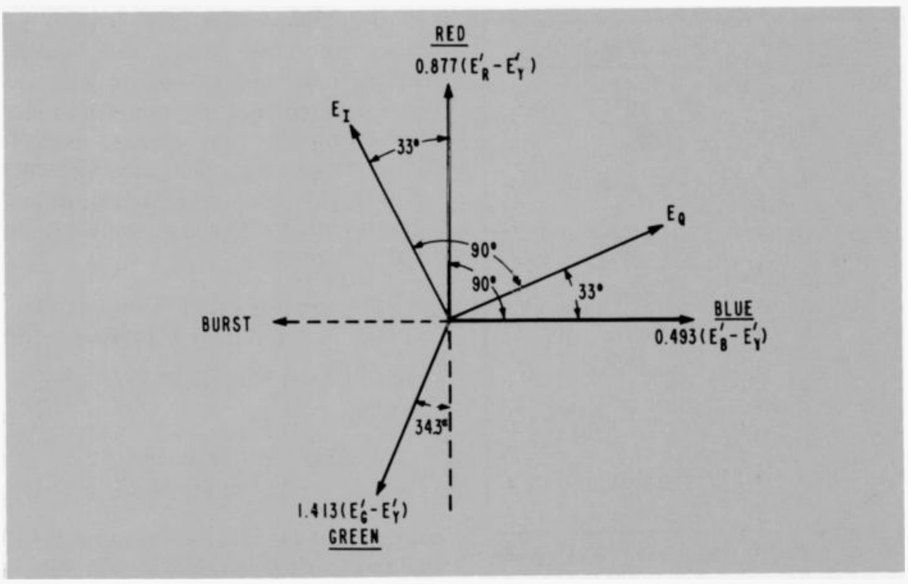


Fig. 6. In NTSC, chrominance information is amplitude-and phase-modulated onto a subcarrier. The *I* (orange-cyan) and *Q* (green-magenta) color-difference signals are formed to take advantage of the human eye's decreased color acuity with decreased object size.

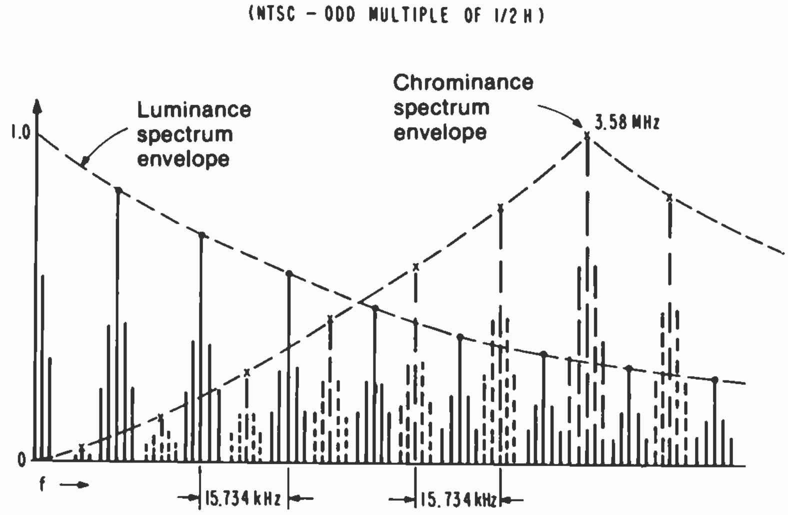


Fig. 8. NTSC's frequency interlace is done to allow luminance and chrominance signals to operate in the same channel without interference, and also reduces the visibility of the 3.58-MHz subcarrier. Reasons for frequency choices are given in text; calculations are in Fig. 9.

average value of the sound carrier. For total compatibility reasons, the sound carrier was left unchanged at 4.5 MHz and the line number remained at 525. Thus, the resulting line-scanning rate and field rate varied slightly from that of the monochrome values, but stayed within the previously existing tolerances.

A good rule of thumb is that the difference is exactly one part in a thousand. The exact specifications and method of calculating the frequencies are shown in Fig. 9. It is seen that the line rate is 15.734 kHz, the field rate is 59.94 Hz and the color subcarrier is 3.579545 MHz.

The NTSC system fundamentals have been reviewed in some detail since it was the first truly compatible system placed in commercial use and because the other systems subsequently proposed use most of their basic principles, differing mainly in the techniques of color encoding, primarily to overcome early implementation difficulties.

CHOICE OF EXACT FREQUENCIES

$$f_{LINE} = \frac{4.5 \times 10^6}{286}$$

$$= 15{,}734.26 \text{ Hz}$$

$$f_{FIELD} = \frac{f_{LINE}}{525/2}$$

$$= 59.94 \text{ Hz}$$

$$f_{SC} = \frac{13 \times 7 \times 5}{2} \times f_{LINE}$$

$$= 3.579545 \text{ MHz}$$

Fig. 9. NTSC field, line, and color-subcarrier frequencies were chosen to allow horizontal frequency interlace and still be compatible with black-and-white broadcast standards.

PAL color system

The major change — color-signal phase reversal

Except for some minor details, the color encoding principles for PAL are the same as that for NTSC. However, the phase of the color signal, $E_V = R\text{-}Y$, is reversed by 180° from line-to-line. This is done to average or cancel certain color errors resulting from amplitude and phase distortion of the color-modulation sidebands. These distortions might occur as a result of equipment or transmission-path problems.

The NTSC chroma-signal expression within the frequency band common to both *I* and *Q* is given by:

$$C_{NTSC} = [(B\text{-}Y)/2.03] \sin\omega_{sc}t + [(R\text{-}Y)/1.14] \cos\omega_{sc}t \quad (3)$$

The PAL chroma signal expression is given by:

$$C_{PAL} = (U/2.03) \sin\omega_{sc}t \pm (V/1.14) \cos\omega_{sc}t \quad (4)$$

where U and $\pm V$ have been substituted for $B\text{-}Y$ and $R\text{-}Y$ signal values, respectively.

The PAL system employs equal bandwidths for the *U* and *V* color-differences signal components, which are about the same as the NTSC *I*-signal bandwidth (1.3 MHz at 3 dB). Different PAL systems have slight differences in their *U* and *V* bandwidths because of differences in luminance bandwidth and sound-carrier frequencies. Refer to the final section of this article and to the CCIR documents[1] for specific details.

The *V* component was chosen for the line-by-line reversal process, since it has a lower gain factor than *U* and therefore is less susceptible to switching rate ($f_{H/2}$) imbalance. Figure 10 indicates the vector diagram for the PAL quadrature-modulated and line-alternating color-modulation approach.

PAL line switching

The result of the switching of the *V* signal phase at line rate is that any phase errors produce complementary errors from *V* into the *U* channel. In addition, a corresponding switch of the decoder *V* channel results in a constant *V* component with complementary errors from the *U* channel. Thus, any line-to-line averaging process at the decoder, such as the retentivity of the eye (simple PAL), or an electronic averaging technique such as the use of a 1-H delay element (standard PAL), cancels the phase (hue) error and provides the correct hue but with somewhat reduced saturation — this error being subjectively much less visible.

Obviously, the PAL receiver must be provided with some means by which the *V* signal switching sequence may be identified. The technique employed is known as AB sync, PAL sync, or "swinging burst," and consists of alternating the phase of the reference burst by ±45° at a line rate as shown in Fig. 10. The burst is constituted from a fixed value of *U* phase and a switched value of *V* phase. Since the sign of the *V* burst component is the same sign as the *V* picture content, the necessary switching "sense" or identification information is available. At the same time, the fixed-*U* component is used for reference-carrier synchronization.

Figure 11 explains the degree to which horizontal frequency (dot) interlace of the color-subcarrier components with the luminance components is achieved in PAL. It may be summarized as follows: In NTSC, the *Y* components are spaced at f_H intervals due to the horizontal sampling (blanking) process. Thus, the choice of a color subcarrier, whose harmonics are also separated from each other by f_H, as being an odd multiple of $f_{H/2}$, provides a half-line offset and results in a perfect "dot" interlace pattern that moves upward. Four complete field scans are required to repeat a specific picture-element "dot" position.

In PAL, the luminance components are also spaced at f_H intervals. However, since the V component is switched symmetrically at the half-line rate, only odd harmonics exist, resulting in an f_H spacing from each other of the V components. They are spaced half-line from the U components, which, in turn, have f_H spacing intervals due to blanking. If half-line offset were used, the U components would be perfectly interlaced, but the V components would coincide with Y and, thus, be interlaced, creating vertical, stationary, dot patterns.

Therefore, in PAL, a ¼-line offset for the subcarrier frequency is used, as shown in Fig. 11. The expression for determining the PAL subcarrier specific frequency for 625-line/50-field systems is given by:

$$f_{sc} = (1135/4)f_H + f_V/2 \qquad (5)$$

The additional factor $f_V/2$ = 25Hz is introduced to provide motion to the color dot pattern, thereby reducing its visibility. The degree to which interlace is achieved is, therefore, not perfect, but is acceptable, and eight complete field scans must occur before a specific picture-element "dot" position is repeated.

One additional function must be accomplished in relation to PAL color synchronization. In all systems, the burst signal is eliminated during the vertical synchronizing pulse period. Since, in the case of PAL, the swinging burst phase is alternating line-by-line, some means must be provided for ensuring that the phase is

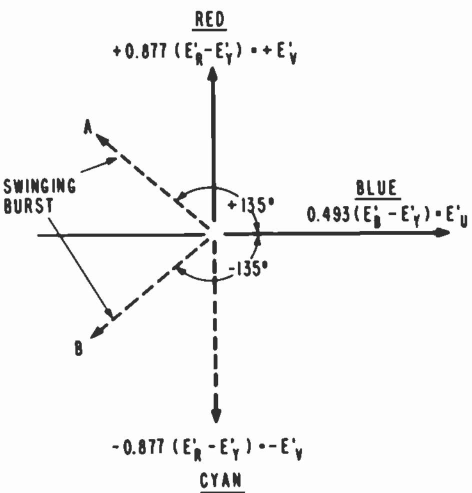


Fig. 10. PAL color phase diagram for chrominance modulation; compare with Fig. 6. "Burst" switches between "A" & "B" positions.

the same for the first burst following vertical sync on a field-by-field basis. Therefore, the burst reinsertion time is shifted by one line at the vertical field rate by a pulse referred to as the "meander" gate.

"Simple" vs. "standard" PAL

The transmitted signal specifications for PAL systems include the basic features discussed above. Description of a great variety of receiver decoding techniques is outside the scope and intent of this material. However, a brief mention of the major features is as follows: "Simple" PAL relies upon the eye to average the line-by-line color-switching process and can be plagued with line beats, or "Hanover bars," caused by the system nonlinearities introducing visible luminance changes at line rate. "Standard" PAL employs a 1-H delay line element to separate U color-signal components from V color-signal components in an averaging technique coupled with summation and subtraction functions. Hanover bars can also occur in this approach if imbalance of amplitude or phase occurs between the delayed and direct paths.

Reference is made to a book by Carnt and Townsend,[2] entitled *Colour Television — Volume* 2, for an excellent discussion of the variety of other decoder approaches such as Chroma Lock, Super PAL, New PAL, or PAL_N (not to be confused with N/PAL).

In a PAL system, vertical resolution in chrominance is reduced as a result of the line-averaging processes. The visibility of the reduced vertical color resolution as well as the vertical time coincidence of luminance and chrominance transitions differ, depending upon whether the total system, transmitter through receiver, includes one or more averaging (comb filter) process.

Thus, PAL provides a similar system to NTSC and has gained favor in many areas of the world, particularly for 625-line/50-field systems.

SECAM color system

The "optimized" SECAM system, called SECAM III, was adopted by France and the USSR in 1967. The SECAM method has several features in common with NTSC, such as the same E'_Y signal and the same $E'_B - E'_Y$ and $E'_R - E'_Y$ color-difference signals. However, this approach differs considerably from NTSC and PAL in the manner in which the color information is modulated onto the subcarrier(s).

SECAM modulation system

First, the R-Y and B-Y color-difference signals are transmitted alternately in time sequence from one successive line to the next — the luminance signal being common to every line. Since there is an odd number of lines, any given line carries R-Y information on one field and B-Y information on the next field. Second, the R-Y and B-Y color information is conveyed by frequency-modulation of different subcarriers. Thus, at the decoder, a 1-H delay element, switched in time synchronization with the line-switching process at the encoder, is required in order to have simultaneous existence by B-Y and R-Y signals in a linear matrix to form the G-Y component.

The R-Y signal is designated as D'_R and the B-Y signal as D'_B. The undeviated frequency for the two subcarriers, respectively, is determined by:

$$f_{0B} = 272\ F_H = 4.250000\ \text{MHz}$$
$$f_{0R} = 282\ F_H = 4.406250\ \text{MHz.} \qquad (6)$$

These frequencies represent zero-color-difference information (zero output from the fm discriminator), or a neutral gray object in the televised scene.

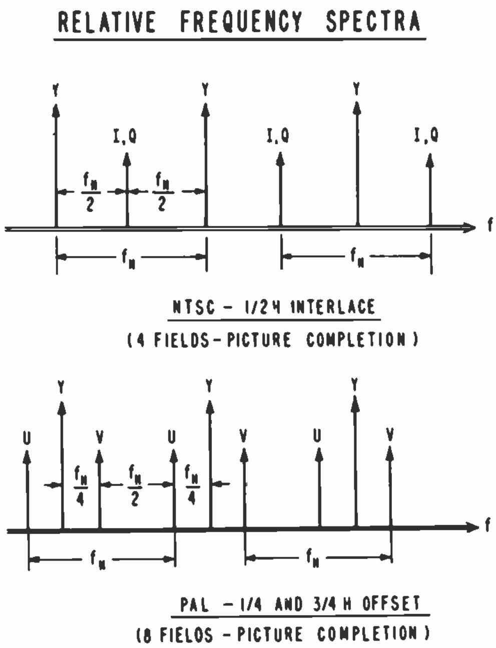


Fig. 11. Frequency interlacing relationships are different in NTSC and PAL systems because of the V-component switching in PAL, which therefore requires a ¼-line offset.

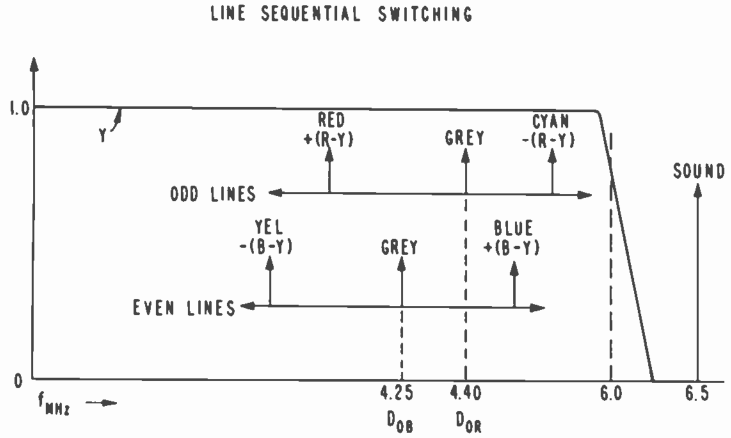


Fig. 12. SECAM modulation system differs significantly from NTSC and PAL methods. The *R-Y* and *B-Y* color-difference signals alternate from line to line, and are also frequency-modulated onto different subcarriers.

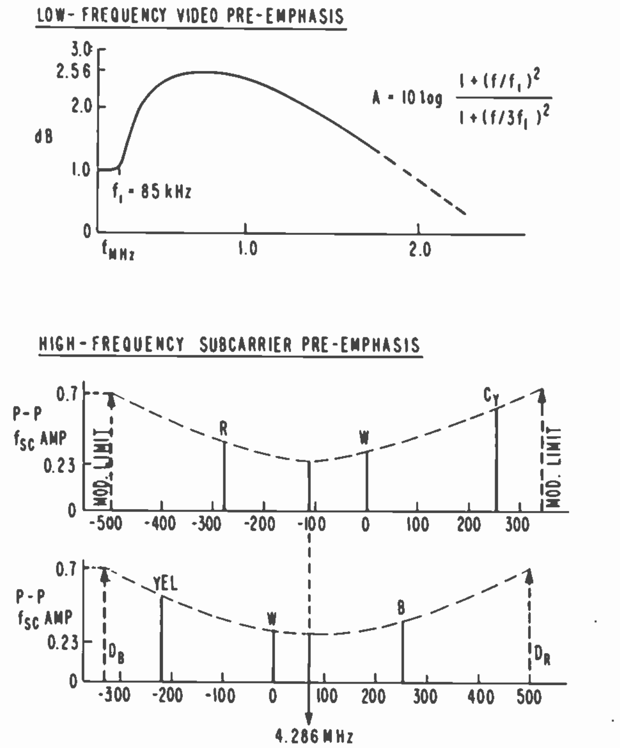


Fig. 13. SECAM uses two simultaneous types of frequency pre-emphasis — low-frequency pre-emphasis of the color-difference signals (top) and high-frequency pre-emphasis of the subcarrier (bottom).

As shown in Fig. 12, the accepted convention for direction of frequency change with respect to the polarity of color-difference signal is opposite for the D_{0B} and D_{0R} signals. A positive value of D_{0R} means a decrease in frequency, whereas a positive value of D_{0B} indicates an increase in frequency. This choice relates to the idea of keeping the frequencies representative of the most critical color away from the upper edge of the available bandwidth to minimize instrumentation distortions.

The deviation for, including preemphasis, D'_R is ±280 kHz and for D'_B is ±230 kHz. The maximum allowable deviation, including preemphasis, for D'_R are −506 kHz and +350 kHz, while the values for D'_B are −350 kHz and +506 kHz.

SECAM pre-emphasis

Two types of pre-emphasis are employed simultaneously in SECAM. First, as shown in Fig. 13, a conventional type of pre-emphasis of the low-frequency color-difference signals is introduced. The characteristic is specified to have a reference-level break-point at 85 kHz (f_1) and a maximum emphasis of 2.56 dB. The expression for the characteristic is given as:

$$A = \frac{1 + j\,(f/f_1)}{1 + j\,(f/3f_1)} \qquad (7)$$

A second form of pre-emphasis (Fig. 14) is introduced at the subcarrier level, where the amplitude of the subcarrier is changed as a function of the frequency deviation. The expression for this inverted "bell"-shaped characteristic is given as:

$$G = M_0 \frac{1 + j16\,[(f/f_c) - (f_c\,/\,f)]}{1 + j1.26\,[(f/f_c - (f_c/f)]} \qquad (8)$$

where f_0 is 4.286 MHz; and $2M_0$ is 23% of the luminance amplitude (100 IRE).

This type of pre-emphasis is intended to further reduce the visibility of the frequency-modulated subcarriers in low-luminance-level color values and to improve the signal-to-noise ratio in high-luminance and high-saturated colors. Thus, monochrome compatibility is better for pastel average-picture-level objects, but sacrificed somewhat in favor of S/N in saturated color areas.

SECAM LINE SEQUENTIAL COLOR

FIELD	LINE #	COLOR	SUBCARRIER Ø
ODD (1)	n	f_{OR}	0°
EVEN (2)	n + 313	f_{OB}	180°
ODD (3)	n + 1	f_{OB}	0°
EVEN (4)	n + 314	f_{OR}	0°
ODD (5)	n + 2	f_{OR}	180°
EVEN (6)	n + 315	f_{OB}	180°
ODD (7)	n + 3	f_{OB}	0°
EVEN (8)	n + 316	f_{OR}	180°
ODD (9)	n + 4	f_{OR}	0°
EVEN (10)	n + 317	f_{OB}	0°
ODD (11)	n + 5	f_{OB}	180°
EVEN (12)	n + 318	f_{OR}	180°

Note: • 2 frames (4 fields) for picture completion.
• Subcarrier interlace is field-to-field and line-to-line of same color.

Fig. 14. SECAM line-switching sequence. Phase reversal at every third line and between each field to help provide black-and-white compatibility.

SECAM line-switching

Of course, precise interlace of frequency-modulated subcarriers for all values of color modulation cannot occur. However, the visibility of the interference represented by the existence of the subcarriers may be reduced somewhat by the use of two separate carriers, as is done in SECAM. Figure 15 indicates the line-switching sequence in that at the undeviated "resting" frequency situation, the two-to-one vertical interlace in relation to the continuous color difference line-switching sequence produces adjacent line pairs of f_{OB} and f_{OR} signals. In order to further reduce the subcarrier "dot" visibility, the phase of the subcarriers (phase carries no picture information in this case) is reversed 180° on every third line and between each field. This, coupled with the "bell" pre-emphasis, produces a degree of monochrome compatibility considered subjectively adequate.

As in PAL, the SECAM system must provide some means for identifying the line-switching sequence between the encoding and decoding processes. This is accomplished, as shown in Fig. 16, by introducing alternate D_R and D_B color-identifying signals for nine lines during the vertical blanking interval following the equalizing pulses after vertical sync. These "bottle"-shaped signals occupy a full line each and represent the frequency deviation in time sequence of D_B and D_R at zero luminance value. These signals can be thought of as fictitious green color that is used at the decoder to determine the line-switching sequence.

During horizontal blanking, the subcarriers are blanked and a burst of f_{OB}/f_{OR} is inserted and used as a gray-level reference for the fm discriminators to establish their proper operation at the beginning of each line.

Thus, the SECAM system is a line-sequential color approach using frequency-modulated subcarriers. A special identification signal is provided to identify the line-switch sequence and is especially adapted to the 625-line/50-field wideband systems available in France and the USSR.

It should be noted that SECAM, as practiced, employs amplitude modulation of the sound carrier as opposed to the fm sound modulation in other systems.

Additional systems

Of the numerous system variations proposed over the intervening years since the initial development of the NTSC system, at least two others, in addition to PAL and SECAM, should be mentioned briefly. The first of these is ART(Additional Reference Transmission), which involves the transmission of a continuous reference pilot carrier in conjunction with a conventional NTSC color subcarrier quadrature-modulation signal. A modification of this involved the "multiburst" approach that utilizes three color bursts, one at black level, one at an intermediate gray level, and one at white level, to be used for correcting differential phase distortion.

Perhaps a better known system, referred to as NIR (Nautschnuiu Issledowatelskaja Rabota), SECAM IV was developed by the USSR. This system consists of alternating lines of: (1) an NTSC-like signal *m* using an amplitude- and phase-modulated subcarrier; and (2) a reference signal *r* having *U* phase used to demodulate the *m* signal. In the linear version, the reference is unmodulated, and in the nonlinear version, the amplitude of the reference signal is modulated with chrominance information.

To the authors' best knowledge, none of these systems were implemented or used for commercial broadcast.

Comparisons of systems standards

History has shown that it is impossible to obtain total international agreement on "universal" television broadcasting standards. Even with the first scheduled broad-

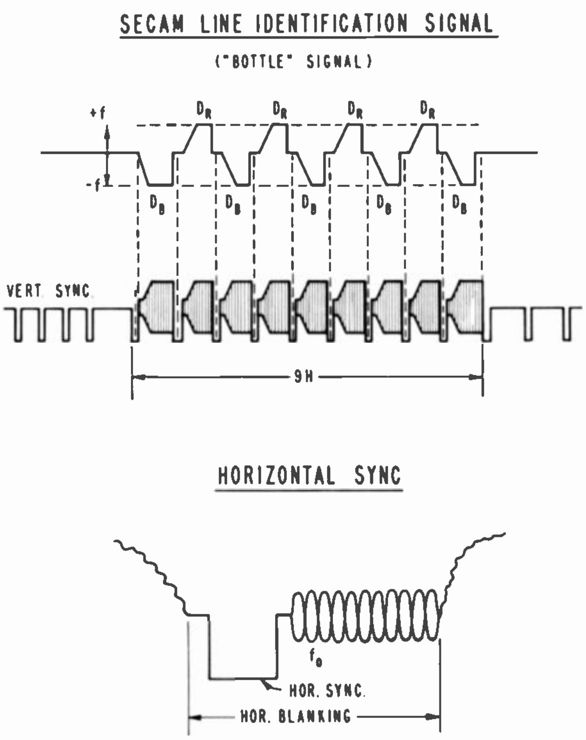


Fig. 15. SECAM "bottle" signals identify the line-switching sequence.

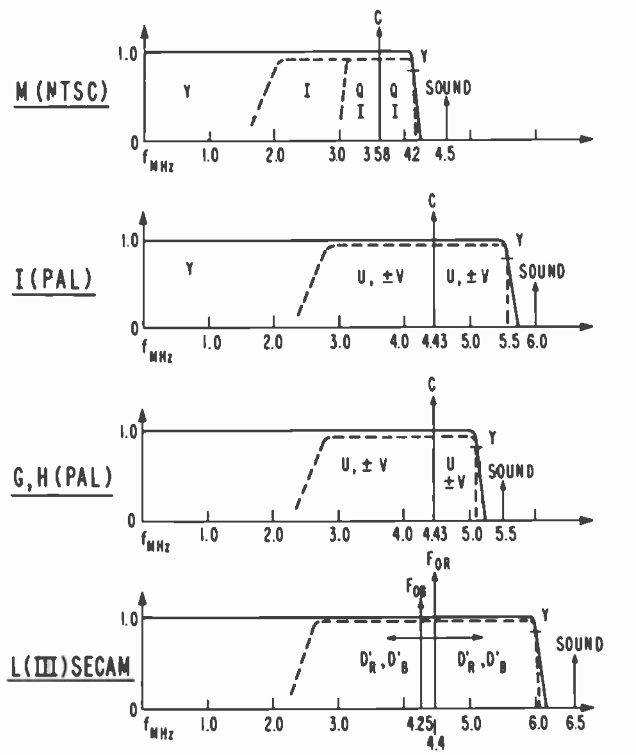


Fig. 16. Bandwidth comparison shows that M(NTSC) system used in U.S.A. and elsewhere has the least total channel width.

casting of monochrome television in 1936 in England, the actual telecasting started using two different systems on alternate days from the same transmitter. The Baird system used 250 lines (non-interlaced) and 50-Hz frame rate, while the EMI system used 405 lines (interlaced) and a 25-Hz frame rate.

These efforts were followed in 1939 in the United States by broadcasting a 441-line interlaced system at 60 fields per second (RMA). In 1941, the NTSC initiated the present basic monochrome standards in the U.S. of 525 lines (interlaced) at 60 fields per second, designated as system *M* by the CCIR. In those early days, the differences in power-line frequency were considered important factors and were largely responsible for the proliferation of different line rates versus field rates as well as video bandwidths. However, the existence and extensive use of monochrome standards over a period of years soon gave top priorty to reciprocal compatibility of any developing color system.

The CCIR designations

The CCIR documents[1] define recommended standards for world-wide color television systems in terms of three basic color approaches — NTSC, PAL, and SECAM. The variations are given in alphabetical letter designations (A, M, N, C, B, G, H, I, D, K, KI, L, E) totalling at least 13 versions, some representing major differences and some, for example representing only very minor frequency-allocation differences in channel spacings or the differences between the vhf and uhf bands. As of 1978, at least 98 countries are listed as either employing or considering one or more of the proposed systems in monochrome and/or color format.

The key to understanding the CCIR designations lies in recognizing that the letters refer primarily to local monochrome standards for line and field rates, video-channel bandwidth, and audio-carrier relative frequency. Further classification in terms of the particular color system then adds NTSC, PAL, or SECAM, as appropriate. For example, the letter "M" designates a 525-line/60-field, 4.2-MHz-bandwidth, 4.5-MHz-sound-carrier monochrome system. Thus, M(NTSC) describes a color system employing the NTSC technique for introducing the chrominance information within the constraints of the above basic monochrome signal values. Likewise, M(PAL) indicates the same line/field rates and bandwidths, but employing the PAL color-subcarrier-modulation approach.

In another example, the letters "I" and "G" relate to specific 625-line/50-field, 5.0- or 5.5-MHz-bandwidth, 5.5- or 6.0-MHz-sound-carrier monochrome standards. Thus, G(PAL) describes a 625-line/50-field, 5.5-MHz-bandwidth, color system utilizing the PAL color subcarrier modulation approach. The letter "L" refers to a 625-line/50-field, 6.0-MHz-bandwidth system to which the SECAM color modulation method has been added (often referred to as SECAM III).

System "E" is an 819-line/50-field, 10-MHz-bandwidth, monochrome system

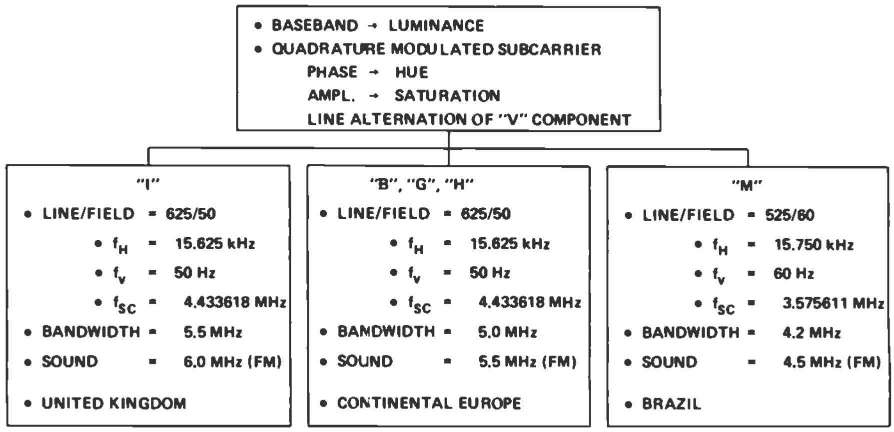


Fig. 17. PAL and its five configurations.

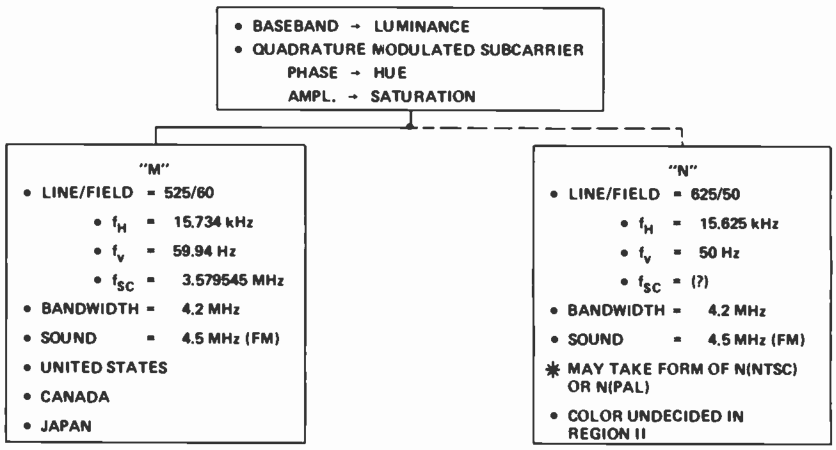


Fig. 18. NTSC and its two configurations.

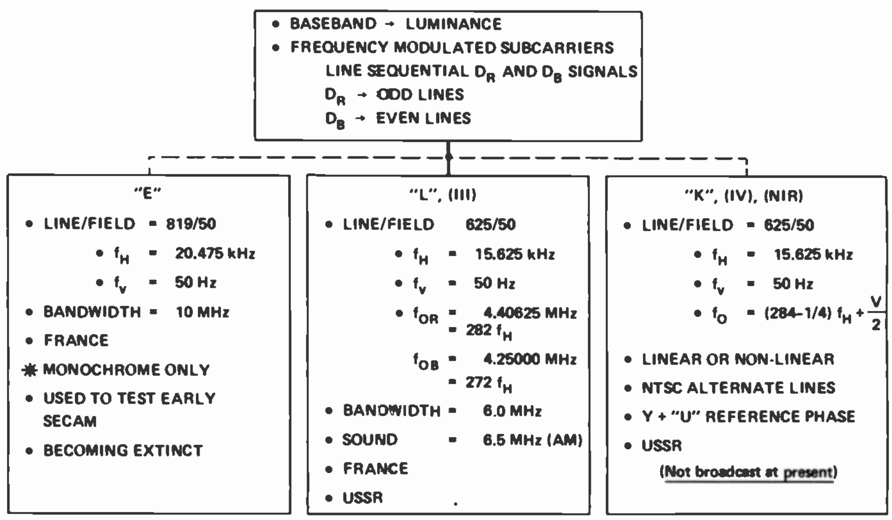


Fig. 19. SECAM and its three configurations.

that was used in early SECAM tests and is gradually becoming less used as a broadcast system.

General comparisons

Some general comparison statements can be made. (1) There are four different scanning standards: 405-line/50-field, 525-line/60-field; 625-line/50-field, and 819-line/50 field. (2) There are six different spacings of video to sound carriers, namely: 3.5, 4.5, 5.5, 6.0, 6.5, and 11.15 MHz. (3) Some systems use fm and others use am for the sound modulation. (4) Some systems use positive-polarity (black relative to white) modulation of the video carrier while others use negative modulation. (5) As previously discussed, there are the differences in techniques of color-subcarrier encoding represented by NTSC, PAL, and SECAM. Of course, in each case there are many differences in the details of various pulsewidths, timing, and tolerance standards so that one must refer to the CCIR documents for accurate results.

Figure 17 presents a comparison of the relative bandwidths, color subcarrier frequencies, and sound-carrier spacing for the major color systems used in the world today.

The signal in the M(NTSC) system occupies the least total channel width, which, when the vestigial sideband plus guard-bands are included, requires a minimum radio-frequency channel spacing of 6 MHz. The L(III) SECAM system occupies greater channel space with a full 6-MHz luminance bandwidth. The two versions of PAL also occupy greater channel space and vary in vestigial sideband widths as well as color luminance bandwidths. NTSC is the only system to incorporate the *I, Q* color-acuity bandwidth variation. PAL minimizes the color-quadrature phase-distortion effects by line-to-line averaging and SECAM avoids this problem by only transmitting the color components sequentially at a line-by-line rate.

System specification summaries

Figures 17 through 19 summarize, in "organization chart" form, the CCIR designations for NTSC, PAL, and SECAM basic system identifications and characteristics. In Fig. 18, M(NTSC) identifies the system used in the United States, Canada, Japan, Mexico, the Phillippines, and several other Central American and Carribean area countries. The N system may be implemented in color either in the NTSC or the PAL format. At the present, many Latin American countries are in the process of adopting one or the other version of this approach.

Figure 17 provides a summary of the PAL systems. These systems are predominately used in continental Europe and the United Kingdom. However, an "M" version of PAL has been in use in Brazil for some time.

Figure 19 summarizes the SECAM III system, which is in use primarily in France and the USSR. The SECAM IV system, as a proposal[3], almost gained favor in 1966 as a universal European approach, but to the authors' knowledge, has never been used in a commercial situation. The "E" 819-line, very wideband system, originally used in France, is limited to monochrome broadcasts and is slowly becoming extinct even in this application.

Figure 20 provides a "summary-at-a-glance of the major color-television system general characteristics as presently practiced, whether it be monochrome only or includes the addition of chrominance information.

Figure 21 characterizes the fundamental features relating to the differences among NTSC, PAL, and SECAM in the critical areas of color-encoding techniques.

	NTSC	PAL	SECAM
• TV SYSTEM	M	G, I	L
• FIELD RATE (f_V Hz)	59.94	50	50
• TV LINES	525	625	625
• LINE RATE (f_H kHz)	15.734	15.625	15.625
• LUMA BANDWIDTH (MHz)	4.2	(5.0) (5.5)	6.0
• SOUND (MHz)	4.5 (F 3)	(5.5) (6.0) (F3)	6.5 (A3)
• VERTICAL INTERLACE	2:1	2:1	2:1
• GAMMA	2.2	2.8	2.8
• WHITE	ILL. "C" (D6500)	D6500	D6500

Fig. 20. General comparison of the three systems.

	NTSC	PAL	SECAM
• COLOR SUBCARRIER (MHz)	3.579545	4.433618	4.250000 = f_{OB} 4.406500 = f_{OR}
• f_{SC} MULTIPLE OF f_H	$\frac{455}{2} f_H$	$\frac{1135}{4} f_H + \frac{f_v}{2}$	272 f_H = f_{OB} 282 f_H = f_{OR}
• CHROMA ENCODING	PHASE & AMP. QUAD. MDD.	PHASE & AMP. QUAD. MOD. (LINE ALTERNATION)	FREQUENCY MODULATION (LINE SEQUENTIAL)
• COLOR DIFFERENCE SIGNALS	I, Q. (1.3 MHz) (0.6 MHz)	U, ± V (1.3 MHz) (1.3 Mhz)	D_R (f_{OR}) (> 1.0 MHz) D_B (f_{OB}) (> 1.0 MHz)
• COLOR BURST PHASE	-(B-Y)	U and ± V	f_{OR} AND f_{OB} 180° PHASE SWITCH EVERY 3rd LINE AND EVERY FIELD
• COLOR SWITCH IDENT.	NOT REQUIRED	SWINGING BURST ± 45°	9 LINES OF D_R AND D_B DURING VERTICAL INTERVAL
• ADDITIONAL SIGNALS	NONE	"MEANDER" GATE $f_{H/2}$	$f_{H/2}$, $f_{H/4}$, f'_v, $f_{v/2}$

Fig. 21. Comparison of color-encoding techniques.

	LINE (N)	LINE (N + 1)	LINE (N + 2)	LINE (N + 3)
NTSC:				
CHROMA:	I, Q	I, Q	I, Q	I, Q
BURST PHASE:	-(B-Y)	-(B-Y)	-(B-Y)	-(B-Y)
PAL				
CHROMA:	U, + V	U, − V	U, + V	U, − V
BURST PHASE:	−U + V = + 135°	−U − V = +225°	−U + V = + 135°	−U − V = +225°
SECAM: (FM)				
CHROMA:	D_R ± 280 kHz	D_B ± 230 kHz	D_R ± 280 kHz	D_B ± 230 kHz
BURSTS:	(D_R DEVIATION = + 350 kHz / − 500 kHz)		(D_B DEVIATION = + 500 kHz / − 350 kHz)	

CHROMA SWITCH IDENT. LINES DURING VERTICAL INTERVAL

LINE #:	7	8	9	10	11	12	13	14	15
	320	321	322	323	324	325	326	327	328
INDENT SIGNALS:	D_R	D_B	D_R	D_B	D_R	D_B	D_R	D_B	D_R

(NOTE: Phase reversed 180° every 3rd line and every field).

Fig. 22. Line-by-line color-sequence comparisons.

Similarly, Fig. 22 indicates the color encoding line-by-line color sequence operation for the three systems.

The information represented in these last seven charts highlight the technical equalities and differences and attempts to place some degree of order in understanding the existing world-wide situation as well as pointing out the difficulties in entertaining the notion of a "universal" system.

International exchange of images

The international exchange of images in broadcast television, in face of the variety of standards, is difficult. It should be remembered that all TV systems, both monochrome and color, can be operated from movie film. Special television camera chains have been manufactured to operate at 625-lines and 48-field rate — the field rate purposely being made to be compatible with the 24-frame-rate motion-picture standards.

It is comparatively straightforward to exchange television-program material by tape, microwave or satellite between areas employing the same scanning rates — the video bandwidth differences are, of course, not equivalent, but do not result in major image degradation. Electronic standard converters have been developed and used for converting between 50- and 60-field-rate systems.

The direct exchange of color television programs between the three major systems is obviously more complex. Special transcoding systems have been developed to translate color-subcarrier frequencies between similar color systems having different scanning rates. More complex transcoders are possible which translate from one color technique to another, always however, at some degradation of resolution or degree of performance. Even the translation between different scanning rates as well as different color systems, such as 525-line NTSC and 625-line PAL, has been accomplished.

James Gibson joined RCA Laboratories in 1956 where he has been involved in a variety of projects related to broadcasting consumer electronics, and solid-state circuits including television bandwidth compression, FM broadcasting of stereophonic and quadraphonic sound, TV antennas, computer circuits, and integrated memories. His current research activities are primarily related to the RCA VideoDisc projects.

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Dalton Pritchard has been involved with communications and information display systems since he joined RCA in 1946. At present, he is engaged in the development and evaluation of video processing circuitry for color TV receivers, particularly in areas of colorimetry and decoded matrix techniques.

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Television Research Laboratory
RCA Laboratories
Princeton, N.J.
Ext. 2205

As previously stated, the advent of satellite worldwide television relay, coupled with recent advances in digital processing of television signals, has made the topic of standards conversion rise to a new level of importance in the exchange of program material on an international basis. Thus, the intent of this worldwide color systems standards review is to highlight the similarities as well as the major differences for those who desire an overview of the related television concepts and standards.

Acknowledgment

The authors acknowledge the aid and suggestions provided by A. Lind of RCA Broadcast Systems and are especially grateful for the assistance and information provided by R. Mills and E. Rutishauser of RCA Laboratories, Zurich.

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2. Carnt, P.S., and Townsend, G.B., *Colour Television*, Volume 1 (NTSC), Volume 2 (PAL and SECAM), ILIFFE Books Ltd., (Wireless World), 42 Russell Square, London, W.C. 1, England (1959).
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6. Hirsch, C.J., "Color Television Standards for Region 2," *IEEE Spectrum* (Feb. 1968).

Dates and Deadlines

Upcoming meetings

Ed. Note: Meetings are listed chronologically. Listed after the meeting title (in bold type) are the sponsor(s), the location, and the person to contact for more information.

MAR 24-25, 1980—**Radio Transmitters and Modulation Techniques** (IEE, IERE) IEE, Savoy Place, London, WC2 **Prog Info:** Conference Dept., IEE, Savoy Place, London WC2R OBL, England

MAR 24-27, 1980—**Magnetic Fluids 2nd Intl. Conf.** (MAG) Marriott Inn, Orlando, FL **Prog Info:** Markus Zahn, Dept of EE, Univ. of Florida, Gainesville, FL 32611 (904-392-4964 Ofc., 904-392-4960 Sect.)

APR 7-11, 1980—**Optical Computing Int'l. Conference** (C) Hyatt Regency, Washington, DC **Prog Info:** Sam Horvitz, P.O. Box 274, Waterford, CT 06385 (Office: 203-447-4270, Home: 203-442-0829)

APR 8-10, 1980—**Reliability Physics Symposium** (R, ED) Caesar's Palace, Las Vegas, NV **Prog Info:** Glen T. Cheney, Bell Laboratories, 555 Union Blvd., Allentown, PA 18103 (215-439-7628)

APR 9-11, 1980—**Intl. Conf. on Acoustics, Speech and Signal Processing** (ASSP, IEEE), Fairmount Hotel, Denver, CO **Prog Info:** J. Robert Ashley, Univ. of Colorado, Coll. of Engr. & Appl. Sci., Dept. of Elec. & Comp. Engr., 1100 14th Street, Denver, CO 80202 (303-629-2554 or 2872)

APR 13-16, 1980—**Southeastcon '80**, Opryland Hotel, Nashville, TN **Prog Info:** Larry K. Wilson, Box 1687, Station B, Nashville, TN 37235 (615) 322-2771)

APR 21-23, 1980—**American Power Conference** Ill. Inst. Tech., PES & 8 other engr. societies, Palmer House, Chicago, IL **Prog Info:** R.A. Budenholzer, 246 E-1, IIT, Chicago, IL 60616 (312-567-3196)

APR 21-24, 1980—**Intl Magnetics Conf.** (INTERMAG) (MAG), Boston Sheraton Hotel, Boston, MA **Prog Info:** D.I. Gordon, Naval Surface Weapons Center, White Oak Lab., Silver Spring, MD 20910 (202-394-2167)

APR 28-30, 1980—**Internation Radar Conference** (IEEE, AES, IEEE Wash. section), Stouffer's National Center Hotel, Arlington, VA **Prog Info:** R.T. Hill/J. Kalitta, c/o Conference Office, 777 14th St., NW Suite 917, Washington, DC 20005 (202-637-4217)

APR 28-30, 1980—**30th Electronic Components Conference** (CHMT, EIA) Hyatt Regency San Francisco, San Francisco, CA **Prog Info:** Dr. H.J. Gisler, Electro Scientific Industries, 13900 N.W. Science Park Dr., Portland, OR 97229 (503-641-4141)

APR 28-30, 1980—**Circuits and Systems Int'l. Symposium** (CAS) Shamrock Hilton Hotel, Houston, TX **Prog Info:** Prof. R.J.P. DeFigueiredo, General Chairman, Dept. of Electrical Engineering, Rice University, P.O. Box 1892, Houston, TX 77001 (713-527-8101, ext. 3568)

MAY 12-15, 1980—**Industrial and Commercial Power Systems Conference** (IA, IEEE, Houston Section), Stouffer's Greenway Plaza, Houston, TX **Prog Info:** Baldwin Bridger, Powell Elect. Mfg. Co., P.O. Box 12818, Houston, TX 77017 (713-944-6900)

MAY 13-15, 1980—**Electro** (IEEE sponsors) Reg 1, New Eng. Council, METSAC, (ERA, New Eng. & N.Y. chapters), Boston-Sheraton Hynes Auditorium, Boston, MA **Prog Info:** Dale Litherland, Electronic Conventions, Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245 (213-772-2965)

MAY 19-20, 1980—**Southeast Symp. on System Theory** (C), Old Dominion University, Cavalier Hotel, Virginia Beach, VA **Prog Info:** Harry Hayman, P.O. Box 639, Silver Spring, MD 20901 (301-439-7007)

MAY 28-30, 1980—**Intl. Microwave Symp.** (MTT) Shoreham Americana Hotel, Washington, D.C. **Prog. Info:** Lawrence R. Whicker, Naval Research Lab Code 5250, Washington, DC 20375 (202-767-3312)

JUNE 8-11, 1980—**Intl. Conference on Communications,** Red Lion Inn, Seattle, WA **Prog Info:** W.W. Keltner, Room 1402, 1600 Bell Plaza, Seattle, WA 98191 (206-345-3999) & (206-655-3601)

June 9-11, 1980—**Int'l. Symposium on Electrical Insulation** (IEEE) (EI) 57 Park Plaza Hotel, Boston, MA **Prog Info:** Dr. H. St. Onge, IREQ-Hydro Quebec Institute of Research, P.O. Box 1000, Varennes, PQ, Canada, JOL 2 PO (514-652-8420)

JUNE 10-12, 1980—**Development in Power-System Protection, 2nd International Conference** (IEEE UKRI SEC., IEE, IMA) IEEE, Savoy Place, London WC2 **Prog Info:** Conference Dept., IEE Savoy Place, London WC2R OBL, England

JUNE 23-27, 1980—**Conference on Precision Electro-Magnetic Measurements (CPEM)** (IEEE Sponsors: IM; other sponsors: NBS, URSI/USNC) Stadthalle, City of Braunschweig, Fed. Rep. Germany **Prog Info:** Prof. Horst Captuller, Physikalisch Technische, Bundesanstalt, Bundsealle-100, D-3300 Braunschweig, Fed. Rep. Germany

JULY 15-18, 1980—**Nuclear and Space Radiation Effects Conference** (IEEE sponsors. NPS, other sponsors: DNA, JPL)Cornell University, Ithaca, NY **Prog Info:** Harold L. Flescher, Raytheon Company, 528 Boston Post Rd., Mailstop 1K5, Sudbury, MA 01776 (617) 443-9521, (ext. 3057)

AUG 13-15, 1980—**Joint Automatic Control Conference** (IEEE sponsors: CS, other sponsors: ASME, AIAA, ISA) Sheraton Palace, San Francisco, CA **Prog Info:** Prof. David Hullender, Dept. of Mechanical Engineering, University of Texas, Arlington, TX 76010 (817) 273-2561

AUG 18-19, 1980—**Picture Data Description and Management Symposium** (IEEE Sponsors: C) Asilomar, CA **Prog Info:** Prof. K.S. Fu, School of Electrical Engineering, Purdue Univ., W. Lafayette, IN 47907 (317) 494-8825

AUG 18-22—**Intersociety Energy Conversion Engineering Conference (IECEC)** (IEEE Sponsors: ED, AES; other sponsors: AIChE, ASME, SAE, AIAA, ACS) Olympic Hotel, Seattle, Washington **Prog Info:** Sidney W. Silverman, 19630 Marine View Drive SW, Seattle, WA 98166 (206) 773-2457

SEPT 8-10, 1980—**Engineering in the Ocean Environment (Oceans) '80** (IEEE Sponsors: COE, other sponsor: MTS) Olympic Hotel, Seattle, Washington **Prog Info:** Dr. Stanley R. Murphy, Director of the Division of Marine Resources, University of Washington, Seattle, Washington 98105

SEPT 8-10, 1980—**Petroleum and Chemical Industry Technical Conf.** (IEEE Sponsors: IA) Shamrock Hilton, Houston, Texas **Prog Info:** F.P. Gertson, Texas Eastern Corp., P.O. Box 2521, 1Hc-2712, Houston, TX 77001 (713) 759-5103

SEPT 9-11, 1980—**European Workshop on the Two Dimensional Signal Processing** (IEEE sponsors: ASSP, Swiss section, other sponsors: EURASIP) Scuola Superiore, Guglielmo, Resinn Romoli, L'Aguila, Italy **Prog Info:** J. M. Tribolet, Centro De Analise E., Processamento Sinais Das Universidades De Lisbora, Complexo 1 Do INIC, Instutito Superior Technico, Av. Rouisco Pais, Lisbora 1, De Portugal

SEPT 15-17, 1980—**VTS-80/Convergence**

80 (IEEE sponsors: VT, other sponsors: EVC, IEEE, ISATA, SAE, DOE) Hyatt Regency, Dearborn, Mich. **Prog Info:** Trevor O. Jones, TRW Automotive Worldwide, 23555 Euclid Ave., Cleveland, OH 44117 (216) 383-3644

SEPT 15-19, 1980—**Electromagnetic Compatibility** (IEEE sponsors: EMC, Cooperating, UKRISEC, other sponsor: IERE) University of Southhampton, Southhampton, England **Prog Info:** Mr. G.A. Jackson, 99 Gower Street, London, WC1E 6AZ, England (01-338-3071)

SEPT 15-19, 1980—**International Symposium on Sub Scriber Loops and Services (ISSLS '80)** (IEEE sponsors: COM, other sponsors: IECEJ, SEE, NTG, IEE) Munich, West Germany **Prog Info:** F.T. Andrews, Jr. Bell Laboratories, Whippany, N.J. 07981 (201) 386-1460

SEPT 16-18, 1980—**Western Electronic Show and Convention (WESCON)** (IEEE sponsors: IEEE L.A. & SFPAC Councils, other sponsors: ERA Northern & Southern CA Chapters) Anaheim, Convention Center, Anaheim, Calif. **Prog Info:** Dale Litherland, Electronic Conventions, Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245 (213) 772-2965

SEPT 17-19, 1980—**30th Annual Broadcast Symposium** (IEEE sponsors: BCCE) The Washington Hotel, Washington, D.C. **Prog Info:** Robert A. O'Connor, CBS TV Network, 51 W. 52nd St., N.Y., NY (212) 975-3791

SEPT 22-26, 1980—**COMPCON Fall '80** (C) Capitol Hilton, Washington, D.C. **Prog Info:** Harry Hayman, COMPCON Fall, P.O. Box 639, Silver Spring, MD 20901 (301) 439-7007

SEPT 23-25, 1980—**ESMO-80** (IEEE sponsors: PE) The Sheraton O'Hare, Chicago, Ill. **Prog Info:** A.A. Chase, Technical Program Chairman, c/o Northeast Utilities Service Co., P.O. Box 270, Hartford, CT 06101 (203) 666-6911, ext. 5305

SEPT 23-26, 1980—**3rd Int'l. Conf. on Security Through Science & Engineering** (IEEE sponsors: AES, other sponsors: Univ. of Kentucky) Technical University, Berlin, West Germany **Prog Info:** Mrs. Sue McWain, Office of Continuing Education, College of Engineering, 779 Anderson Hall, Lexington, KY 40506 (606) 257-3971

SEPT 27-28, 1980—**Frontiers of Engineering in Health Care** (IEEE sponsors: EMB) Washington Hilton Hotel, Washington, D.C. **Prog Info:** L.E. Ostrander, Ph.D, Center for Biomedical Engineering, Rensselaer Polytechnic Institute, Troy, NY 12181 (518) 270-6548

SEPT 28/OCT 2, 1980—**Joint Power Generation Conf.** (IEEE sponsors: PE, other sponsors: ASME/ASCE) Hyatt Regency Hotel, Phoenix, Ariz. **Prog Info:** Charles Jarman, Conf. Chairman, Arizona Public Service Company, P.O. Box 21666, Phoenix, AZ 85036 (602) 271-7550

SEPT 29/OCT 2, 1980—**Applied Superconductivity Conference** (IEEE sponsors: MAG) Sweeney Convention Center, Santa Fe, N.Mex. **Prog Info:** William E. Keller, LASL, P.O. Box 1663, MS764, Los Alamos, NM 87545 (505) 667-4838

SEPT 29/OCT 3, 1980—**Industry Applications Society Annual Meeting** (IA) Stouffer's Inn, Cincinnati, Ohio **Prog Info:** G.U. Messner, IA Meetings Coordinator, Microswitch Division, Honeywell, Inc. 6 W. Druid Hills Dr., Atlanta, GA 30329 (404) 321-2202

OCT 1-3, 1980—**.Very Large Data Bases 6th Intl. Conf.** (IEEE sponsors: C) Meridien Hotel, Montreal, Canada **Prog Info:** Dr. James B. Rothnie, Computer Corporation of America, 575 Technology Square, Cambridge, MA 02139 (617) 491-3670

OCT 1-3, 1980—**Circuits and Computers, Intl. Conf. (ICCC)** (IEEE sponsors: CAS, REG1, Mid-Hudson Section, C) The Rye Town Hilton Inn, Port Chester, N.Y. **Prog Info:** Dr. NB Guy Rabbat, IBM Corporation, D/818, B/300-45A, Hopewell Junction, NY 12533 (914) 897-8126 (business), (914) 297-5315 (home)

OCT 1-3, 1980—**21st Foundations of Computer Science Annual Symposium** (IEEE sponsors: C) Lake Placid, N.Y. **Prog Info:** Prof. Ronald V. Book, Dept. of Math. & Comp. Science, University of California, Santa Barbara, CA 93106 (805)961-2778/2171

OCT 1-3, 1980—**Fault Tolerant Computing Systems (FTCS 10)** (IEEE sponsors: C) Kyoto, Japan **Prog Info:** Prof. John Meyer, Dept. Elec. & Computer Engineering, University of Michigan, Ann Arbor, MI 48109 (313) 763-0037

OCT 5-8, 1980—**Electronic and Aerospace Systems Convention (EASCON)** (AES, Wash. Sec.) Stouffer's Inn, Washington, D.C. **Prog Info:** Mr. Robert S. Cooper, V.P., Satellite Business Systems, 8003 W. Park Drive, McLean, VA 22102 (703) 827-2000

OCT 7-9, 1980—**Electromagnetic Compatability Symp.** (IEEE sponsors: EMC) Baltimore Hilton, Maltimore, Md. **Prog Info:** Paul Newhouse, IIT Research Institute, ECAC/North Severn, Annapolis, MD 21402 (301 267-2453
Andrew Farrar, ITT Research Institute, ECAC/North Severn, Annapolis, MD 21402 (301) 267-4321

OCT 8-10, 1980—**Cybernetics and Society** (IEEE sponsors: SMC) Hyatt Regency, Cambridge, Mass. **Prog Info:** Dr. Richard F. Vidale, Chm., Dept. of Sys. & Computer Eng., Boston University, College of Engineering, 110 Cummington St., Boston, MA 02215 (617) 353-2805

OCT 15-17, 1980—**Canadian Communications and Power Conf.** (REG. 7, Montreal Section) Montreal, P.Q., Canada **Prog Info:** George Armitage, IEEE Canada Office, 7061 Yonge St., Thornhill, Onario, Canada L3T 2A6

OCT 20-22, 1980—**Frontiers in Education** (IEEE sponsors E, other sponsors: ASEE, Univ. of Houston) Ramada Inn, Houston, Tex. **Prog Info:** Dr. G.F. Paskusz, Univ. of Houston, Dept. of Elec. Engr., Bldg. D, 4800 Calhoun, Houston, TX 77004 (713) 749-1770

OCT 21-23, 1980—**Biennial Display Research Conference** (IEEE sponsors: ED, other sponsors: SID) Cherry Hill Inn, Cherry Hill, N.J. **Prog Info:** Thomas Henion, Palisades Institute, 201 Varick St., N.Y., NY 10014 (212) 620-3384

NOV 3-5, 1980—**Automatic Support Systems for Advanced Maintainability (AUTOTESTCON)** (IEEE sponsors: AES, IM Washington Sec.) Washington, D.C. **Prog Info:** M. Myles, Chairman, Naval Air Systems Command, Washington, DC 20361 Code AIR-55224 (202) 692-3146/7

NOV 5-7, 1980—**Ultrasonics Symp.** (SU) Boston Park Plaza, Boston, Mass. **Prog Info:** R.C. Williamson, MIT Lincoln Labs, Rm. D-331, P.O. Box 73, Lexington, MA 02173 (617) 862-5500, ext. 358

NOV 5-7, 1980—**Nuclear Power Systems Symposium** (IEEE sponsors: NPS) Sheraton-Twin Towers Hotel, Orlando, Fla. **Prog Info:** Ernesto A. Corte, General Atomic Co., P.O. Box 81608, La Jolla, CA 92138

NOV 5-7, 1980—**Nuclear Science Symposium** (IEEE sponsors: NPS) Sheraton-Twin Towers Hotel, Orlando, Fla. **Prog Info:** J.A. Martin, Oak Ridge National Laboratory, P.O. Box X, Oak Ridge, TN 37830

NOV 6-8, 1980—**MIDCON Electronic Show & Convention** (IEEE sponsors: IEEE Region 4 & IEEE Chicago & Dallas Sections, other sponsors: ERA Mid-USA Council ERA Chicago & S.W. chapters) Dallas Convention Center, Dallas, Tex. **Prog Info:** Dale Litherland, Electronic Conventions, Inc., 999 N. Sepulveda Blvd., El Segundo, CA 90245 (213) 772-2965

NOV 9-13, 1980—**COMPSAC** (C) Palmer House, Chicago, Ill. **Prog Info:** Harry Hayman, COMPSAC 80, P.O. Box 639, Silver Spring, MD 20901 (301) 439-7007

NOV. 11-13, 1980—**Cherry Hill Test Conference** (IEEE sponsors: C, Philadelphia Sec.) Philadelphia, Pa. **Prog Info:** Joseph B. Tomei, Program Chairman, Sperry-Univac, P.O. Box 245, Chalfont, PA 18914 (215) 542-5070

NOV 11-14, 1980—**Magnetism and Magnetic Materials Conf.** (IEEE sponsors: MAG, other sponsors: AIP) Statler Hilton, Dallas, Texas **Prog Info:** D.C. Bullock, Texas Instruments, Inc., P.O. Box 5936—MS. 145, Dallas, TX 75222

NOV 30/DEC 4, 1980—**National Telecommunications Conference** (IEEE sponsors: AES, COM, GE, Houston Section) Shamrock Hilton, Houston, Texas **Prog Info:** Dr. Harb S. Hayre, General Chairman, Univ. of Houston, EE Dept., Houston, TX 77004 (713) 749-4503/4534

Pen and Podium

Recent RCA technical papers and presentations

To obtain copies of papers, check your library or contact the author or his divisional Technical Publications Administrator (listed on back cover) for a reprint.

Advanced Technology Laboratories

F.J. Goodman|J.J. Welsh
Digital signal processing applications of the ATMAC microprocessor—1st International Mini- and Micro-computer Conference, Houston, Texas, *Proceedings* (11/14-16/79)

J. Hudson
TI-59 Program gives transient responses—*EDN Magazine*, Vol. 24, No. 21, pp. 222 & 229 (11/20/79)

Automated Systems

O.T. Carver
Status Report—Industry/Joint Services Automatic Test Project—Society of Logistics Engineers, Boston Chapter, Nashua, N.H. (12/19/79)

N.L. Laschever
What's an Engineer—Editorial for the *IEEE Reflector* (12/79)

J.C. Phillips
Writing for publication—IEEE Group on Professional Communications Society Meeting, N.E. Chapter, Boston, Mass. (12/11/79)

Broadcast Systems

J.J. Clarke|N.P. Kellaway
Operational features of a microprocessor-controlled TV camera—NAB, Dallas, Texas (3/25/79)

N.L. Hobson/L.J. Thorpe
A microprocessor-controlled television camera—SMPTE, San Francisco, Calif. (2/2/79)

R.S. Hopkins
Digital signal origination and processing in the 525-line TV standard—Montreaux International Symposium, *Montreux Proceedings* (5/30/79)

R.S. Hopkins
Report of the Committee of New Technology—SMPTE (2/2/80)

R.N. Hurst
Digital TV: A new aid to creative television production—*Video Systems Magazine*

A.H. Lind
Comments on digital recording—Montreux International Symposium (5/30/79)

A.C. Luther
Remarks on digital recording—SMPTE, San Francisco, Calif. (2/2/79)

V.F. Renna|F.D. Galey|H.P. Howard
New product development-quality assurance system approach—ASQC, Houston, Texas (5/14/79)

W.S. Sepich
Broadcast Systems provides a wealth of customer support service—*TREND* Digest

C.R. Thompson
Recent advances in digital video recording—SMPTE (2/2/80)

L.J. Thorpe|R.A. Dischert
The microprocessor-controlled TK-47 autocam camera—Montreux Int'l. Symposium, *Proceedings* (5/27/79)

J.W. Wentworth
Color television fundamentals—*Broadcast Engineering Magazine*

Government Communications Systems

D. Hampel
Low-cost low-power dissipation micro signal processor for acoustic signal processing—33rd Navy Symposium on Underwater Acoustics NRL, Washington, D.C. (12/3-5/79)

J. Springer
The architecture and operation of a multiple microprocessor communications front-end—MIMI '80 ASILOMAR, Pacific Grove, Calif. (1/30-2/1/80)

Laboratories

G.A. Alphonse|D. Vilkomerson
Broadband random phase diffuser for ultrasonic imaging—*Ultrasonic Imaging 1*, pp. 325-332 (1979)

A.E. Bell|R.A. Bartolini|F.W. Spong
Optical recording with the encapsulated titanium trilayer—*RCA Review*, Vol. 40 (9/79)

A.E. Bell
Review and analysis of laser annealing—*RCA Review*, Vol. 40 (9/79)

D.J. Channin|M. Ettenberg|H. Kressel
Self-sustained oscillations in (AlGa) As oxide-defined stripe lasers—*J. Appl. Phys.* Vol. 50, No. 11 (11/79)

J.I. Gittleman|E.K. Sichel
H.W. Lehmann|R. Widmer
Textured silicon: A selective absorber for solar thermal conversion—*Appl. Physics Letters*, Vol. 35, No. 10 (11/15/79)

J.M. Hammer
Optical waveguide modulation techniques—*Fiber and Integrated Optics* (1979)

L. Jastrzebski|A.E. Bell|C.P. Wu
The depth of defect annihilation in silicon by pulse laser annealing: experiment and theory—*Applied Physics Letters*, Vol. 35, No. 8 (10/15/79)

W.F. Kosonocky|D.J. Sauer
Low-loss charge-coupled device—*RCA Review*, Vol. 40 (9/79)

A. Okada|T. Oka
AES observation of electron-beam-induced layer formation on ZnS in the presence of water vapor—*J. Appl. Phys.*, Vol. 50, No. 11 (11/79)

J.R. Sandercock, *et al.*
Brillouin scattering from surface phonons in A1-coated semiconductors—*Physical Review Letters*, Vol. 43, No. 3 (7/16/79)

D.J. Sauer
Analysis of the effective transfer losses in a low-loss CCD—*RCA Review*, Vol. 40, No. 3 (9/79)

H. Schade|J.I. Pankove
Photoemission from cesiated hydrogenated amorphous silicon—*Surface Science* 89 (1979)

A.C. Schroeder
The development of color error formulas useful in color television—*SMPTE Journal*, Vol. 88 (10/79)

H.S. Sommers, Jr.
Experimental properties of injection laser: VII. Narrow stripe lasers with rigid waveguide—*J. Appl. Phys.*, Vol. 50, No. 11 (11/79)

H.S. Sommers, Jr.
Experimental properties of injection lasers: VIII. Narrow stripe lasers with induced waveguide—*J. of Applied Physics*, Vol. 50, No. 11, Part 1 (11/79)

C.P. Wu|G.L. Schnable
Laser annealing to round the edges of silicon structures—*RCA Review*, Vol. 40 (1979)

C.P. Wu|E.C. Douglas
C.W. Mueller|R. Williams
Techniques for lapping and staining ion-implanted layers—*J. of the Electrochemical Society*, Vol. 126, No. 11 (11/79)

Missile and Surface Radar

J.A. Bauer
High temperature high density microelectronics—High Temperature Electronics and Instrumentation Seminar, Houston, Texas (12/79)

H.B. Boardman
The U.S. Navy's "ORTS"-A classic integrated test system development experience—Automatic Testing '79, Brighton, England, Conference, *Proceedings* (12/11-13/79)

B.F. Bogner
How to defend yourself against radar in traffic court without an attorney—Brehn Corp., Mt. Holly, N.J. (1/80)

F.J. Buckley
Software quality assurance management—Computers in the 1980s Conference, Washington, D.C. Conference *Proceedings* (12/79)

J.E. Friedman|J. Haness
Documentation-the hidden cost of management—IEEE Engineering Management Conference, Arlington, Va. (11/79)

R.L. Schelhorn
A universal probing technique for continuity and isolation testing of HCC circuits—1979 Int'l. Microelectronics Symposium, Los Angeles, Ca. (11/79)

A. Schwarzmann
Printed transmission lines—Phila. Chapter IEEE Meeting (11/79)

D. Staiman
Automated near-field antenna test set for phased array production—Antenna Measurements Symposium, Symposium *Digest*, Atlanta, Ga. (10/79)

H. Urkowitz
Models for radar design and evaluation—USAF Warning Information Correlation (WIC) Program, meeting of WIC Threat Working Group, Arlington, Va. (10/11/79)

Patents

Commercial Communications Systems

Breithaupt, D.W.
Remote control TV subcarrier phase shifter system—4183044

Herrmann, D.C.|Bazin, L.J.
Chroma keying selector system—4183045

Johns, M.R.
Circularly polarized antenna system using a combination of horizontal and bent vertical dipole radiators—4180820

Consumer Electronics

Harford, J.R.
Synchronization signal separator circuit—4185299

Haslau, H.E.
Winding structure—4183002

Lagoni, W.A.
LED channel number display responsive to ambient light level—4181915

Distributor and Special Products

Bachman, Jr., W.J.|Dimeo, F.R.
Plug-in circuit cartridge with electrostatic charge protection—4179178

Government Communications Systems

Hudson, K.C.|Herzog, D.G.
Optical scanner and recorder—4180822

Hulls, L.R.|Dowdell, Jr., T.
Alternator test apparatus and method—4178546

Khalifa, J.R.
Phase lock loop data timing recovery circuit—4180783

Laboratories

Alig, R.C.
CRT with field-emission cathode—4178531

Anderson, C.H.|Bloom, S.
Guided beam flat display device—30195

Aschwanden, F.
Phase locked loop tuning system including stabilized time interval control circuit—4182994

Aschwanden, F.
Comb filter system—4184174

Babcock, W.E.
Television S-correction circuit with improved linearity—4181874

Barnette, W.E.|Spong, F.W.
Capacitance distance sensor apparatus for video disc player/recorder—4183060

Bloom, A.|Hung, L.K.
Novel liquid crystal dyestuffs and electro-optic devices incorporating same—4184750

Bohringer, W.
Voltage regulator for a television deflection circuit—4186330

Cantanese, C.A.|Endriz, J.G.
Electron multiplier device with surface ion feedback—4182969

Chang, K.K.
Flat cathode ray tube having magnetically collimated electron beam device—4180760

Denhollander, W.
Raster correction circuit with low dissipation resistive damping—4179642

Etzold, K.F.
Matching network for switchable segmented ultrasonic transducers—4181864

Flatley, D.W.
Process of making a planar MOS silicon-on-insulating substrate device—4178191

Forster, G.
Drive circuit for a television deflection output transistor—4177393

Gange, R.A.
Proximity focused electron beam guide display device including mesh having apertures no greater than 23 microns in one dimension—4181871

Goel, J.
Self biasing of a field effect transistor mounted in a flip-chip carrier—4183041

Haferl, P.E.
Current switching networks—4177392

Ham, W.E.
Method for cleaning and drying semiconductors—4186032

Hammer, J.M.|Neil, C.C.
Fiber-optic thermometer—4176551

Hammer, J.M.
Fiber-optic thermometer—4176552

Hawrylo, F.Z.
Laser diode with thermal conducting, current confining film—4182995 (assigned to U.S. government)

Henderson, J.G.
Liquid crystal channel number display responsive to ambient light level—4181916

Hsu, S.T.|Cartwright, Jr., J.M.
Complementary MOS inverter structure—4178605

Keneman, S.A.|Endriz, J.G.
Electron multiplier with ion bombardment shields—4182968

Ladany, I.|Ettenberg, M.
Kressel, H.|Lockwood, H.F.
Half wave protection layers on injection lasers—4178564 (assigned to U.S. government)

Levin, J.S.
Flow controller—4178974

Liu, S.|Duigon, F.C.
Thin film pattern generation by an inverse self-lifting technique—4181755

McCandless, H.E.
Method for establishing uniform cathode-to-grid spacing in an electron gun—4176432

Olsen, G.H.|Ettenberg, M.
Low cost high efficiency gallium arsenide homojunction solar cell incorporating a layer of indium gallium phosphide—4179308

Palmer, R.C.
Track skipper for a video disc player—4183059

Roach, W.R.
Depth estimation system using diffractive effects of the grooves and signal elements in the grooves—4180830

Sauer, D.J.
Readout of a densely packed CCD—4178614

Sheng, P.|Firester, A.H.
Optical playback system having increased depth-of-field—4179708

Weisbrod, S.
Row addressing apparatus for a bistable display device—4183062

Missile and Surface Radar

Woodward, O.M.
Broad band, four loop antenna—4184163

Solid State Division

Ahmed, A.A.
Current mirror amplifier—30173

Dingwall, A.G.
High speed resettable dynamic counter—4181862

Dingwall, A.G.
Inhibitable counter stage and counter—4182961

Grill, G.P.|Doner, C.E.
Double-tuned output circuit for high power devices using coaxial cavity resonators—4184123

Kaplan, L.A.
Biasing and drive circuitry for quasi-linear transistor amplifiers—4180781

Kaplan, L.A.
Phantom full-bridge amplifier—4180782

Kucharewski, N.
Electrical circuits—4185211

Leidich, A.J.
Level shifting circuit—4185212

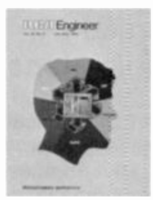
Polinsky, M.A.
Method of making a bipolar transistor with high-low emitter impurity concentration—4178190

Schade, Jr., O.H.
Amplifier with field effect and bipolar transistors—4183020

Shambelan, R.C.
Apparatus for simultaneously processing a plurality of substrates—4185585

Stewart, R.G.
Non-volatile memory device—4185319

Zuk, B.
Contact de-bouncing circuit with common mode rejection—4185210



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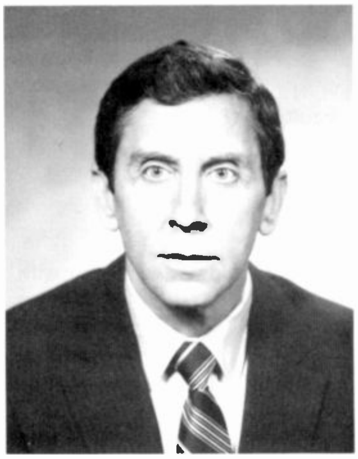
Engineering News and Highlights

Podmolik elected to new RCA Globcom post



Election of **Valerian F. Podmolik** as Executive Vice President, Operations and Engineering, for RCA Global Communications, Inc., was announced today by **Eugene F. Murphy,** President. "The appointment will assist in enabling RCA Globcom to meet the challenges of a rapidly changing and intensely competitive business environment." Mr. Murphy said.

Flanagan and Carlen new Ed Reps for AS

Sara Flanagan joined RCA in August of 1979 in the Technical Publications Department. She was recently appointed editorial representative. Sara is a part of the special projects and proposal group. A graduate of Massachusetts College of Art in Boston, Sara's background is journalism and graphics. She has experience in newspaper, magazine and book publication. Contact her at: Automated Systems, Burlington, Mass., ext. 2975.

Jim Carlen joined the RCA, Burlington Technical Communications Group in May 1979, as a Senior Publications Engineer. He was recently given responsibility for the special projects and proposals group which, in addition to the *RCA Engineer* and *TREND* articles, provides publications engineering support for proposals, reports, presentations, and other technical communications projects. Contact him at: Automated Systems, Burlington, Mass., ext. 2975.

Staff Announcements

Commercial Communications Systems

RCA Mobile Communications Systems today announced the promotion of **Lee F. Crowley,** a key engineering manager in product development programs, to the newly-created position of Manager, Product Operations. **Jerry L. Copeland,** Division Vice President and General Manager, said Mr. Crowley would be responsible for engineering, product marketing and field technical operations. An 18-year RCA employee, he formerly was Manager, Engineering and Technical Services.

Consumer Electronics

The appointment of **Gerald A. Gradek** to Plant Manager, Monticello Plant, was announced by **Leonard J. Schneider,** Division Vice President, Manufacturing.

The appointment of **Randall R. Mitchell** to Manager, Plant Quality Control and Manufacturing Engineering, was announced by **Gerald A. Gradek,** Plant Manager, Monticello Plant.

Global Communications

Martin L. Finkelstein has been named to the newly created position of Vice President, Service Assurance for RCA Global Communications, Inc., it was announced today by **Robert J. Angliss,** Executive Vice President, Switched Services. In this position, Mr. Finkelstein is responsible for quality control programs for all RCA Globcom's services to assure customer satisfaction and compliance with company standards of reliability and quality.

Joe T. Swaim, Vice President, Engineering announces the organization of Engineering as follows: **Nicholas DiSanti,** Manager, Customer Engineering; **John P. Shields,** Manager, Facilities Engineering; **William I. Meehan,** Manager, Circuit Switching Engineering; **John F. Scannapieco,** Manager, Message Switching Engineering; **Solomon J. Nahum,** Manager, Construction and Installation; and **Walter N. Bauer,** Manager, Engineering Administration.

Laboratories

Appointment of **Carmen A. Catanese** as Head of the Kinescope Systems Research Group has been announced by **Brown F. Williams,** Director of the Display and Energy Systems Research Laboratory.

Appointment of **Emilie M. Lengel** as Head of the Data Communications Research Group has been announced by **Daniel A. Walters,** Director of the Communication Systems Research Laboratory, at RCA Laboratories in Princeton, N.J.

Solid State Division

Robert S. Pepper, Vice President and General Manager, announces the organization of the Solid State Division as follows: **Walter J. Glowczynski,** Division Vice President, Finance; **Ben A. Jacoby,** Division Vice President, Marketing; **Donald Kirchhoffer,** Division Vice President, Industrial Relations; **Robert S. Pepper,** Acting Division Vice President, Integrated Circuits; **Ralph E. Simon,** Division Vice President, Electro-Optics and Power Devices; and **Carl R.**

Turner, Division Vice President, Product Assurance and Planning.

Ralph E. Simon, Division Vice President, announces the organization of Electro-Optics and Power Devices as follows: **Charles W. Bizal,** Manager, Operations Support—Lancaster; **William E. Bradley,** Manager, Quality and Reliability Assurance, Lancaster; **Harold R. Krall,** Director, Solid State Systems Products;**Thomas T. Lewis,** Director, Electro-Optics and Devices Operations; **John E. Mainzer,** Director, Power Operations; **Robert E. O'Brien,** Manager, Power Administration and Technology; and **Donald Watson,** Director, Product Marketing—Power.

Thomas T. Lewis, Director, announces the organization of Electro-Optics & Devices Operations as follows: **Scott I. Alexander,** Manager, Imaging and Display Tubes; **Clarence H. Groah,** Administrator, Electro-Optics & Devices Administration; **Leonard W. Grove,** Manager, Electro-Optics & Devices Manufacturing; **Fred R. Hughes,** Manager, Solid State Emitters; **Ron G. Power,** Manager, Photodetectors (Montreal, Canada); **Carl L. Rintz,** Manager, Power Tubes; **Eugene D. Savoye,** Manager, Charged Couple Devices (CCD); and **C. Price Smith, Manager, Photo Tubes.**

Scott I. Alexander, Manager, announces the organization of Imaging and Display Tubes as follows: **Thaddeus J. Grabowski,** Administrator, Market Planning; **William S. Lynch,** Manager, Engineering—Broadcast Products and Materials & Processes; **Donald C. Reed,** Manager, Engineering—Imaging Product Development & Special Products; and **Scott I. Alexander,** Acting, Applications Engineering.

Leonard W. Grove, Manager, announces the organization of Electro-Optics & Devices Manufacturing as follows: **David L. Brubaker,** Manager, Manufacturing & Production Engineering—Photo Conductive Camera; **William H. Hackman,** Manager, Manufacturing & Production Engineering—Silicon; **John G. Kindbom,** Manager, Power Products Manufacturing—Triodes, Tetrodes & External Anodes; **Richard J. Miller,** Manager, Manufacturing & Production Engineering—Electro-Optics Assembly; **Richard H. Phillips,** Manager, Engineering—Photo Tubes; **Herbert W. Sawyer,** Manager, Power Products Manufacturing—Internal Anodes & Pencil Tubes; **Joseph D. Schmitt,** Manager, Production Planning & Materials—Power Tubes; **William M. Sloyer,** Manager, Production Planning & Materials—Electro-Optics; and **Kenneth A. Thomas,** Manager, Manufacturing—Photo Tubes.

Fred R. Hughes, Manager, announces the organization of Solid State Emitters as follows: **George S. Brody,** Administrator, Market Planning; **Fred R. Hughes,** Acting, Manufacturing & Special Products; and **James T. O'Brien,** Manager, Engineering—Product Development & Applications.

Carl L. Rintz, Manager, announces the organization of Power Tubes as follows: **Ronald M. Bowes,** Manager, Market Planning—Power Tubes; **Peter Harvest,** Manager, Fabrication & Processing; and **Walter E. Kauffman,** Administrator, Thermoelectric Operations.

Eugene D. Savoye, Manager, announces the organization of Charged Couple Devices as follows: **N. Richard Hangen,** Administrator, Market Planning—Charged Couple Devices and Electro-Optics & Devices; and **William N. Henry,** Manager, Manufacturing & Production Engineering.

C. Price Smith, Manager, announces the organization of Photo Tubes as follows: **Fred A. Helvy,** Manager, Market Planning & Applications Engineering; **C. Price Smith,** Acting, Machine Shop; **Daniel L. Thoman,** Manager, Engineering—Product Development & Special Products; and **John J. Walsh, Jr.,** Manager, Customer Services & Control—Electro-Optics & Devices.

Harold R. Krall, Director, announces the Microprocessor Systems organization as follows: **Michael Caterina,** Manager,

Obituaries

Newton A. Teixeira

Newton A. Teixeira, who was Manager, ATE Program Operations at RCA Automated Systems, died on December 31 at his home in West Newton, Mass. A part of RCA since 1955, he was prior to that a founder, and for 20 years a director, of the Associated Engineering Corporation in Boston.

Active in the First Unitarian Church of Newton, Mass., he lived his beliefs and philosophies both professionally and privately.

Professionally, he created an atmosphere of a single team with a single purpose — trying to do best for a product area and, more significantly, trying to do best with a group of people. A quote from his office wall reads, "There is no limit to what can be accomplished if it doesn't matter who gets the credit."

Newton A. Teixeira, a skilled professional, a philosopher, and wordsmith, sums up his overview of life:

"... it is nonsense to talk about technology versus nature. Even if we restrict ourselves to man's technology, we are contained within an overall view of nature. As an integral part of nature, man cannot do anything unnatural. It may seem to us that we alter the process of evolution but the inexorable process works on us too. We are part of the experiment."

Wieslaw W. Siekanowicz

Wieslaw W. Siekanowicz died on January 2, 1980. He joined the RCA Microwave Tube Operations at Harrison, New Jersey where he developed the first commercial periodic permanent magnetic focused traveling-wave tubes. This type of tube is used in many important applications including communication satellites. In 1956, he became a member of the technical staff at the David Sarnoff Research Center in Princeton, New Jersey. He has been engaged in applied research and advanced development work on microwave tubes, permanent magnets, ferrite devices, integrated microwave circuits, semiconductor bulk-effect devices, electron beam semiconductor amplifiers and electron-beam display devices. He received RCA Laboratories' Achievement Awards in 1967 and in 1970 for his work on microwave ferrite switches and limiters, and in 1976 for new types of beam-focusing structures for display devices. His work on ferrite limiters resulted in a product that is used in the weather radar systems of many commercial airlines. He has received 11 U.S. patents and has four pending applications, plus ten disclosures. Dr. Siekanowicz was a member of Sigma Xi and the IEEE.

Product Marketing; **Edwin Fulcher,** Manager, Microprocessor Systems Engineering; and **Floyd D. Rue,** Administrator, Market Planning.

John E. Mainzer, Director, announces the Power Operations organization as follows: **Donald E. Burke,** Manager, Power Development Engineering; **George W. Ianson,** Manager, Strategic Planning and Administration; **Vincent J. Lukach,** Manager, Quality and Reliability; **Joseph R. Spoon,** Manager, Industrial Relations; **Chin Bin Teh,** Manager, Power Operations—Malaysia; and **Parker T. Valentine,** Manager, Power Manufacturing.

Donald Watson, Director, announces the Power Marketing organization as follows: **Dale M. Baugher,** Manager, Applications Engineering; **Charles Cianciarulo,** Manager, Product Control; **Donald W. Hasenzahl,** Administrator, Product Planning; **Donald A. Pahls,** Manager, Product Marketing; **Frank J. Rohr,** Manager, Market Planning; **George S. Scholes,** Manager, Product Marketing; and **Edward F. Uhler,** Manager, Product Marketing.

Carl R. Turner, Division Vice President, Product Assurance and Planning, announces the appointment of **Edward M. Troy** to Director, Operations Planning and Support.

Edward M. Troy, Director, announces the organization of Operations Planning and Support as follows: **Anthony J. Bianculli,** Manager, Engineering Publications and Standards; **James J. Kollmar,** Manager, Industrial Engineering; **Thomas E. Swander,** Manager, Plant Facilities Engineering; and **Edward M. Troy,** Acting Administrator, Operations Planning.

Degrees granted

Government Communications Systems

G.M. Friedman—Masters of Science, Systems Engineering; University of Pennsylvania, Phila., Pa.

Licensed engineers

When you receive a professional license, send your name, PE number and state in which registered, RCA division, location, and telephone number to *RCA Engineer*, Bldg. 204-2, RCA Cherry Hill, N.J. New listings (and corrections or changes to previous listings) will be published in each issue.

Professional activities

Dr. Hillier inducted into National Inventors Hall of Fame

Dr. James Hillier, who retired as Executive Vice President and Scientist in 1977, has been elected to the National Inventors Hall of Fame for his development of the electron microscope. He was inducted on February 10 with three other inventors: Dr. Lewis Sarett (synthesis of cortisone; posthumously, Major Edwin Armstrong (superheterodyne radio receiver); and Charles F. Kettering (self-starter).

Dr. Hillier is the second man to be elected to the Inventors Hall of Fame in connection with his work at RCA. **Dr. Vladimir Zworykin,** who hired Dr. Hillier as an RCA employee in 1940, was installed in 1977 for his television developments.

The electron microscope provides extremely high-power magnifications, substantially greater than ones obtained with any optical microscope. The instrument is widely used in medical, biological, and metallurgical research studies.

The National Inventors Hall of Fame was established in 1973 by the National Council of Patent Law Associations in cooperation with the Patent and Trademark Office. Thomas A. Edison was the first inductee in 1973.

Rosenthal elected to ANSI Board of Directors

Howard Rosenthal was elected to the American National Standards Institute Board of Directors on December 5, 1979. As Staff Vice President, Engineering, RCA Research and Engineering, he is responsible for coordinating the engineering activities for RCA's product divisions and for Corporate Engineering Services, which includes corporate standards engineering, engineering education, information programs, and technical information systems groups.

Mr. Rosenthal has been with the corporation since 1949 when he joined RCA Laboratories as a member of the technical staff. He is a member of the American Chemical Society and the Institute of Electrical and Electronics Engineers.

RCA authors to speak at International Radar Conference

The IEEE sponsored 1980 International Radar Conference will be held on April 28 through 30 in Arlington, Va. A two-parallel session format is expected for the three days to encourage moving from session to session between papers. The authors of papers will make themselves available in a designated reception room after their presentations for detailed questions.

The following is a list of RCA authors and titles of their papers:

John A. DiCiurcio, "AN/TPQ-27 Precision Tracking Radar" (MSR)

Michael R. Ducoff, "Closed-Loop Angle Tracking of Unresolved Targets" (MSR)

Robert G. Higbee/John J. Ratkevic, "The NIDIR System—Performance and Economy for Range Insturmentation" (MSR)

Lee E. Kitchens, "The HR-76 Fire Control Radar" (MSR)

John W. Parnell, "The Probability of Range Resolution of Closely Spaced Radar Targets" (MSR)

Willard T. Patton, "Low-Sidelobe Antennas for Tactical Radars" (MSR)

Samuel M. Sherman, "Comparison of Pure and Doppler-Coupled Range Measurements for Prediction" (MSR)

David Staiman, "Automating Near-Field Antenna Testing for Phased Array Radars" (MSR)

G.A. Lucchi, "Commercial Airborne Weather Radar Technology" (Avionics Systems)

Three RCA engineers elected IEEE Fellows

The membership grade of Fellow is the highest attainable in the Institute of Electrical and Electronic Engineers. The IEEE annually recognizes as Fellows those members who have made outstanding contributions to the field of electronics.

Martin Caulton

"for technical contributions and leadership in development of microwave integrated circuits and high-power transistors."

Since joining RCA Laboratories in 1960, Martin Caulton has engaged in research on microwave power tubes, multivelocity flow problems in electron beams and plasmas, and microwave solid-state devices. He has been directing projects in microwave integrated circuits since 1966, and has authored numerous papers in this field. In 1968 and 1971, he was the recipient of RCA Laboratories' Achievement Awards for this work. He has worked on the basic design and measurement of microstrip circuits and integration methods for the miniaturization of high-power amplifiers and microwave circuits, including FET devices.

Jack Hilibrand

"for contributions to the development of integrated circuits."

Jack Hilibrand, who is Staff Technical Advisor, Engineering, for RCA's Government Systems Division has been responsible for planning and coordinating integrated circuit development for the business activities of the Government Systems Division for the past nine years. Prior to coming to the Government Systems Division, Jack Hilibrand had been at the RCA Solid State Division in Somerville, N.J. where he was involved in the development of integrated circuits and power transistors. He joined RCA in 1956 as a member of the technical staff at the David Sarnoff Research Center, Princeton, N.J., and spent five years there in the research and development of semiconductor devices.

Robert J. McIntyre

"for theoretical work on the noise properties of avalanche photodiodes, and for leadership in their development."

Robert McIntyre has contributed to the understanding of avalanche multiplication in semiconductor diodes, generating theories to explain the noise spectral density and gain distribution in avalanche photodiodes, among others. The photosensor R&D program under his direction has led to the establishment of a rapidly expanding business in this area for RCA Ltd.

technical excellence

Fourth quarter 1979 Technical Excellance Award Winners announced by MSR


Clapper


Mauldin


O'Leary


Schisler

CETEC has completed its review of the Technical Excellence Award nominations for the fourth quarter 1979 and has selected four winners. The citations are summarized below.

S.L. Clapper—for his concept, design, and development effort on a digital-logic simulator now being used in the AEGIS Advanced Signal Processor (AASP) project to eliminate the time-consuming breadboard stage. Used by all the AASP logic designers, his simulator models more than 100 different integrated circuits, including bit-slice LSI microprocessors and VLSI CMOS/SOS devices.

J.D. Mauldin—for his work in the development of computer programs for an automatic computerized facility for testing the large elevation beamformer assemblies used in the AEGIS antenna arrays. Faster, cheaper, and simpler than the manual methods formerly used, his automated test facility also eliminates the need for tedious mathematical reduction and analysis of test data.

W.J. O'Leary—for his contributions in the planning and implementation of the AEGIS system level reliability program, culminating in the achievement of OT III-B reliability scores and system MTBF significantly higher than the specified values. His practical, directly usable reliability specifications and reliability design practices were key elements in achieving the outstanding system reliability performance demonstrated to date.

J.E. Schisler—for her design, development and checkout of the software for implementing the SSURADS (*S*hip *SU*rveillance *RAD*ar System) timing evaluation. Ms. Schisler's implementation on the bit-slice eight-microprocessor test bed, previously developed by the Advanced Technology activity, verified the feasibility of using distributed microprocessors for radar control and processing to meet tactical mission requirements.

Harmening Named MSR 1979 Annual Technical Excellence Award Winner

CETEC has completed its selection process from the list of nominees for the Annual Technical Excellence Award, and the selection of **Wayne Harmening** was announced as the award winner. This is not Wayne's first CETEC recognition; in addition to his quarterly award in 1979, he was also honored for his development work in 1975 on a laser system steering mechanism.

Wayne's award this year is for the design, development, and implementation of the Near Field Scanner, an essential part of the Near Field Test Facility now in use for AN/SPY-1A array antenna testing. This new facility, located adjacent to the manufacturing area, enables indoor pattern measurements and performance tests of antennas. Compared with conventional outdoor far-field test ranges, the near field facility offers rapid, convenient testing in a small area unaffected by weather conditions.

Solid State Electro-Optics Symposium Held in Lancaster Plant

A technical symposium on solid state electro-optics was held on January 23 in Lancaster, Pa. Its purpose was to update attendees on the technology and related applications and provide an opportunity for members of the RCA technical community to meet and exchange information.

The program actually began at a dinner reception the night of the 22nd with a welcome by **Dr. Ralph E. Simon,** Division Vice President, Electro-Optics and Power Devices, and an address, entitled "Photons for Sale," by special guest, **Dr. Albert Rose.** Dr. Rose, formerly of the RCA Laboratories, spoke on the growing use of cheaper materials and inexpensive processing for Vidicons, office copiers, and solar cells, where once only sophisticated, expensive processing techniques were deemed appropriate for the task. **Ralph Engstrom,** Electro-Optics and Power Devices, was Chairman of the program which included the topics and speakers below.

A tour after the presentations included a look at the work going on in integrated circuits for TV cameras, the CCD color camera, photoresist technology, fiber-optics communications, low-light-level TV, and custom LSIs for cameras.

Copies of the viewgraphs used in the talks will be available in RCA technical libraries. For more information on a specific talk, contact the respective author.

"Development of LEDs and Solid-State Lasers," **Fred Hughes,** Electro-Optics and Power Devices.

"Silicon Optical Detectors," **Bob McIntyre,** Electro-Optics and Power Devices, RCA Limited, Canada.

"Silicon Target Development for Vidicons, SIT Tubes, and CCDs," **Dick Savoye,** Electro-Optics and Power Devices.

"Amorphous Silicon: Materials and Devices," **Art Firester,** RCA Laboratories.

"Single-Chip CCD Color Camera," **Peter Levine,** RCA Laboratories.

"Development of Infrared CCDs (Schotkky Barrier Detectors)," **Walter Kosonocky,** RCA Laboratories.

"Application of Infrared Schottky Barrier Detectors to Perimeter Surveillance," **Ferd Martin,** Automated Systems.

"Applications of Injection Lasers," **Mike Ettenberg,** RCA Laboratories.

"CCD Color Camera," **Harold Krall,** Electro-Optics and Power Devices.

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